MOPANI DISTRICT WATER AND WASTE WATER REVITALISATION PROGRAMME: GIYANI WASTE WATER TREATMENT WORKS

Wetland Specialist Basic Assessment Report

ENVIRONMENTAL IMPACT MANAGEMENT SERVICES
20 YEARS 1993 - 2013
Leaders in Environmental Management

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Wetlands • Ecology • Responsibility

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Declaration of Interest

Details of specialist and declaration of interest in respect of an

application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

MOPANI DISTRICT WATER AND WASTE WATER REVITALISATION PROGRAMME: GIYANI WWTW

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The specialist appointed in terms of the Regulations

I, Piet-Louis Grundling , declare that -

General declaration:

- 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 will take into account, to the extent possible, the matters listed in Regulation 8;
- 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 form 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 specialist:

Imperata Consulting CC

Name of company:

11 January 2016

Date:

Signature of Commissioner of Oaths

Date:

Designation:

Official stamp (below)

Suggested Citation: Grundling, P., Ngobela, N. and Grobler, L.E.R. 2014. Wetland Assessment Report for the Mopani District Water and Waste Water Revitalisation Programme: Giyani WWTW near Giyani, Limpopo Province. Wetland Specialist Basic Assessment Report for EIMS, Johannesburg.

Approach and Disclaimer

This report provides a brief description of wetlands, as defined by the National Water Act (NWA), Act No. 36 of 1998 that are present within the study areas, including wetlands present within a 500m radius of the study area. The report focuses on the delineation and assessment of these watercourses, which include wetlands and riparian habitat. The investigation furthermore provides a description of selected aspects of the study area and identifies potential project related impacts that are assessed in specialist studies. This includes the provision of impact mitigation measures.

This study does not provide detailed descriptions of the local geology, agricultural potential, climatic conditions, hydrology of the aquatic environments (including volumes and flow patterns), surface and ground water quality, aquatic and terrestrial flora and fauna, or a detailed review of the legal constraints associated with potential project related impacts on the environment. It has been assumed for the purposes of this report that these aspects have been the subject of separate specialist studies should they be required as part of the environmental authorisation process.

Executive Summary

Imperata Consulting CC was appointed by EIMS to undertake wetland assessment study for Giyani Waste Water Treatment Works (WWTW) as part of the Mopani District Water and Waste Water Revitalisation Programme near Giyani, Limpopo Province.

Based on our understating of the proposed development layout for the upgrade works, the majority of the proposed infrastructure features will be located within the existing WWTW footprint (Figure 2). Laubscher (2015) provides the following motivation for the proposed new upgrade work to the existing Giyani Waste Water Treatment Works (WWTW):

- The existing Giyani WWTW, with a capacity of only 4.2Ml/day, is presently being operated over its design capacity, namely at about 6Ml/d on average during dry seasons. Excessively high storm water infiltrations can occur during the rainy seasons with inflows higher than 12Ml/d that have been experienced. The works is currently operating at a hydraulic loading of approximately 6 Ml/day.
- The works will soon be receiving even more pressure with the implementation of a development strategy whereby all sub-RDP standard serviced stands will receive full waterborne water supply and wastewater collection systems over the next 15 to 20 years. The Technical Report proves that a works of at least 14Ml will be required over the design period of 10 years.
- The excessively high storm water ingress into the sewage system needs to be catered for. Massive volumes of storm water penetrate the municipal sewerage system mainly due to incorrect landscaping, which causes surface storm water to be channelled towards sewer manholes.
- The existing WWTW infrastructure located within the study area include evaporation ponds, sludge reactors, inlet works, incoming pipelines, clarifiers, volute dehydrator, main pump station, existing chlorination building, office facilities, internal roads and other features (Laubscher, 2015).

Investigated watercourses that were assessed as part of this study were based on the following, as specified in the National Water Act (Act No. 36 of 1998) (NWA):

- A river or spring.
- A natural channel in which water flows regularly or intermittently.
- A wetland, lake or dam into which, or from which, water flows.

The study area (also referred to as the site) is located within Luvuvhu and Letaba Water Management Area (WMA) on the banks of the Klein Letaba River and falls within Quaternary

Catchment B82G. The entire study area and its immediate surroundings are indicated as Lowveld Rugged Mopaneveld, a vegetation type included in the Mopane Bioregion. The Lowveld Rugged Mopane veld vegetation type classified as Vulnerable due to transformation mainly by cultivation and settlement development. However, 17% of the vegetation are conversed in statutory protected areas such as Kruger National Park and in Hans Merensky Nature Reserve. The study area does not overlap with any listed Threatened Ecosystem areas according to the 2011 Schedule (Government Gazette of December 2011) of the Biodiversity Act (Act 10 of 2004). However, the Limpopo Conservation Plan version 2 (LCPv2) indicated that a large portion of the 500 m buffer is located in a Critical Biodiversity Area 1 (CBA1) and also include an Ecological Support Area2 (ESA2) and Critical Biodiversity 2 (CBA 2).

Wetlands and riparian habitat were delineated based on the delineation method developed by the Department of Water & Sanitation (DWAF, 2005). All of the delineated wetlands were then classified up to the hydro-geomorphic (HGM) level, based on the method developed by Ollis *et al.* (2013). A seep wetland of 3.29 ha and a riparian habitat, which includes a 100 m wide active channel (13.19 ha), were delineated within a 500 m radius around the the received study area coordinate (23°19'31.89" S and 30°42'30.23"E).

The Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of delineated watercourses within the study area were not assessed as part of this basic assessment and the study focused therefore on identifying, classifying and delineate wetlands located within proposed development footprints, while surrounding wetlands in the study area were mainly assessed at a desktop level with limited sampling. Site surveys were undertaken from 9 - 13 November 2015.

The planned expansion as illustrated in Figure 2 is not expected to impact directly on any wetland or riparian watercourse. However, the proposed plans to convert the existing ponds into emergency overflow ponds (Laubscher, 2015) have the potential to encroach into the seep wetland and riparian habitat along the Klein Letaba River should the existing dams increase in size (Figures 3 & 8).

Any sewage or greywater spills due to overloading, malfunctioning or leakage could result in the pollution of these systems by high nutrient loads. Furthermore, erosion of the banks of the Letaba is potentially possible by concentrated outflows as is evident in places along the existing WWTW boundaries.

Recommended mitigation measures associated with the above mentioned potential impacts include the following:

- Develop and implement monitoring programme on the boundaries of the seep wetland and the riparian zone with the WWTW to detect
    - Sewage spills and grey water leakage, as well as

  - Erosion in these two natural watercourses due to spills/leakage
- It is recommended that baseline aquatic ecological data should be collected for the Klein Letaba River prior to the start of construction activities. This information can then be used for future monitoring purposes to provide a reference for the ecological condition of the river prior to the start of the proposed upgrade works. This information would be required to develop and implement a water quality monitoring programme within the Klein Letaba River, with sample points upstream and downstream WWTW to detect water pollution changes and possible causes by the upgraded WWTW.
- Monitoring should also evaluate the water quality of the final effluent prior to release, in order to ensure that it continues to meet General Standards as specified by Laubscher (2015).
- Direct stormwater discharge into the natural watercourses should be avoided as far as possible, while energy dissipating measures should be used to spread out flows at outlets, in order to restrict scour erosion and habitat degradation.
- Where unavoidable or potential erosion features along flow paths to the river are expected or recorded, they should be stabilised (e.g. with channel armour, weirs or drop inlets) and incorporated into a stormwater management plan for the WWTW.
- Channelization in the wetland and other watercourses for stormwater release should be avoided. No drains or channels should therefore be created within the seep wetland.
- Gravel infill in the seep wetland can be covered with topsoil obtained from the construction activities and revegetated with suitable wetland species. Mulching and brush packing are also recommended. Affected areas should be fenced off for at least 2 growing seasons to prevent trampling by livestock.
- Dams that partially overlap with the 32 m and 100 m buffer zones should be lined to help restrict seepage of low water quality into the natural watercourses (Figure 8).
- Release points at these dams should have energy dissipating measures that will help to prevent erosion in the wetlands and channel banks of the Klein Letaba River.
- Material from existing infrastructure that is demolished to make space for infrastructure associated with the proposed phase 2 development should not be stored (stockpiled) within the 32 or 10 m buffers (Figure 8).
- Stockpiles and designated areas used for refuelling during the construction phase should not be located within the 32 m and 100 m buffers.
- Develop and implement an alien plant control plan based on the evaluation of species present within the study area and in close proximity to infrastructure features. This can form part of a larger rehabilitation plan that can be developed during the latter stage of the construction phase.

- Any proposed upgrade works to the existing ponds (dams) to convert them into emergency overflow dams should be restricted to the existing footprints of the existing dams as far as possible to prevent the loss of additional watercourse habitat.
- All of the proposed development infrastructure should be restricted to existing footprints as far as practically possible.

Table of Contents

1. Introduction

1.1. Background

EIMS appointed Imperata Consulting CC to undertake a wetland assessment study for Giyani Waste Water Treatment Works (WWTW) as part of the Mopani District Water and Waste Water Revitalisation Programme near Giyani, Limpopo Province. The survey was undertaken by Dr. P. Grundling an associate of Imperata Consulting CC; as well as Mr. T. Ngobela, a junior ecologist at Imperata Consulting.

1.2. Scope of Works and Terms of Reference

This watercourse study is not a detailed investigation as is normally the case for wetlands and other watercourses, such as rivers, affected by a proposed WWTW project of this nature. It will primarily provide a delineation of identified watercourses, classification of watercourses and an impact assessment with recommended mitigation measures for use in the WWTW Basic Assessment Report. The terms of references associated with the specialist investigation will therefore include the following:

- The delineation of wetlands and other watercourses present within the study area, including the delineation of wetlands within a 500 m buffer around the proposed development footprints at a secondary level of detail.
- Watercourses identification will be based on definitions specified in the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Watercourse definitions used as part of the investigation include (NWA):
    - A river or spring.
    - A natural channel in which water flows regularly or intermittently.
    - A wetland, lake or dam into which, or from which, water flows.
- The description and classification of delineated wetlands areas into corresponding hydro-geomorphic (HGM) units according to Ollis *et al.* (2013).
- The identification of potential project-related impacts and the recommendation of appropriate mitigation and management measures, as well as the consideration of alternatives.

1.4. General Assumptions

- This study assumes that the project proponents will always strive to *avoid, mitigate* or *offset* potentially negative project related impacts on the environment, with impact avoidance being considered the most successful approach, followed by mitigation and offset. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.

- Spatial GIS shapefiles received from client used to demarcate the study area and proposed development layout are accurate.
- The project proponents will commission an additional study to assess the impact(s) if there is a change in the size and/or extent of the study area or proposed infrastructure that is likely to have a potentially highly significant and/ or unavoidable impact on watercourses (e.g. wetlands).

1.5. Overview of Wetlands and Riparian Habitat

1.5.1. What are wetlands and other watercourses, and which pieces of environmental legislation pertain to them?

In terms of the Ramsar Convention on Wetlands (Iran 1971), to which South Africa is a contracting party, "… wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs" (Ramsar Convention Secretariat 2007).

In South Africa, wetlands are defined as "…land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil" National Water Act (Act No. 36 of 1998) (NWA). Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to the aforementioned will also be applicable to wetlands. The types of features included within the definition of a watercourse include:

- "…a river or spring…"
- "…a natural channel in which water flows regularly or intermittently…"
- "…a wetland, lake or dam into which, or from which, water flows…"
- "…any collection of water which the Minister may, by notice in the *Gazette*, declare to be a watercourse…"

In addition, the NWA stipulates that "…reference to a watercourse includes, where relevant, its bed and banks…". This has important implications for the management of watercourses and encroachment on their boundaries, as discussed further on in this document.

The NWA defines riparian areas as "…the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas…" Note that this does not imply that the plant species within a riparian zone must be aquatic, only that the species composition of plant assemblages must be different within the riparian area and adjacent uplands.

In terms of the wetland delineation document available from the Department of Water Affairs and Forestry (DWAF), now known as the Department of Water and Sanitation (DWS), "wetlands must have one of the following attributes" (DWAF 2005):

- **Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation.
- The presence, at least occasionally, of **water loving plants (hydrophytes)**.
- A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.

It follows that the level of confidence associated with a specific area being considered as a wetland is proportionate to the number of confirmed indicators that positively correlate with wetland habitat. Not all indicators are always present within a specific biophysical and land use setting, while not all indicators are always reliable and/or useful under all conditions. The use of additional wetness indicators from different disciplines that are internationally applied therefore adds value and confidence in the identification and delineation of wetland habitats, especially in challenging environments.

Wetland and riparian areas are not necessarily mutually exclusive types of watercourses, as some riparian areas also contain adjacent seep wetlands. Seep wetlands are more consistent with wetland features and definitions. In the case where both of these watercourses are present the larger/ wider/ more prominent of the two watercourse types will be used to determine the boundaries of the combined demarcated watercourse.

The National Environmental Management Act (Act No. 107 of 1998) (NEMA), list specific activities for which environmental authorization should be obtained when located within a watercourse, 32m of a watercourse or in some cases even within 100 m of a watercourse. Details pertaining to restrictions associated with different listed activities have been recently updated under sections 24(5) and 44 of the NEMA as set out in the Schedule under Government Gazette Notice 38282 date 4 December 2014:

- R. 982 National Environmental Management Act (107/1998): Environmental Impact Assessment Regulations, 2014
- R. 983 do.: Listing notice 1: List of activities and competent authorities identified in terms of sections 24 (2) and 24 D
- R. 984 do.: Listing notice 2: List of activities and competent authorities identified in terms of sections 24 (2) and 24 D
- R. 985 do.: Listing notice 3: List of activities and competent authorities identified in terms of sections 24 (2) and 24 D

Wetlands and other watercourses are protected water resources in the NWA. Development or transformation of the watercourses is regarded as a water use, which can only be allowed through an approved Water Use License, irrespective of the condition of the affected watercourse.

The implication is that authorization will have to be obtained from the Department of Water and Sanitation (DWS) before water use activities can be initiated in demarcated wetlands and dams.

Section 21 of the NWA defines different types of water use in a watercourse, which for wetland and riparian watercourses primarily refer to the following:

(c) impeding or diverting the flow of water in a watercourse

(i) altering the bed, banks, course or characteristics of a watercourse.

A recent stipulation published by the DWS (in Government Gazette No 32805 (December 2009) require that a Water Use License should be applied for when any wetland is present within a 500 m radius of Section 21 *(c)* and *(i)* water use activities.

2. Methods

The following methods and approaches were applied as part of the wetland investigation:

- Existing spatial datasets that indicate potential watercourses an ecologically important areas were used as part of an initial desktop approach:
    - The 1:50 000 river and drainage line data of the study area and its surroundings was used, as illustrated on the relevant topographic map (2330BC Giyani).
    - The National Freshwater Ecosystem Priority Areas (NFEPA) Wetlands spatial database was used to identify potential wetland areas within the study area and its immediate surroundings. The wetland layer was downloaded from the BGIS website in November 2015 (http://bgis.sanbi.org/nfepa/NFEPAmap.asp). This wetland layer has been formed by combing information from the National Land Cover 2000 data set (NLC 2000), with 1:50 000 topographic maps and sub national data (Van Deventer *et al.* 2010).
    - The National Spatial Biodiversity Assessment (NSBA) spatial dataset, which is based on the DWA 1:500 000 rivers GIS layer (Driver *et al.* 2004). The GIS layer was obtained via the BGIS website hosted by the South African National Biodiversity Institute (SANBI), (http://bgis.sanbi.org/nfepa/NFEPAmap.asp).
    - The Limpopo Conservation Plan version 2 (LCPv2) was consulted.
    - Desktop PES and EIS of the associated quaternary and sub quaternary catchments (B82G) were obtained from the Department of Water and Sanitation (DWS 2014).
- The watercourse site surveys were undertaken on 9 - 13 November 2015.
- Watercourses were identified and delineated within the study area through the procedure described by the Department of Water and Sanitation (DWS; previously also known as DWAF

and DWA) in their document entitled: "A Practical field procedure for the identification and delineation of wetlands and riparian areas" (DWAF 2005).

- Available wetland indicators that were investigated included hydromorphic (wetland soil) features, the presence of wetland plant species (e.g. hydrophytes and hygrophytes), riparian species and vegetation features, alluvial soil features, and terrain unit indicators.
- Other indicators associated with natural headwater channels and inundated conditions that are published in scientific literature were also used (Gomi *et al*., 2002; Noble *et al*., 2005).
- In addition to the above, aerial photograph interpretations were also used to help identify preferential drainage paths and drainage-associated landscape features.
- Sample points were generally arranged along transects perpendicular to discernible flow paths or slopes, in order to record gradients of change between terrestrial and watercourse habitats.
- The field surveys primarily focussed on the delineation of watercourses within the study area, while selected areas were investigated within a 500 m radius of the site. The majority of suspected wetland areas within the 500m buffer area were mainly delineated and classified through a desktop approach with restricted site surveying.
- Identified wetland areas and other watercourses were delineated into GIS polygon shapefiles, originally on Google Earth Pro, which were used for map creation.
- All natural wetlands identified within the study area were classified according to the recently completed 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' up to the hydrogeomorphic (HGM) unit level (Ollis *et al*. 2013).
- The HGM classification system is based on three key parameters pertaining to the wetland: the geomorphic setting of the wetland, the source of water inputs into the wetland, and its hydrodynamics (how does water move through the wetland), (Brinson 1993; Kotze *et al.* 2008; Ollis *et al*., 2013).
- Limitations associated with the study include the following:
    - No development footprint or study area boundary was received for the proposed phase 2 WWTW in spatial format, such as GIS shapefiles or a KML file. Consequently the spatial extend of the study area has not been mapped and is merely indicated by a point based on the received coordinates for the phase 2 study area. Uncertainty therefore remains regarding the spatial extent of the proposed development.

3. Study Area Description

3.1. Location

- The existing Giyani Waste Water Treatment Works (WWTW) and proposed upgrade is on the southern outskirts of Giyani Town (between Mongope and Hlophekane area), in the Mopane District Municipality, Limpopo Province.
- The area associated with the proposed upgrade of the Giyani WWTW is henceforth also referred to as the study area or the site, and is located at coordinates 23°19'31.89" S and 30°42'30.23"E (Figure 1).
- The study area is located adjacent to a cultivated (temporary to commercial) irrigated area on a lowland topography.
- The study area is located approximately 1.5 km north of the arterial route joining the R81 towards the west and located northeast of the left hand bank of the Klein Letaba River. Other nearby features include Shamavunga Hospital located approximately 2 km to the northwest

3.2. Proposed Development

Laubscher (2015) provides the following motivation for the proposed new upgrade work to the existing Giyani Waste Water Treatment Works (WWTW):

- The existing Giyani WWTW, with a capacity of only 4.2Ml/day, is presently being operated over its design capacity, namely at about 6Ml/d on average during dry seasons. Excessively high storm water infiltrations can occur during the rainy seasons with inflows higher than 12Ml/d that have been experienced. The works is currently operating at a hydraulic loading of approximately 6 Ml/day.
- The works will soon be receiving even more pressure with the implementation of a development strategy whereby all sub-RDP standard serviced stands will receive full waterborne water supply and wastewater collection systems over the next 15 to 20 years. The Technical Report proves that a works of at least 14Ml will be required over the design period of 10 years.
- The excessively high storm water ingress into the sewage system needs to be catered for. Massive volumes of storm water penetrate the municipal sewerage system mainly due to incorrect landscaping, which causes surface storm water to be channelled towards sewer manholes.
- The existing WWTW infrastructure located within the study area include evaporation ponds, sludge reactors, inlet works, incoming pipelines, clarifiers, volute dehydrator, main pump station, existing chlorination building, office facilities, internal roads and other features (Laubscher, 2015).

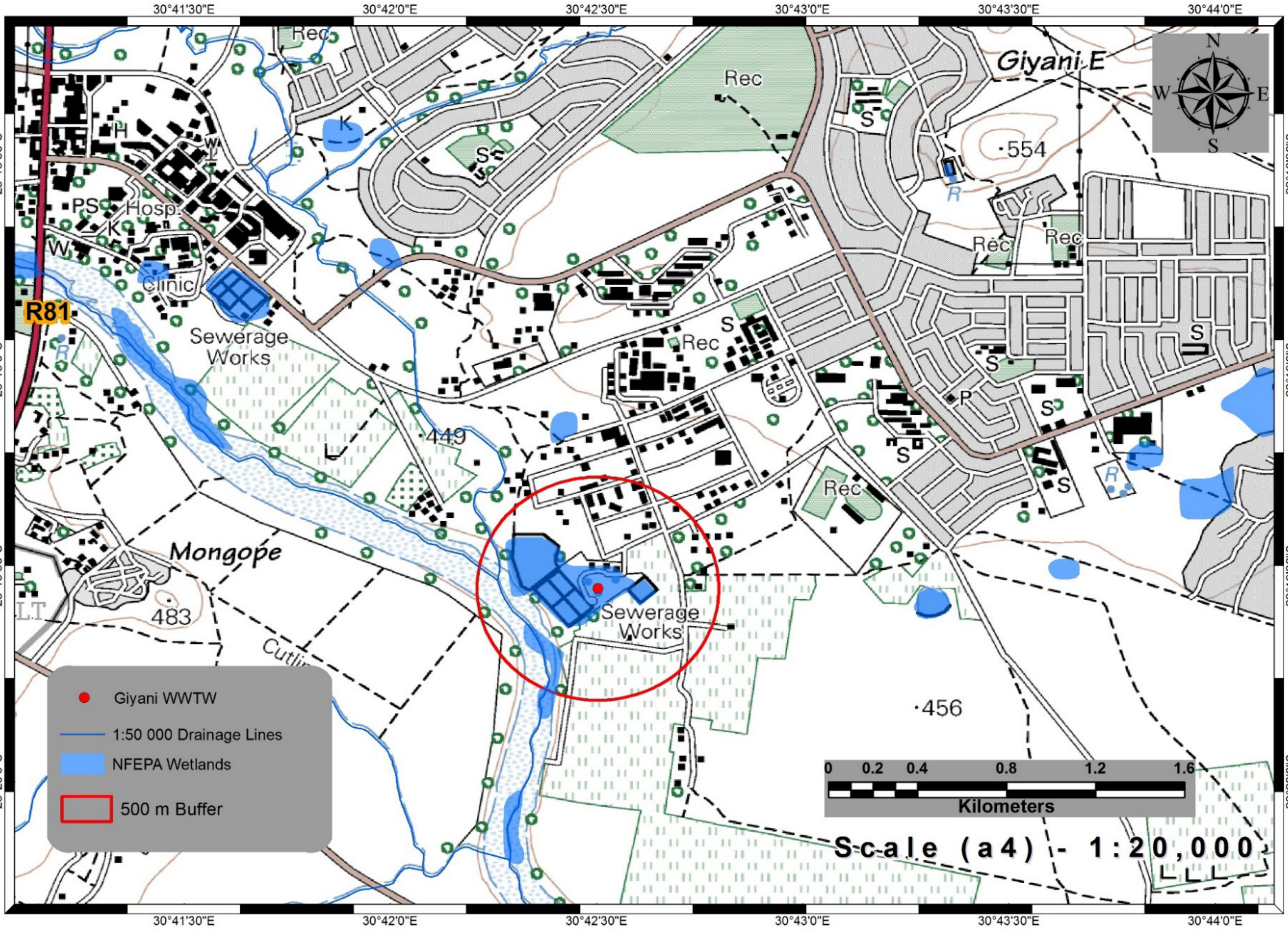

Figure 1: Locality map for phase 2 of the Giyani Waste Water Treatment Works (WWTW).

In order to make provision for the increased capacity the following proposed features will form part of the upgrade to the existing WWTW. Some of the aspects include the following (Laubscher, 2015):

- The existing works will be demolished to create space for the proposed upgraded works of 14Ml. The new works will consist of two equal activated sludge reactors, each of 7Ml capacity. The upgrade will also incorporate a new inlet works able to handle the projected inflow at the end of the 20 year planning period
- The facultative ponds shall be converted to emergency overflow dams in order to deal mainly with storm water ingress during rainy periods.
- The final effluent will be to General Standards as per requirements and it will be disposed of in the Little Letaba River.

Based on our understating of the proposed development layout for the phase 2 expansion works, the majority of the proposed infrastructure features will be located within the existing WWTW footprint (Figure 2). This can, however, not be confirmed as the proposed layout was not received in spatial format, nor were the positioning of all of the proposed infrastructure features indicated. E.g. the preliminary design report makes mention of converting the existing ponds into emergency overflow ponds (Laubscher, 2015). It remains uncertain whether the existing ponds will extend beyond their current footprints or not.

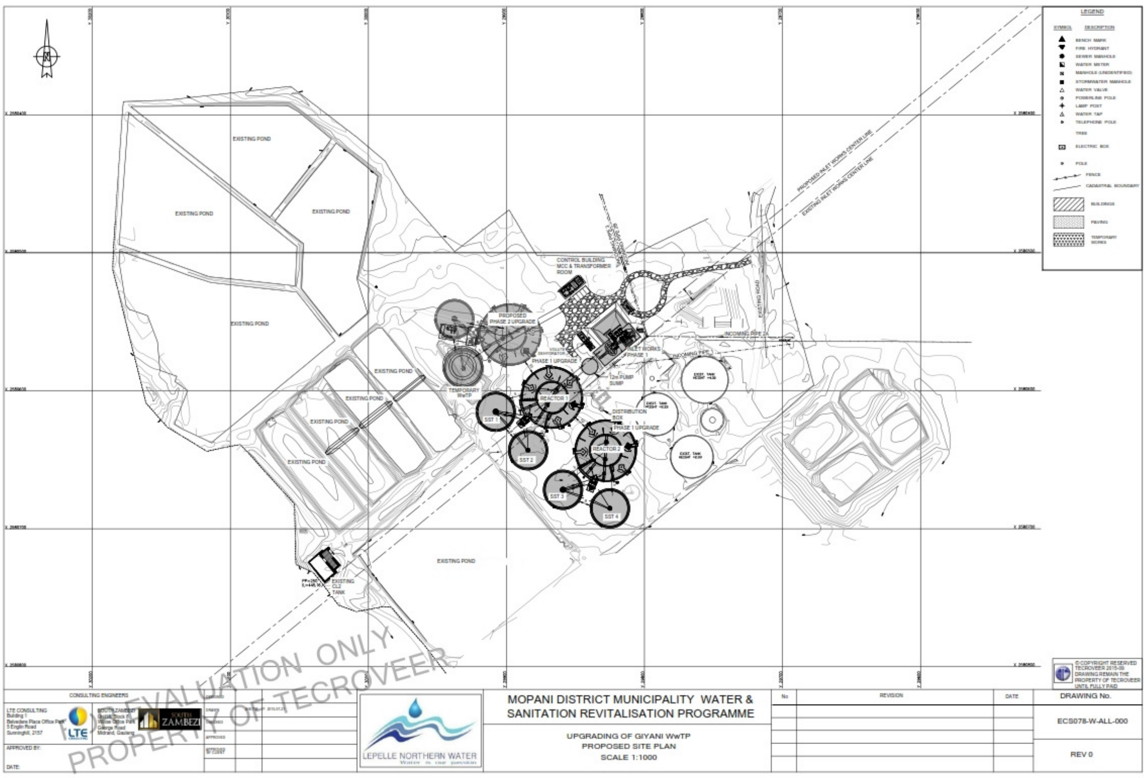

Figure 2: Illustrates the available layout design for the proposed phase 2 WWTW (Laubscher (2015)). Existing infrastructure, such as the existing ponds to the south and southwest of the site can be used for orientation.

3.3. Study Area Geology, Catchment and Surface Hydrology

- The study area is situated on Giyani Strata comprised of Schist and Lava (Middleton and Bailey, 2008), and according to Laubscher (2015) the site lies on decomposed schist and amphibolites of the Giyani Group within the Murchison Sequence. Furthermore the sequence has been heavily intruded by a diabase dyke that trends south west to north east, dividing the site in half (Laubscher 2015).
- The study area is located within the Luvuvhu and Letaba (Water Management Area) and falls within the Quaternary Catchment B82G.
- Quaternary Catchment B82G has a Moderate conservation status and a Moderately Modified condition (Class C) Present Ecological State (PES) as provided by (Middleton and Bailey, 2008).
- Quaternary Catchment B82G is largely developed with high urban density developments, buildings (hospital and clinic), WWTW infrastructure and cultivated lands used for irrigation and commercial use.
- No drainage lines from the 1:50000 topographical map overlap with the study area that may indicate the presence of known or expected watercourses.
- The Klein Letaba River, the primary river of the Quaternary Catchment B82G, is located approximately 180 m southwest of the study area, as identified on topographical map 2330BC (Figure 1). The river previously contained more flows, but has become drier as a result of the upstream Middle Letaba Dam, located approximately 31 km west of the site.
- A recent desktop assessment by the Department of Water and Sanitation (DWS) indicate the following information for the nearby reach of the Klein Letaba River:
  - The river is wide and characterised by alluvial depositions, while it only contains a single geomorphological zone.
  - The river has a class D (largely modified) Present Ecological State (PES).
  - The mean Ecological Importance (EI) class is High
  - The mean Ecological Sensitivity (ES) Class is High
  - The river reach has a class B Ecological Category (EC) based on the median PES and highest of EI or ES means.
- A non-perennial stream forms a confluence with the Klein-Letaba River, northwest of where the majority of the proposed phase 2 infrastructure will be located (Figure 1).

3.3. Local Climate and Regional Vegetation

- Quaternary Catchment B82G has an overall Mean Annual Precipitation (MAP) of 524 mm falling mostly during summer months (Middleton & Bailey, 2008).
- The Mean Annual Temperature (MAT) is 20.9°C (Mucina & Rutherford, 2006).
- The vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006) indicate that the entire study area falls within the Savanna Biome and includes one bioregion (subgroup). The entire study area and its immediate surroundings are indicated as Lowveld Rugged Mopane veld, a vegetation type included in the Lowveld Bioregion.

- The Granite Lowveld vegetation type is classified as Vulnerable due to transformation mainly by cultivation and settlement development, however, 17% of the vegetation are conversed in statutory protected areas, such as the Kruger National Park (Mucina & Rutherford, 2006).
- The study area does not overlap with any listed Threatened Ecosystem areas according to the 2011 Schedule (Government Gazette of December 2011) of the Biodiversity Act (Act 10 of 2004).
- The Limpopo Conservation Plan version 2 (LCPv2) indicates the following categories for the study area:
    - The site is mainly located in a Critical Biodiversity Area 1 (CBA1), while other portions of the 500m buffer include an Ecological Support Area 2 (ESA1) and a Critical Biodiversity Area2 (CBA 2).
    - CBA 1 represent irreplaceable sites, which are areas required to meet biodiversity pattern and/or ecological process targets. No alternative sites are available to meet targets.
    - CBA 2 represent best design selected sites, which are areas selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets.
    - ESA 2represent areas with no natural habitat that is important for supporting ecological processes.
    - The core management objective of CBA 1 and CBA 2 is to maintain these areas in a natural state with limited or no biodiversity loss. The management objective associated with ESA 2 is to avoid additional / new impacts on ecological processes.

4. Spatial Sensitivity Features: Delineated and Classified Watercourses

- The study area overlaps with wetland areas indicated on the National Freshwater Ecosystem Priority Area (NFEPA) spatial dataset of 2011 (Figure 1). Wetland areas indicated in NFEPA are primarily associated with artificial dams around the WWTW.
- Information from the recently completed 2013-14 South African Land-Cover spatial dataset does not indicate the presence of any wetland areas, seasonal or permanent water in a radius of 200 m around the received site coordinate. However, areas with seasonal and permanent water are indicated to be present within one of the existing evaporation dams and in a localised area within the Klein Letaba River. The dominant land-cover class along the river alignment, as indicate on the topographical map, is mainly associated with low shrubland.
- The 2013-14 South African Land-Cover map does not indicate the presence of the wetland land-cover category within a 500 m radius of the received site coordinate.
- A river in the form of an active channel and adjacent riparian zones are associated with the Klein Letaba River and has been delineated west of the site coordinate within the surrounding 500 m buffer (Figure 3). The entire river has been delineated as riparian habitat, but a broad active channel of approximately 100 m wide is present in the center of the demarcated watercourses and is bordered by riparian habitat on either side.
- Ollis *et al.* (2013) define the river hydro-geomorphic unit as "a linear landform with clearly discernible bed and banks, which permanently or periodically carries concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit" (Figure 4).
- The delineated river, mapped as a single riparian unit, which includes a prominent active channel, occupies 13.19 ha within the 500 m buffer (Figure 3; Table 1).
- Delineated riparian habitat (Figure 3) exhibits typical riparian features, such levees and deposited alluvium.
- A seep wetland that forms a tributary of the Klein Letaba River has been identified and delineated south and southeast of the of the site coordinate within the 500 m buffer (Figure 3 & 4).
- Ollis *et al.* (2013) define seep wetlands as "a wetland on gently to steeply sloping land and dominated by the colluvial (gravity-driven), unidirectional movement of water and material downslope. Water inputs are mainly via subsurface flow from an upslope direction".
- The delineated seep wetland is entirely located within the 500m buffer and has a size of 3.29 ha (Figure 3; Table 1).
- The seep wetland HGM unit drains into the Klein Letaba River and has a western aspect with a slope of <1 % (Figures 3 & 5).
- Hydromorphic wetland features are not always evident in riparian habitat or in alluvium environments along rivers, such as the Klein Letaba (DWAF 2005).

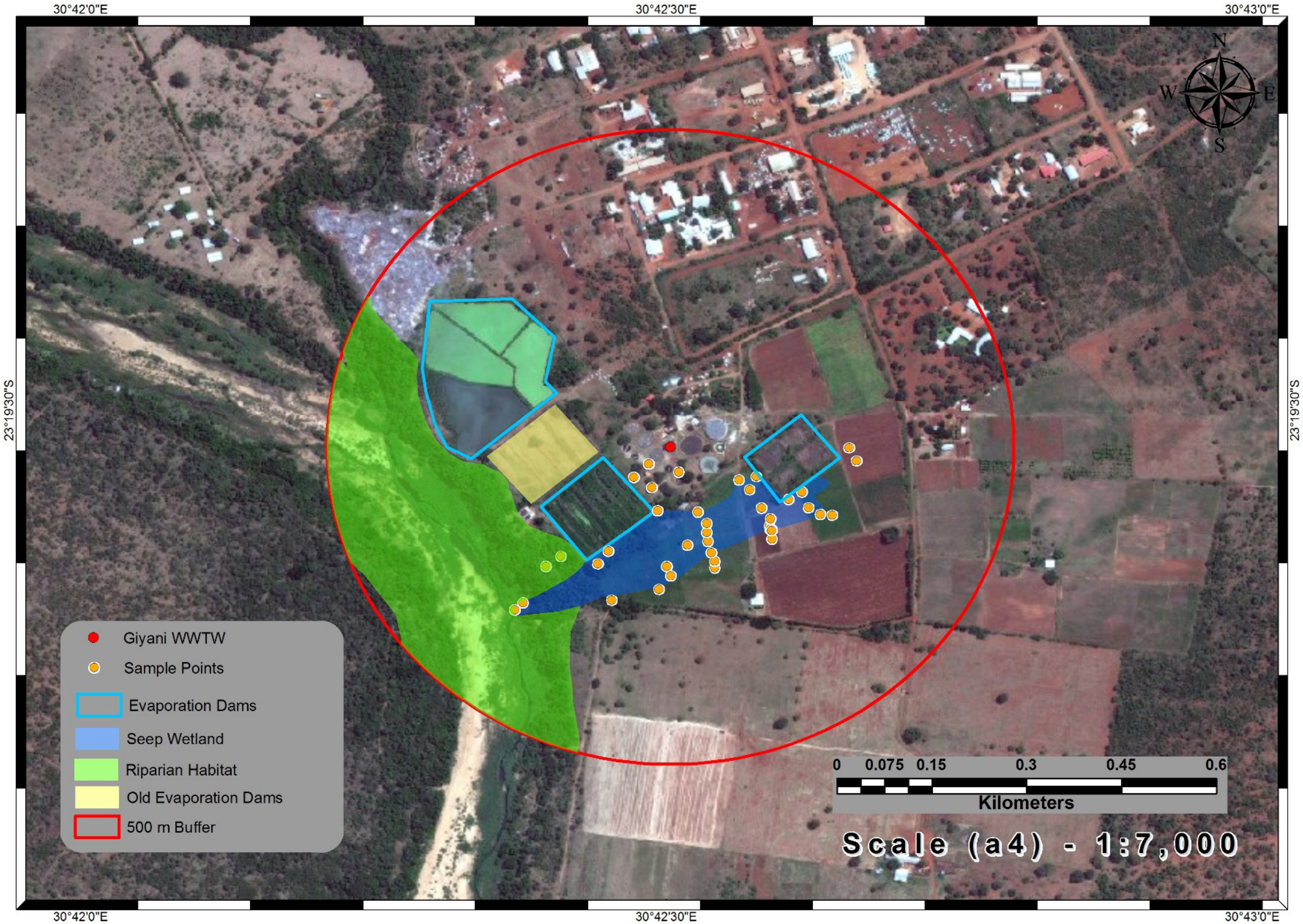

Figure 3. Illustrates delineated watercourses within a 500 m radius of the site coordinate. Natural watercourses include a seep wetland and the Klein Letaba River (demarcated as riparian habitat only, but a prominent active channel is also present in the centre of the watercourse). Artificial watercourses include several dams associated with the WWTW.

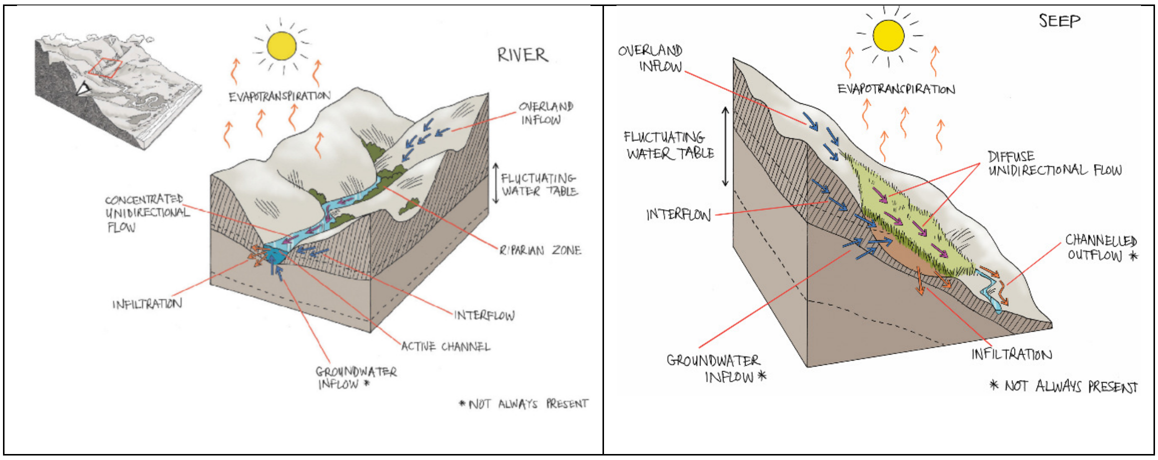

Figure 4. Illustrates the river HGM unit with riparian habitat and an active channel a seep wetland HGM unit as identified and delineated within the 500 m buffer zone.

Table 1: **Indicates the type and size of different watercourses identified and delineated within a 500 m radius around the site coordinate (also refer to Figure 3).**

Watercourse Type	**Surface area within the 500m buffer (ha)**
Riparian Habitat (including the active channel)	13.19 ha
Seep Wetland	3.29 ha
Old dams	1.27 ha
New dams	5.94 ha
Total	**23.69 ha**

- Hydromorphic (wetland soil) features were recorded in the seep wetland and included mottling, spots of iron depletion, low chroma matrix colours, gleying and organic enrichment in the A horizon. Organic enrichment, mottling and spots of iron depletion were regularly recorded within the top 0.5m of wetland associated soil profiles, while gleying generally occurred at deeper depths, but were also occasionally present within the first 0.5m of selected profiles (Figure 6). Wetland features in the seep is associated with temporary to seasonal wetness. Appendix A provides a summary of recorded field notes at specific coordinates.

- Artificial watercourses in the form of several dams have also been delineated within the 500 m buffer and are associated with the WWTW to release treated water via evaporation and for release into the Klein Letaba River. The combined dam surface area within the 500 m buffer is 7.22 ha (Figure 3; Table 1).

- The western and south-western most portions of the existing evaporation dams, located furthest from the centre point of the site, overlap with the historical extent of riparian habitat along the Klein Letaba River. The affected outer margin of the riparian area has been replaced by dams and no longer exists (Figure 3). Once such dam also overlap partially with the seep wetland and have resulted in permanent wetland habitat loss. The expected habitat loss by the dam is, however, expected to be small (Figure 3).

- Assessments to determine the ecological conditions of delineate watercourses, such as Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessments, do not form part of the terms of reference for this study. However, it clear that the natural watercourses (wetland and river) are disturbed by the encroachment of alien species, infill material, access tracks, cultivated land and sewage effluent (Appendix 1). Prominent catchment impacts in the Klein Letaba River include the Middle Letaba Dam, which restrict concentrated water flow and sediment influx into the delineated portion of the river reach.

Figure 5: Illustrate a portion of the seep wetland that drains into the riparian habitat of the Klein Letaba River visible in the background.

Figure 6: **Illustrates selected soil features (hydromorphic indicators) recorded in the seep wetland. These include: signs of organic enrichment in the A horizon (left) and orange mottles in a dark grey matrix the topsoil profile (right).**

5. Impact Assessment & Suggested Mitigation Measures

The functioning and ecological health of wetlands and other watercourses are determined by various drivers and responders that form part of different specialist fields. Examples include water quality, surface and ground hydrology, geomorphology, vegetation, and soil features. Impacts affecting watercourses, and in particular wetlands, are therefore determined by factors from several different specialist disciplines. This impact assessment section deals with natural watercourses in the form of the seep wetland and Klein Letaba River located within a 500 m radius from the centre point of the proposed phase 2 Giyani WWTW upgrade. Impact assessments and related recommendations made in other specialist studies that pertain to these watercourses should also be taken into consideration.

5.1. Impact Assessment Method

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). Please note that the impact assessment applies different infrastructure components associated with the proposed development.

5.1.1. Determination of Environmental Risk

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER).

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$\boldsymbol{C} = \frac{(\boldsymbol{E} + \boldsymbol{D} + \boldsymbol{M} + \boldsymbol{R})}{\boldsymbol{4}} \times \boldsymbol{N}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 2.

Table 2: **Criteria for Determining Impact Consequence**

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 3.

Table 3: Probability Scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows (Table 4):

$$\boldsymbol{ER = C \times P}$$

Table 4: Determination of Environmental Risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 5.

Table 5: Significance Classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

5.1.2. Impact Prioritisation

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in the Section above it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented. The impact priority is therefore determined as follows (Table 6):

$$\boldsymbol{Priority = PR + CL + LR}$$

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (Table 6 & 7).

Table 6: **Criteria for Determining Prioritisation**

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

Table 7: **Determination of Prioritisation Factor**

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance), (Table 8).

Table 8: **Final Environmental Significance Rating**

Environmental Significance Rating	
Value	**Description**
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).

5.2. Description of Potential Impacts

No wetlands occur within the footprint of the new planned structures of the Giyani WWTW based on available information as illustrated in Figure 2. However, some sections of the existing WWTW in the form of dams to the west of the proposed phase 2 coordinate are partially located on historical riparian habitat of the Klein Letaba River. These outer margins of the riparian habitat have, however been permanently transformed by them dams. (Figure 3)

Direct impacts to the seep wetland, such as habitat loss, are therefore not expected, but riparian habitat loss may occur should the proposed existing ponds (dams) be extended in size into remaining riparian habitat. Laubscher (2015) mentions that the current dams will be converted into emergency overflow dams to deal with storm ingress during rainfall events. Information about the size and extend of the proposed dam conversion works were not available at the time of report writing. This needs to be verified in order to determine impacts to the Klein Letaba River more accurately, as well as to the seep wetland, as one of the existing dams also partially overlap with the seep wetland (Figure 3).

Any sewage or greywater spills due to overloading, malfunctioning or leakage could result in the pollution of these systems by high nutrient loads (Figure 7). Furthermore, erosion of the banks of the Letaba is potentially possible by concentrated outflows as is evident in places along the existing WWTW boundaries (Figure 7). Stormwater runoff and treated effluent that have been released from the proposed upgrade works can result in an influx of nutrients and erosion damage within the seep wetland, as the proposed works appear to be located within 32 m of the wetland (Figures 2 & 8).

A 32 m wetland buffer is used as several listed activities specified in NEMA are triggered once they are located within 32 m of a watercourse, such as the seep wetland (Figure 8). The 32 m buffer also provides a general means to help mitigate several impacts, which are discussed in section 5.3. The 100 m buffer around the outer boundary of the delineated Klein Letaba riparian zone is used to help identify proposed activities that may have potential negative impacts on the watercourse, while it also provide a general means of impact mitigation (section 5.3). Large portions of the existing dams are located within the 100 m riparian buffer

Figure 7: Eutrophication of the Klein Letaba is evident at the inflow of the seep wetland into the Klein Letaba (top photo). Gullying is evident where the seep wetland enters the Riparian Habitat at a preferential flow point from an evaporation pond of the WWTW at the edge of the seep wetland (bottom photo).

5.2.1. Construction Phase

As mentioned in the above the expansion of the existing ponds (dams) may extent into the riparian habitat and seep wetland. This impact cannot be quantified at this stage as the spatial extent of upgrade works into the dams remains unknown.

Other potential impacts include sedimentation and erosion as new infrastructure is established. Culverts or pipes will concentrate stormwater runoff from the work areas along roads/tracks, which can lead to erosion and channel scour, which in return caused a desiccation effect (Figure 7).

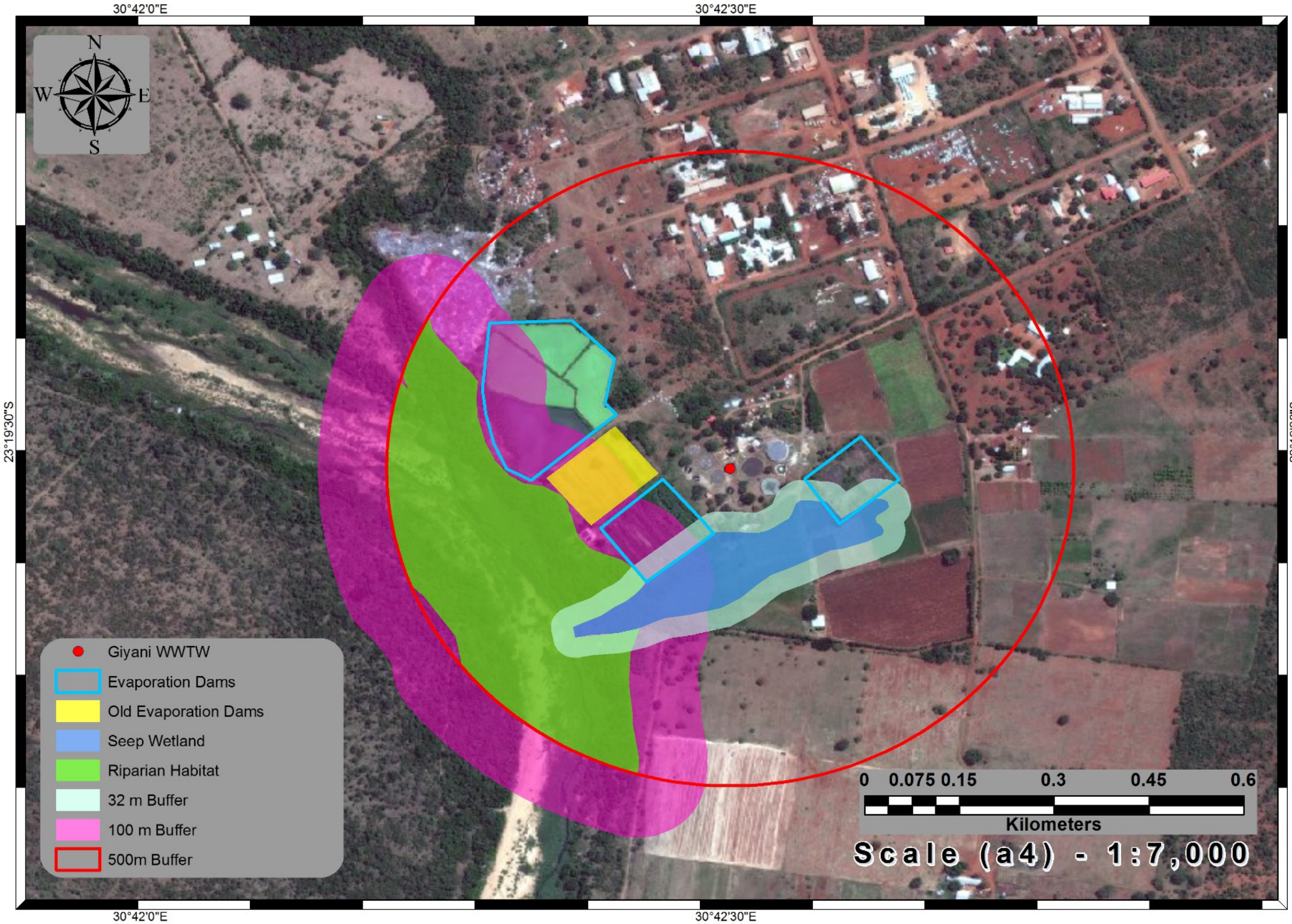

Figure 8: Illustrates a 32 m wetland buffer zone and a 100 m riparian habitat buffer around the two natural watercourses. Layout designs of the proposed phase 2 WWTW upgrade were not available in spatial format to be overlaid with the mapped watercourses at the time of report writing. Refer to Figure 2 for an illustration of selected features of the proposed development works.

Runoff from processing plants, loading bays, office, hydrocarbon storage facilities and access roads have a lower water quality compared to natural runoff, which will impact negatively on receiving watercourses (Figures 2, 7 & 8).

5.2.2. Operational Phase

The operational phase is associated with similar potential impacts as the construction phase of the proposed development. Furthermore, any sewage or greywater spills due to overloading, malfunctioning or leakage could result in the pollution of these systems by high nutrient loads whilst erosion of the banks of the Letaba is potentially possible by concentrated outflows from the WWTW. The encroachment of invasive plant species are likely at disturbed WWTW area (edge effects) as is presently evident (Appendix 1).

It is recognised that increased dam capacity to deal with water ingress during storm events of these dams will help to reduce the risk of low water quality input into the Klein Letaba River and the seep wetland. Care should however be taken to help ensure that the dams themselves do no become sources of low water quality into the watercourses or result in erosion due to outlets that concentrate water flow.

5.2.3. Decommissioning Phase

Decommissioning of the WWTW without a comprehensive clean-up of the facilities can result in remnant and long term pollution of the Klein Letaba River and associated watercourses. Furthermore, stormwater and erosion control requires continued maintenance; without which the identified natural watercourses will experience degradation.

5.3. Suggested Mitigation Measures and Impact Assessment

Management objective

To reduce the risk of water pollution and the degradation of water by erosion and excessive sedimentation. Significance rating results of the identified risk and impacts and selected impacts have been assessed based on the site assessment and is presented in Table 9.

Mitigation measures

- Develop and implement monitoring programme on the boundaries of the seep wetland and the riparian zone with the WWTW to detect
  - Sewage spills and grey water leakage, as well as
  - Erosion in these two natural watercourses due to spills/leakage
- It is recommended that baseline aquatic ecological data should be collected for the Klein Letaba River prior to the start of construction activities. This information can then be used for future monitoring purposes to provide a reference for the ecological condition of the river prior to the start of the proposed upgrade works. This information would be required to develop and implement a water quality monitoring programme within the Klein Letaba River, with sample points upstream and downstream WWTW to detect water pollution changes and possible causes by the upgraded WWTW.
- Monitoring should also evaluate the water quality of the final effluent prior to release, in order to ensure that it continues to meet General Standards as specified by Laubscher (2015).
- Direct stormwater discharge into the natural watercourses should be avoided as far as possible, while energy dissipating measures should be used to spread out flows at outlets, in order to restrict scour erosion and habitat degradation.
- Where unavoidable or potential erosion features along flow paths to the river are expected or recorded, they should be stabilised (e.g. with channel armour, weirs or drop inlets) and incorporated into a stormwater management plan for the WWTW.
- Channelization in the wetland and other watercourses for stormwater release should be avoided. No drains or channels should therefore be created within the seep wetland.
- Gravel infill in the seep wetland can be covered with topsoil obtained from the construction activities and revegetated with suitable wetland species. Mulching and brush packing are also recommended. Affected areas should be fenced off for at least 2 growing seasons to prevent trampling by livestock.
- Dams that partially overlap with the 32 m and 100 m buffer zones should be lined to help restrict seepage of low water quality into the natural watercourses (Figure 8).
- Release points at these dams should have energy dissipating measures that will help to prevent erosion in the wetlands and channel banks of the Klein Letaba River.

- Material from existing infrastructure that is demolished to make space for infrastructure associated with the proposed phase 2 development should not be stored (stockpiled) within the 32 or 10 m buffers (Figure 8).
- Stockpiles and designated areas used for refuelling during the construction phase should not be located within the 32 m and 100 m buffers.
- Develop and implement an alien plant control plan based on the evaluation of species present within the study area and in close proximity to infrastructure features. This can form part of a larger rehabilitation plan that can be developed during the latter stage of the construction phase.

Key performance indicators

- Implementation and evaluation based on the proposed watercourse monitoring plans (water quality and erosion/sedimentation).
- Surface water monitoring reports (e.g. Appendix B), implementation of mitigation strategies during rehabilitation.
- Maintenance of storm water management system. Regulatory compliance.
- The proposed alien/invasive control plan should include a monitoring phase to evaluate successes achieved. Timing of treatments are essential, as control for most alien/invasive plant species can only be done during the growing season.

Other mitigation measures

- Any proposed upgrade works to the existing ponds (dams) to convert them into emergency overflow dams should be restricted to the existing footprints of the existing dams as far as possible to prevent the loss of additional watercourse habitat.
- All of the proposed development infrastructure should be restricted to existing footprints as far as practically possible.

Table 9: **Significance rating results of the identified risk and impacts; selected impacts have been assessed based on the site assessment.**

IMPACT DESCRIPTION		PRE - MITIGATION							POST - MITIGATION								IMPACT PRIORITISATION				
Impact	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Pre-mitigation ER	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Post-mitigation ER	Confidence	Public response	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
Loss of wetland habitat	Construction	-1	1	4	5	3	4	-13	-1	1	4	3	3	3	-8.25	High	2	1	2	1.33	-11.00
Wetland geomorphology disruption: excavation of substrate	Operation	-1	2	5	5	4	4	-16	-1	1	4	4	3	3	-9	High	1	1	2	1.17	-10.50
Wetland altered hydrology	Operation	-1	2	4	5	3	4	-14	-1	2	3	3	3	3	-8.25	High	1	1	2	1.17	-9.63
Wetland erosion and sedimentation	Decommissioning	-1	2	3	3	3	2	-5.5	-1	1	2	2	2	2	-3.5	High	1	1	1	1.00	-3.50
Encroachment of invasive plants	Operation	-1	1	1	2	2	2	-3	-1	1	1	1	1	2	-2	High	1	1	1	1.00	-2.00
Encroachment of invasive plants	Decommissioning	-1	1	4	3	2	2	-5	-1	1	1	1	1	1	-1	High	1	1	1	1.00	-1.00

6. Conclusion

The Giyani WWTW was historically established on the banks of the Klein Letaba River. Two natural wetlands in the form of a seep wetland (3.29 ha) and riparian habitat, which includes a broad active channel (13.19 ha), were identified and delineated within a 500 m radius around the received study area coordinate (23°19'31.89" S and 30°42'30.23"E). The proposed phase 2 development will replace the existing Giyani Waste Water Treatment Works (WWTW) to accommodate more sewage as a result of existing and planned future development within the Giyani area.

The planned expansion as illustrated in Figure 2 is not expected to impact directly on any wetland or riparian watercourse. However, the proposed plans to convert the existing ponds into emergency overflow ponds (Laubscher, 2015) have the potential to encroach into the seep wetland and riparian habitat along the Klein Letaba River should the existing dams increase in size (Figures 3 & 8). The proposed development layout was not available in a format to overlay with delineated watercourses and their buffers at the time of report writing. Uncertainty therefore remains regarding the direct impact of watercourse habitat loss as a result of the proposed phase 2 WWTW upgrade.

Any pollution due to overloading, malfunctioning or leakage could result in the contamination of the natural watercourse due to high nutrient loads. Erosion of the banks of the Klein Letaba River is potentially possible by concentrated outflows as is evident in places along the existing WWTW boundaries. The control of existing alien species in watercourses, particularly riparian watercourses, is another way in which value can be added through the proposed watercourse rehabilitation plan.

The proposed development triggers listed activities within the NEMA as development footprints are located within 32 m of a watercourse. Section 21 water use activities, as defined by the NWA, may not be applicable as the project is undertaken for the Department of Water Affairs and Sanitation (DWS). Authorization will therefore have to be obtained from the Department of Environmental Affairs (DEA), while clarity should be obtained from DWS whether a Water Use License will be required to allow Section 21 water use activities. Rehabilitation work in wetlands also require a Water Use Licence as it affected Section 21 (c) and (i) water use activities.

The significance of pre-mitigation impacts range from low to medium, but decreases with the implementation of the recommended mitigation measures (Table 9). The successful implementation of mitigation measures are therefore important. This includes the development of a monitoring plan due to the present of the seep wetland and river watercourse in close proximity to the proposed development. The proposed monitoring plan should be adaptive and make provision for intervention to rectify recorded watercourse impacts.

7. References and Further Reading

Brinson M. 1993. A hydro-geomorphic classification for wetlands. Wetland Research Programme Technical Report WRP-DE-4. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Broderson, J.M.. 1973. Sizing buffer strips to maintain water quality. M.S. Thesis, University of Washington, Seattle.

Bullock, A. and Acreman, M. 2003. The role of wetlands in the hydrological cycle. Hydrology and Earth System Sciences, 7, 3, 358-389.

Department of Water Affairs and Forestry (DWAF). 1999a. Resource Directed Measures for Protection of Water Resources. Wetland Ecosystems. Version 1.0, September 1999.

Department of Water Affairs and Forestry (DWAF). 1999b. Habitat Integrity Assessment Method for River Ecosystems.

Department of Water Affairs and Forestry (DWAF). 1999c. R7: Assessment of Ecological Importance and Sensitivity. Resource Directed Measures for Protection of Water Resources: River Ecosystems Version 1.0. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF). 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.

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

Department of Water Affairs and Forestry (DWAF). 2009. Government Gazette No. 32805. Impeding or Diverting the Flow of Water in a Watercourse [Section 21(c)] and Altering the Bed, Banks, Course or Characteristics of a Watercourse [Section 21(i)]. Pp66-71, Pretoria.

Department of Water and Sanitation (DWS). 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: B8. Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx accessed on [January 2015].

Driver, A., Maze, K., Lombard, A.T., Nel, J., Rouget, M., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. & Strauss, T. 2004. South African National Spatial Biodiversity Assessment 2004: Summary Report. Pretoria: South African National Biodiversity Institute.

Environmental Law Institute 2008. Planner's Guide to Wetland Buffers for Local Governments. Washington D.C., USA. http://www.eli.org

EPA 1996. Protecting Natural Wetlands – A Guide to Stormwater Best Management Practices. Environmental Protection Agency (EPA). Washington, United States of America.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. & Collins, N.B. 2008. Wetland-Ecoservices: A rapid assessment procedure for describing wetland benefits. WRC Report TT 339/08. Water Research Commission, Pretoria.

Laubscher C. 2015. Giyani WWTW: Preliminary Design Report for the Refurbishment and Upgrading of the Works.

Macfarlane D.M, Kotze D, Walters D, Ellery W, Koopman V, Goodman P, and Goge C. 2008. WET-Health: A Technique for Rapidly Assessing Wetland Health. WRC Report TT 340/08. Water Research Commission, Pretoria.

Middleton, B.J. & Bailey, A.K. 2008. Water Resources of South Africa, 2005 Study (WR2005). Water Research Commission (WRC) Report TT380/08, Pretoria.

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

Noble, C. V., Martel, D. J., & Wakeley, J. S. 2005. A national survey of potential wetland hydrology regional indicators, WRAP Technical Notes Collection (ERDC TNWRAP- 05-1). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Rountree, M.W. and H. Malan (editors). 2010. Rapid Ecological Reserve Determination Methods for Wetlands (Version 2.0). Joint Department of Water Affairs and Water Research Commission, Pretoria.

Schulze, R. E. (Ed). 2006. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06, Section 5.4.

Appendix 1: Giyani WWTW – Field notes

Giyani Waste Water Treatment Works (WWTW) (alien species are indicated by an *)

Site	**WWT1**	**WWT2**	**WWT3**	**WWT4**	**WWT5**
Coordinates	S 23 19'34.56 E 30 42 36.25	S 23 19'34.18 E 30 42 36.94	S 23 19 33.39 E 30 42'34.60	S 23 19 33.17 E 30 42'30.62	S23 19 34.0 E30 42 29.2
Topography	Lowlands	Lowlands	Lowlands	Lowlands	Lowlands
Geology	Hard rock layer and coarse granite material from construction material. Schist	Hard rock layer and coarse granite material from construction material. Schist	Hard rock layer and coarse granite material from construction material. Schist	Hard rock layer and coarse granite material from construction material. Schist	Hard rock layer and coarse granite material from construction material. Schist.
Soil	Organic matter cover, soft ferricrete, signs of charcoal and iron up to 10 cm of the soil surface and constructed material brought on the surface.	Organic matter cover, soft ferricrete, signs of charcoal and iron up to 10 cm of the soil surface and constructed material brought on the surface.	Red soils with clear signs of scrapping, the soil is loamy to clay and grains (0-10 cm), infilling material and floodplain production soils. Signs of charcoal were observed and heavy structured soil low with peds. Quarts pebble recorded 35 cm, natural rounded coarse gravel.	The soil is indicates the presence of infilled materials and signs of reworking. Gravel layer is 20-30 cm.	Red soils indicating presence of infilled material and no clear signs of mottling. 20 cm rock layer.
Land form/cover	Waste Water Treatment works	Waste Water Treatment works	Waste Water Treatment works	Waste Water Treatment works	Waste Water Treatment works
Vegetation The vegetation is dominated mainly by	Species recorded include **Lantana camara,* **Argemone mexicana,* **Ricinus communis,*	Species recorded include **Lantana camara,* **Argemone mexicana,* **Ricinus*	**Lantana camara,* **Bidens pilosa,* **Solanum mauritianum,* **Ricinus communis*	Indicates disturbed surface with presence of *Mangifera indica* (Mango) and other	Species recorded included: **Ricinus communis,* **Lantana camara,* **Bidens pilosa,*

weeds and alien plants indicating disturbance.	**Amaranthus* sp., *Panicum maximum, Ziziphus mucronata, Cyperus* sp., **Conyza albida, Cynodon dactylon* and **Flaveria bidentis.*	*communis, *Amaranthus spinosus, Panicum maximum, Ziziphus mucronata, *Nerium oleander* and *Cyperus* sp.	*Hibiscus* sp., **Flaveria bidentis, *Schkuhria pinnata* and **Alternanthera pungens.*	species.	**Amaranthus spinosus, *Solanum elaeagnifolium*
Impacts	Infilling material, weed encroachment and sewage effluent.	Infilling material, weed encroachment and sewage effluent.	Infilling material, weed encroachment and sewage effluent.	Infilling material, weed encroachment and sewage effluent.	Infilling material, weed encroachment and sewage effluent.
Description	Fill material	Fill material		Slope change and *Typha capensis* and *Phragmites mauritianus* in ponds.	

Site	**WWT6**	**WWT7**	**WWT8**	**WWT9**	**WWT10**
Coordinates	S 23 19'32.75 E 30 42'29.09		S 23 19 33.43 E 30 42 28.32	S 23 19'35.14 E 30 42 29.55	S 23 19'37.21 E 30 42'27.01
Description	Red refusal at 20cm	10 m downslope from the previous sample point. The point was in a trench.	Infill disturbed close to ponds	Slope change, channel outside parallel to the fence, low point.	Low point on fence channel outside *Ficus* sp. tree, S\secondary channel with 5 m high bank and it is 10-20 m open.
Topography	Lowlands	Lowlands	Lowlands	Lowlands	Valley bottom
Geology	Hard rock layer and no presence of soil mottles, and indications of material	Coarse gravel material, filled material.	Hard rock layer and coarse granite material from construction	Hard rock layer and coarse granite material from construction	Dolerite formation.

	from construction material.		material.	material.	
Soil	Red soils and no mottles were observed on the soil profile. The soil is sandy and becomes hard.	Grey profile with no signs of mottling. The soil is sandy and becomes loamy from 10 to 20 cm and then hard rock.	Red soils with clear signs of scrapping, the soil is loamy to clay and grains (0-10 cm), infilling material and floodplain production soils. Signs of charcoal were observed and heavy structured soil low with peds. Quarts pebble recorded 35 cm, natural rounded coarse gravel.	No soil mottles observed. Red soils with fine sediments.	Alluvial soil and wash down material from the dam.
Land cover/landform	Waste Water Treatment works	Waste Water Treatment works	Waste Water Treatment Works	Waste Water Treatment Works	Vegetation
Vegetation **The vegetation is dominated mainly by weeds and alien plants indicating disturbance.**	Species recorded include *Bidens pilosa, Tribulus terrestris, *Richardia brasiliensis, *Solanum elaeagnifolium, *Amaranthus spinosus* and *Panicum maximum*	Species recorded around the point include **Solanum elaeagnifolium, *Bidens pilosa, *Amaranthus spinosus, Dichondra micrantha, *Schkuhria pinnata* and *Mangifera indica* (Mango).	Species recorded included **Ricinus communis, Chloris pycnothrix, Cynodon dactylon* and *Urochloa* sp., **Schkuhria pinnata, *Gomphrena celosioides* and *Mangifera indica* (Mango).	**Melia azedarach, Urochloa sp., *Gomphrena celosioides* and *Ricinus communis var. communis.*	The species recorded include Tall *Ficus sycomorus, Grewia flava, *Melia azedarach* and **Lantana camara.*
Impacts	Infilling material, weed encroachment and Sewage	Infilling material, weed encroachment and	Infilling material, weed encroachment and	Infilling material, alien plants and Sewage	Alien plant trees, sediment runoff from

	effluent.	Sewage effluent.	Sewage effluent.	effluent.	tracks and erosion.

Site	**WWT11**	**WWT12**	**WWT13**	**WWT14**	**WWT15**
Coordinates	S 23 19 37.86 E 30 42'26.48	S 23 19'38.00 E 30 42 23.82	S 23 19'39.86 E 30 42 22.64	S 23 19'40.22 E 30 42'22.23	S 23 19'39.73 E 30 42'27.20
Description	Org sedge waste top alluvium below, located on high levee bank.	Located between the riparian banks and the high levee.	Edge of river bed, major slope change and bottom of channel. Sand banks covered with sand and fine sediments and open water for 20 m.	Secondary channel entry point, slope change, channel outside parallel to the fence, low point.	Edge of levee, edge of wetland field? Erosion is active and the area is located edge of the farm and the WWTW.
Topography	Valley bottom	Valley bottom	Valley bottom	Valley bottom	Valley bottom
Geology	Dolerite formation	Dolerite formation	Dolerite formation.	Dolerite formation.	Dolerite formation.
Soil	Moist and humid soils, no mottles recorded.	Grey profile with no signs of mottling. The soil is sandy and becomes loamy from 10 to 20 cm and then hard rock.	Alluvium sandy soil from sandy banks.	No soil mottles observed. Red soils with fine sediments.	Clear alluvium soil and erosion active. No sign of mottles. 4- 6 m deep erosion.
Land cover/landform	Natural vegetation	Natural vegetation	Natural vegetation	Vegetation	Vegetation
Vegetation	The area is located on riparian forest and the species recorded include Tall *Ficus sycomorus, Grewia bicolor, Melia azedarach and Lantana camara.*	Well defined riparian bank vegetation and species recorded include *Acacia caffra, Combretum erythrophyllum, Ficus sycomorus, Lantana camara* and *Ipomoea purpurea*.	Species recorded included on the banks *Phragmites mauritianus, Ipomoea purpurea, Ricinus communis, Lonchocarpus capassa, Ficus sycomorus* and *Lantana camara*.	*Acacia caffra, Lonchocarpus capassa, Combretum erythrophyllum, Gymnosporia senegalensis* and *Lantana camara.*	*Dominated by Melia azedarach, Lonchocarpus capassa* and *Dichrostachys cinera* on the terrestrial zone.
Impacts	Infilling material and	Livestock	Livestock	Livestock	Erosion gully

	Sewage effluent material				formations close to the channel, irrigation system above and run-runoff causing erosion.

Site	**WWT16**	**WWT17**	**WWT18**	**WWT19**	**WWT20**
Coordinates	S 23 19 38.07 E 30 42'32.47	S 23 19'37.73 E 30 42'32.46	S23 19 37.3 E30 42 42.3	S 23 19 36.71 E 30 42'32.12	S 23 19'37.99 E 30 42'30.01
Description	Terrestrial Area, Soil profile conducted in a trench.	Terrestrial Area. Disturbed ploughed field.	Terrestrial Area. Disturbed ploughed field and edge of the wetland.	Seasonal wetland, low point and man-made furrow.	Temporary zone wetland with signs of water movement and salt concentrations.
Topography	Gentle flat-plains	Gentle flat-plains	Flat plains	Flat plain	Flat plain
Geology	Granite-Gabbro formation	Granite formation	Granite formation	Granite formation	Dolerite formation.
Soil	Sandy to loamy, red soils and no mottles were observed. 10 cm gravel layer.	Red soils, sandy to loamy soils and no mottles were observed.	Red soils, clay to gravel layer. Presence of grains (0- 10 cm) and lime mottles, soft carbonaceous material (10-30 cm)	Organic accumulation, seasonal or red mottles recorded (10-30 cm), Orange mottles.	Soil mottles recorded 45-50 cm, red to grey soils. Salt deposited cracks.
Land cover/landform	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land
Vegetation	Species recorded include *Argemone Mexicana, Calotropis procera* (Giant milkweed), *Malvastrum coromandelianum, Solanum sisymbrifolium*	Species recorded include *Argemone Mexicana, Chloris pycnothrix, Solanum sisymbrifolium* and *Conyza albida.*	Species recorded include *Verbena bonariensis, Xanthium strumarium, Cynodon dactylon* and *Chloris pycnothrix.*	High biomass accumulation and species recorded included *Chloris pycnothrix* and *Cynodon dactylon.*	Species recorded included *Argemone Mexicana, Chloris pycnothrix, Amaranthus hybridus subsp. Hybridus* and *Conyza albida.*

Impacts	Irrigation effects and weed encroachment	Agricultural, powerlines and weed encroachment.	Agriculture and weed encroachment.	Agriculture and weed encroachment.	Irrigation effects and weed encroachment

Site	**WWT21**	**WWT22**	**WWT23**	**WWT24**	**WWT25**
Coordinates	S 23 19'35.22 E 30 42'31.07	S 23 19'36.90 E 30 42'31.07	S 23 19 37.99 E 30 42 30.01	S 23 19 38.49 E 30 42 30.23	S 23 19'39.16 E 30 42'29.61
Description	Slope change and edge of a flood effect.	Shallow and wide channel starts.	Seasonal-Temporary, edge and water seeps	Temporary wetland	Clear signs of plough, slope to flat. Very marginal.
Topography	Undulating to flat plains	Flat plain to valley channel bottom	Flat plains	Flat plain	Flat plain
Geology	Dolerite	Dolerite	Dolerite	Granite formation	Dolerite formation.
Soil	Loamy soil, red soils and no mottles were observed. Gravel layer 10 cm.	Red soils, sandy to loamy soils and no mottles were observed.	Red soils, clay to gravel layer. Presence of grains.	Soil mottles recorded (10-30 cm), Orange mottles.	No Soil mottles recorded, red soils. Gravel 10 cm.
Land cover/landform	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land
Vegetation	Species recorded include **Ricinus communis var. communis, *Xanthium strumarium, *Bidens pilosa, *Chloris pycnothrix, *Malvastrum coromandelianum, *Solanum sisymbrifolium*	Species recorded include *Chloris pycnothrix* and *Typha capensis, *Lantana camara* lower down.	Species recorded include **Verbena bonariensis, *Ricinus communis, *Amaranthus spinosus, *Xanthium strumarium* and *Chloris pycnothrix.*	High biomass accumulation and species recorded included *Chloris pycnothrix, *Amaranthus spinosus* and *Asimina triloba.*	Species recorded included **Ricinus communis, Chloris pycnothrix, *Conyza albida* and **Flaveria bidentis.*
Impacts	Sewage on the right, deposition of rubbles and	Agricultural, Alien plants, rubble and weed	Irrigation effects and weed encroachment	Irrigation effects and weed encroachment	Irrigation effects and weed encroachment

	agricultural impact.	encroachment.			

Site	WWT26	WWT27	WWT28	WWT29	WWT30
Coordinates	S23 19 36.61 E30 42 35.40	S23 19'36.16 E30 42 35.38	S23 19 38.1 E30 42 30.1	S23 19 35.56 E30 42'35.32	S23 19'35.01 E30 42 34.86
Description	Terrestrial area	Seasonal-temporary zone	Temporary zone	Seasonal wetland, vegetation based seasonal sedge.	Seasonal wetland formed from sewage discharge.
Topography	Undulating to flat plains	Flat plain to bottom	Flat plains	Flat plain	Flat plain
Geology	Dolerite	Dolerite	Dolerite	Granite formation	Dolerite formation.
Soil	Red loamy plough soil and gravel layer 20 cm. No mottles recorded.	Soil mottles (lime) recorded at 5-10 cm. Red to loamy soils.	Soil mottles (lime) at 30 cm on red loamy soils towards weathered rock.	Soil mottles recorded (10-30 cm), Orange mottles.	Soil mottles recorded on sub-surf (10-20 cm) with organic layer, red soils.
Land cover/landform	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land
Vegetation	Species recorded include Lantana camara, **Ricinus communis, *Xanthium strumarium, *Argemone mexicana, *Flaveria bidentis, *Malvastrum coromandelianum, Senecio consaguineus* and *Asimina triloba.*	Species recorded include **Amaranthus spinosus, *Flaveria bidentis, *Lactuca* sp. *Cyperus* cf. *digitatus* subsp. *auricomus, Chloris pycnothrix, *Argemone mexicana, *Malvastrum coromandelianum and Asimina triloba.*	Species recorded include *Cyperus* cf. *digitatus* subsp. *auricomus, Chloris pycnothrix* and **Argemone mexicana.*	High biomass accumulation and species recorded included *Cyperus* cf. *digitatus* subsp. *auricomus* and *Chloris pycnothrix.*	High biomass with thick organic layer and species recorded include *Chloris pycnothrix.*
Impacts	Irrigation effects and weed	Agriculture impacts and	Agriculture impacts and	Agriculture impacts and	Agriculture impacts and

	encroachment	weed encroachment	weed encroachments	weed encroachments	weed encroachments

Site	**WWT31**	**WWT32**	**WWT33**	**WWT34**	**WWT35**
Coordinates	S23 19'34.08 E30 42'34.24	S23 19'33.57 E30 42'33.71	S23 19'34.98 E30 42 37.29	S23 19 35.34 E30 42 37.87	S23 19'35.38 E30 42 38.49
Description	Seasonal wetland	Edge, infilled material from upslope and fence is 15 m away.	Temporary zone	Slope change	Terrestrial. Surface ponding from damming.
Topography	flat plains	Flat plain to bottom	Flat plain	Flat plain	Flat plain
Geology	Dolerite	Dolerite	Dolerite	Shallow bedrock	Dolerite formation.
Soil	Thick organic matter, red soils, soil mottles recorded then grey soil. Fine sediments observed from sewage discharge.	Soil mottles (lime) recorded at 5-10 cm. Red to loamy soils.	Red soils, mottles recorded at 30 cm.	Lime nodes at 30 cm and weathered rock.	Red soils, no mottles recorded.
Land cover/landform	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land	Old cultivated land
Vegetation	High biomass with thick organic layer and species recorded include *Chloris pycnothrix.*	Species recorded include **Amaranthus spinosus, Lantana camara, Chloris pycnothrix, *Ricinus communis, *Melia azedarach, Cyperus* cf. *digitatus* subsp. *auricomus, Cardiospermum grandiflorum, Tribulus terrestris* and *Senecio* sp.	Dominant species recorded include **Argemone mexicana, Euphorbia heterophylla* and **Flaveria bidentis.*	Dominant species recorded include **Argemone mexicana*	Species recorded include **Argemone mexicana* and **Flaveria bidentis.*

Impacts	Agriculture impacts and weed encroachments	Alien plants, weed plants, road crossing, power-lines and infilling.	Agriculture impacts and weed encroachments	Agriculture impacts and weed encroachments	Agriculture impacts and weed encroachments

Site	**WWT36**	**WWT37**
Coordinates	S23 19'32.58 E30 42'39.73	E23 19 31.92 E30 42'39.35
Description	Terrestrial. Surface ponding from damming.	Terrestrial surf ponding behind ponds in WWTW.
Topography	flat plains	flat plains
Geology	Dolerite	Dolerite
Soil	Red soils and loamy. No mottles recorded.	Red soils and loamy. No mottles recorded.
Land cover/landform	Old cultivated land	Old cultivated land
Vegetation	Species recorded include the weeds **Argemone mexicana* and **Flaveria bidentis.*	Species recorded include **Argemone mexicana* and **Flaveria bidentis.*
Impacts	Agriculture impacts and weed encroachments	Agriculture impacts and weed encroachments