Upstream Consulting

Aquatic specialist services

- Cell: 072 444 8243
- Email: debbie@upstreamconsulting.co.za
- Address: 25 Blommekloof Street, George, 6530

www.upstreamconsulting.co.za

AQUATIC BIODIVERSITY IMPACT ASSESSMENT

for the proposed

UPGRADING OF THE GWAING WASTEWATER TREATMENT WORKS, GEORGE LOCAL MUNICIPALITY

DATE: 27 July 2024

PREPARED FOR:

Sharples Environmental Services cc
102 Merriman Street
George
6529

PREPARED BY:

Debbie Fordham
Upstream Consulting
25 Blommekloof St, George, 6529
debbie@upstreamconsulting.co.za

Executive Summary

Background

Debbie Fordham of Upstream Consulting has been appointed by Sharples Environmental Services CC to conduct an aquatic biodiversity impact assessment for the proposed upgrades to the Gwaing Wastewater Treatment Works (WWTW) by George Municipality. The upgrade aims to increase the plant's capacity to 50 million liters per day (MLD) of average dry weather flow (ADWF) while ensuring compliance with the effluent standards required according to the Water Use License. The Gwaing WWTW discharges treated effluent into a tributary of the Gwaing River.

Desktop information

The site is located near the Gwaing River within the DWS Quaternary Catchment K30B and falls within the Outeniqua Strategic Water Source Area for surface water. The Gwaing River, and two watercourses (one north and another south of the WWTW), are mapped as channelled valley bottom wetland habitat by the NWM5. The WCBSP shows that the site is not located upon any biodiversity priority areas, CBA nor ESAs. However, the watercourse downslope of the WWTW outlet structure is classified as CBA 1 wetland habitat, as is the Gwaing River downstream. Downstream habitat of significant ecological importance includes the estuary at the river mouth.

Identified aquatic habitat

A site visit was conducted to ground truth the findings and delineate the aquatic habitat. Five (5) watercourses were identified and mapped within a 500m radius of the proposed activities. Due to the topography of the site resulting in surface runoff in a south westerly direction, and location of the WWTW outlet, it was determined that only the southern watercourse (mapped as HGM 2) has potential to be directly impacted by the upgrades. However, there is also potential for the downstream section of the Gwaing River (mapped as HGM 1) to be indirectly impacted by the project. The other watercourses identified within the 500m radius of the site are unlikely to be impacted by any of the proposed activities and were therefore not assessed further.

The Gwaing River originates in the Outeniqua Mountains and flows southwest towards the Indian Ocean, covering an approximate length of 20 km. The study area is within the upper foothills geomorphic reach and has a perennial flow regime. There is some remaining channelled valley wetland habitat remaining, but the channel has become incised, and alien invasive plants have encroached into the riparian area (such as very large Eucalyptus sp., black wattle and bugweed trees). The water quality of the Gwaing River is poor, influenced by a variety of natural and anthropogenic factors. The George Municipality laboratory services provided water quality monitoring data relevant to the Gwaing WWTW and two testing stations, one upstream and one downstream, on the Gwaing River. For the purposes of this assessment, only the final effluent measurements were analysed relative to (a) the river, (b) the General Limits of the water use license, and (c) the South African Water Quality Guidelines for Aquatic Ecosystems. It was determined that the effluent from the Gwaing WWTW is typically within the General Limits of the General Authorisation for discharging water into a river. This is a good indication of compliance and the performance from the WWTW. However, the river itself has poor water quality with a high E.Coli count. The river reach assessed falls within the 'D' ecological category for present ecological state (PES) as it is in a Largely Modified condition, but it has a High ecological importance and sensitivity (EIS). Despite its ecological value, the Gwaing River faces several threats, including pollution from agricultural runoff, urban development, and invasive alien plant species. Climate change poses additional challenges, potentially altering the river's flow patterns and impacting its ecosystems.

The HGM 2 wetland occupies the valley south of the Gwaing WWTW. Water flows through an incised channel in a westerly direction to the Gwaing River. The upper reaches are severely degraded and have little remaining habitat. The downstream habitat is disturbed but intact. The seasonal and temporary zones have been subjected to soil disturbance and vegetation clearance for grazing, resulting in alien invasive plant encroachment, such as kikuyu grass and bugweed trees. However, the permanent zone is robustly vegetated with indigenous reeds (dense *Phragmites australis* beds) and retains a high level of ecological functioning. The significant habitat loss in the upper reaches, and alien invasive plant infestation throughout the system, results in an overall 'D' (poor) Present Ecological State (PES) score. The wetland supplies important regulatory and supporting ecosystem services such as stream flow regulation, pollutant assimilation and the provision of water. It is therefore recommended that the management objective for the wetland be to improve the system.

Impacts

After reviewing the proposed activities and locations for upgrading the WWTW, and conducting in-field assessment, it was determined that the only realistic potential impacts from the project are associated with the construction at the outlet structure (as it is in close proximity to the HGM 2 wetland) and the increase in effluent to be discharged from the WWTW in the operational phase. There are no immediate impacts associated with the No Go Alternative. However, it is highly likely that, should the plant not receive upgrades, the effluent will become non-compliant due to the expected population growth and result in negative impacts upon aquatic biodiversity.The potential impacts assessed, including cumulative impacts, were:

- Impact 1: Disturbance to aquatic habitat and biota
- Impact 2: Increased water inputs leading to changes to the hydrological regime
- Impact 3: Changes to hydrological regime that could also lead to sedimentation and erosion
- Impact 4: Changes to water quality characteristics

Significance

It was determined that, after mitigation, the project is of Low negative significance to aquatic biodiversity. There is potential for positive impacts and risk avoidance. Therefore, from an aquatic perspective, the proposed project is deemed as acceptable. Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Monitoring should focus on adherence to the No-Go area, preventing erosion and pollution.

Specialist Assessment Protocol Index

Report reference to Table 1 - Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity

2. Aquatic Biodiversity Specialist Assessment	
2.1. The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.	Debbie Fordham SACNASP Registration number 119102 (Ecology)
2.2. The assessment must be undertaken on the preferred site and within the proposed development footprint.	Section 1- Introduction 1.1 –Location & 1.2 – Project description
2.3. The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	
2.3.1. a description of the aquatic biodiversity and ecosystems on the site, including;	Section 6 – Affected Environment Section 7 - Results
(a) aquatic ecosystem types; and (b) presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns;	Section 6.1 – The Drainage Network Section 7.1 – Identified habitat
2.3.2. the threat status of the ecosystem and species as identified by the screening tool;	Low & Very High 1.4 -Screening tool results Section 6.5 – Conservation context Section 6.4 - SAIIAE
2.3.3. an indication of the national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area or sub catchment, a strategic water source area, a priority estuary, whether or not they are free-flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area); and	Section 6 – Affected Environment ESA habitat
2.3.4. a description of the ecological importance and sensitivity of the aquatic ecosystem including:	Section 7. Delineated aquatic habitat Section 6 & 7 – Affected Environment & Results
(a) the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and (b) the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain	Section 6.1 – Drainage network Section 7.1 – Identified aquatic habitat Section 6.7 –Historic land use

habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	
2.4. The assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered appropriate.	Section 7 – Results
2.5. Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions:	
2.5.1. is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Refer to Section 9 – Impact assessment and tables
2.5.2. is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	
2.5.3. how will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include:	Section 8 – Identified Impacts
(a) impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); (b) will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns); (c) what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and (d) to what extent will the risks associated with water uses and related activities change;	Section 8.2 –Flow pattern changes 8.3 - Erosion and Sedimentation Section 8.1 – Loss of aquatic habitat Section 8.4 Water Quality impacts
2.5.4. how will the proposed development impact on the functioning of the aquatic feature? This must include:	Section 9 – Impact Significance Assessment
(a) base flows (e.g. too little or too much water in terms of characteristics and requirements of the system); (b) quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river); (c) change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland); (d) quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); (e) fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and	Refer to Section 9 – Impact assessment and tables Section 8 – Identified Impacts Section 9 Impact Assessment

(f) the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	
2.5.5. how will the proposed development impact on key ecosystems regulating and supporting services especially:	Low Impact (after mitigation) Section 9 – Impact Significance Assessment
(a) flood attenuation; (b) streamflow regulation; (c) sediment trapping; (d) phosphate assimilation; (e) nitrate assimilation; (f) toxicant assimilation; (g) erosion control; and (h) carbon storage?	Section 8 – discussion of identified impacts
2.5.6. how will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 8 and Impact Table of Section 9
2.6. In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered, in relation to: (a) size of the estuary; (b) availability of sediment; (c) wave action in the mouth; (d) protection of the mouth; (e) beach slope; (f) volume of mean annual runoff; and (g) extent of saline intrusion (especially relevant to permanently open systems).	Section 8
2.7. The findings of the specialist assessment must be written up in an Aquatic Biodiversity Specialist Assessment Report that contains, as a minimum, the following information:	
2.7.1. contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	Appendix 2 – Specialist curriculum vitae
2.7.2. a signed statement of independence by the specialist;	Below Declaration of Independence –Page vi
2.7.3. a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	4.2 – Site assessment Section 4 – Approach and methodology Section 5 - Assumptions
2.7.4. the methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;	Section 4 – Approach and methodology

Declaration of Independence

SPECIALIST REPORT DETAILS

This report has been prepared as per the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (Act 107 of 1998), any subsequent amendments and any relevant National and / or Provincial Policies related to biodiversity assessments. This also includes the minim requirements as stipulated in the National Water Act (Act 36 of 1998), as amended in Water Use Licence Application and Appeals Regulations, 2017 Government Notice R267 in Government Gazette 40713 dated 24 March 2017, which includes the minimum requirements for an Aquatic Biodiversity Report.

Report prepared by: Debbie Fordham (Ecology 119102)

Expertise / Field of Study: Internationally certified Professional Wetland Scientist and registered SACNASP ecologist, with 10 years of working experience, specialising in aquatic ecology. Debbie holds a M.Sc. degree in Environmental Science from Rhodes University, by thesis, entitled: The geomorphic origin and evolution of the Tierkloof Wetland, a peatland dominated by *Prionium serratum* in the Western Cape. She is a member of scientific organisations such as the Society of Wetland Scientists (SWS), the South African Wetland Society (SAWS), and the Southern African Association of Geomorphologists (SAAG).

I, **Debbie Fordham** declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs Fisheries and Forestry and or Department of Water and Sanitation.

Signed:…  .... Date:…27 July 2024………

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Debbie Fordham of Upstream Consulting has been appointed by Sharples Environmental Services CC to conduct an aquatic biodiversity impact assessment for the proposed upgrades to the Gwaing Wastewater Treatment Works (WWTW) by George Municipality. The upgrade aims to increase the plant's capacity to 50 million liters per day (MLD) of average dry weather flow (ADWF). The facility, located near the Gwaing River, discharges treated effluent into a nearby tributary. Although the Department of Forestry, Fisheries and the Environment (DFFE) Screening Tool classifies the site as having low sensitivity for aquatic biodiversity, there are areas of high sensitivity nearby. Therefore, an aquatic specialist study is required to inform the National Environmental Management Act (NEMA) environmental authorization process.

1.1 LOCATION

The site is situated within the existing boundaries of the Gwaing WWTW, located on the southwestern outskirts of George, Western Cape. Access to the site is via the R102, north of the location, approximately at the following coordinates: Latitude: 33°59'37.92" S, Longitude: 22°25'27.88" E. The area has been extensively modified due to the construction and operation of the existing Gwaing WWTW and associated infrastructure. Figure 1 illustrates the site location and the 500-meter radius study area, in relation to the town of George, the Gwaing River, and the R102 road.

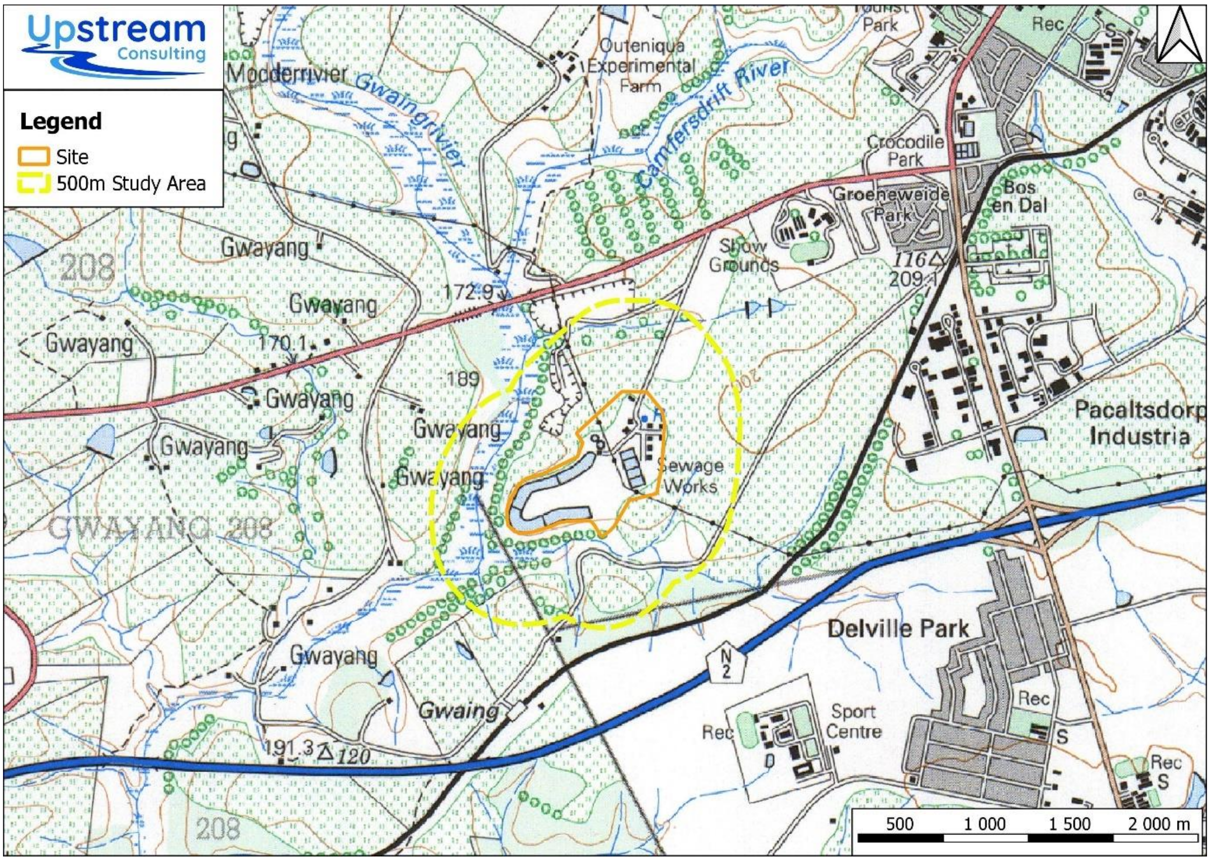

Figure 1: Topo-cadastral map showing the location of the site and 500m radius study area

1.2 BACKGROUND

The Gwaing Wastewater Treatment Works in George, Western Cape, has a total average dry weather flow (ADWF) capacity of 8.6 million litres per day (MLD). Operating with a UCT process, the plant is overloaded at a design chemical oxygen demand (COD) concentration (95th percentile) of 782 mgCOD/l. Currently, the plant receives an ADWF of 10 MLD. Due to population growth in George, expanding the wastewater treatment works is a priority.

1.3 SCREENING TOOL RESULTS

The National Web based Environmental Screening Tool was utilised for this proposal in terms of the Environmental Impact Assessment (EIA) Regulations 2014, as amended, to screen the proposed site for any environmental sensitivity. The Screening Tool identifies related exclusions and/ or specific requirements including specialist studies applicable to the proposed site. The Screening Tool allows for the generating of a Screening Report referred to in Regulation 16 (1) (v) of the Environmental Impact Assessment Regulations 2014, as amended whereby a Screening Report is required to accompany any application for Environmental Authorisation. Requirements for the assessment and reporting of impacts of development on aquatic biodiversity are set out in the 'Protocol for the assessment and reporting of environmental impacts on aquatic biodiversity published in Government Notice No. 648, Government Gazette 45421, on the 10 of May 2020.

According to the Screening Report, the Gwaing WWTW site is of ‘Low’ aquatic sensitivity, but is near the Gwaing River, and the effluent discharge outlet structure is in an area of Very High aquatic sensitivity. It therefore requires the assessment and reporting of impacts on Aquatic Biodiversity (Figure 2).

The site verification assessment was undertaken and is attached as a Site Verification Report in Appendix 3. The Very High aquatic biodiversity sensitivity rating at the outlet was confirmed and it was determined that the project will impact aquatic habitat. Therefore, the Aquatic Biodiversity Impact Assessment report was required and has been compiled in accordance with the latest NEMA Minimum Requirements and Protocol for Specialist Aquatic Biodiversity Impact Assessment (10 May 2020).

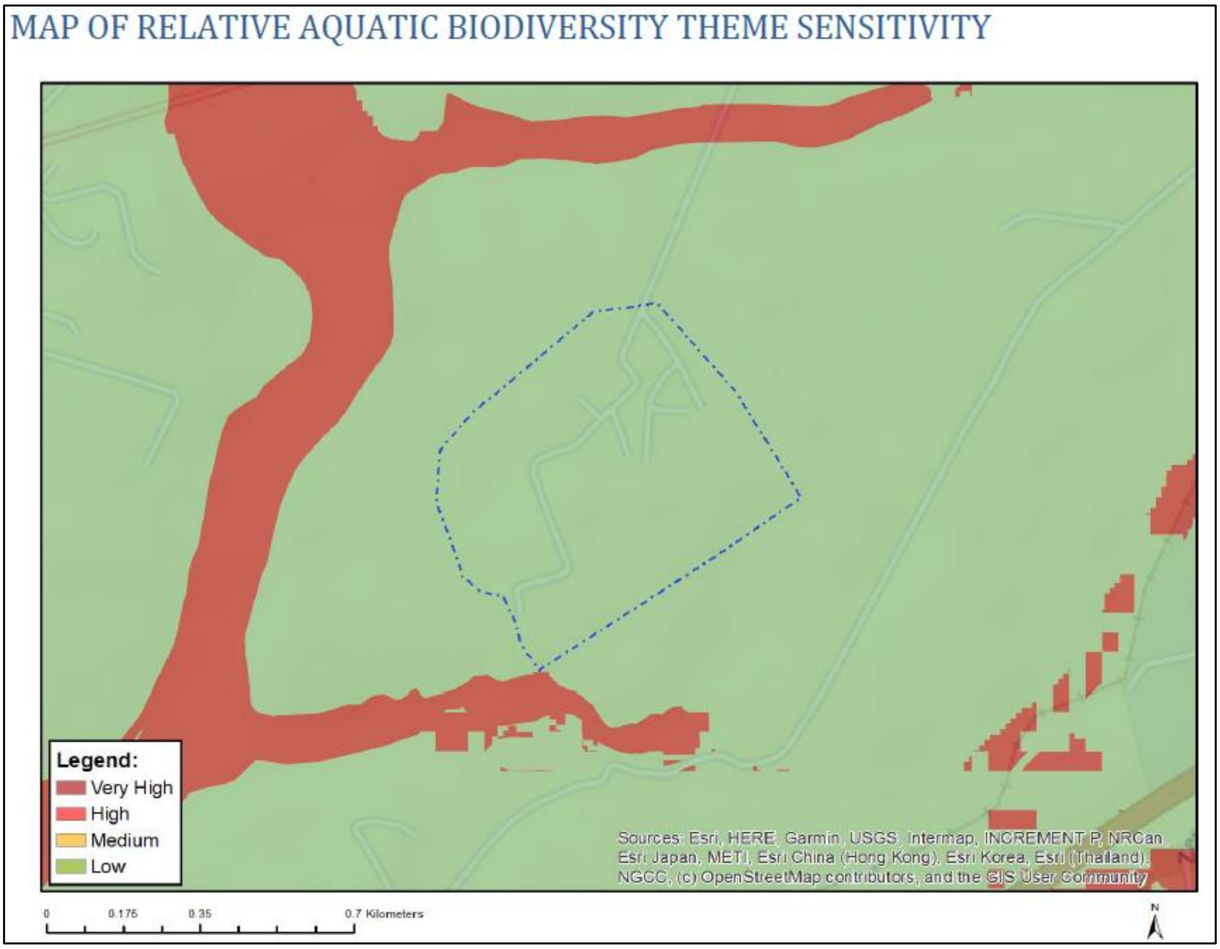

Figure 2: Aquatic biodiversity sensitivity map of the study area from the DFFE Screening Tool

2 PROJECT DESCRIPTION

George Municipality (GM) aims to upgrade the Gwaing WWTW to remain compliant with the effluent standards as dictated by the Water Use Licence (WUL) issued by the Department of Water and Sanitation (DWS). GM have appointed Lukhozi Consulting Engineers (Pty) Ltd (LCE) to create a Master Plan to guide future upgrades in appropriate phases. The upgrades in the first two phases, referred to as Phase A and Phase B, need to be implemented in the short to medium term to achieve an ADWF capacity of 22 MLD. Following the longer-term upgrades (Phases C and D), the design flow for the ultimate solution is 50 MLD for average dry weather flow. The proposed upgrades and refurbishments, as defined in the Sewer Master Plan are contained within the site boundary of the wastewater treatment works.

According to the Concept Design Report by LCE (June 2024), the vision for Gwaing WWTW extends beyond waste management. It aims to transform the facility into a Water Resource Recovery Facility (WRRF), emphasizing resource recovery. Key strategies include:

- Regional grit processing facilities to enable reuse of grit as part of composting or fill material.
- Regional screenings processing facility to minimise volume, odours, pathogens and vector attraction of screenings.

- Sludge beneficiation in the form of composting or fertilizer production is envisaged.
- The methane gas produced from anaerobic digestion will be used for generating heat and power (as part of Phase D).
- Effluent from the Gwaing WWTW can in future be pumped to neighbouring industries or golf courses for non-potable use. Alternatively, it can be further treated together with the effluent from Outeniqua WWTW before it is pumped to the Garden Route Dam as part of an indirect potable reuse scheme.
- Effluent will be recycled and pressurized on-site in a wash water ring main for various uses including irrigation, reducing the potable water demand of the WWTW.
- Energy efficient design principles are used to reduce the power consumption of the plant, while a solar PV plant will both provide backup power during loadshedding events and shift the plant's reliance from the national grid to renewable energy sources.

2.1 OBJECTIVE

Regardless of the above, the main objective of these upgrades is to ensure compliance with the effluent standards required according to the Water Use License.

The Water Use License (WUL), dated 18 December 2015, stipulates the treated effluent compliance in terms of the General Limit Values as detailed in the Government Gazette of 6 September 2013, as shown in Table 3-9 of the Concept Design Report (Table 1). The only deviation of the WUL is that E Coli is limited to 150 cfu/ 100 ml instead of the 1000 cfu/100 ml prescribed by the General Limit. Generally, the standard is achievable with a conventional BNR activated sludge plant including disinfection.

Table 1: Anticipated discharge Standards for the Gwaing WWTW based on the current 11 Mℓ/day WUL (From Table 3-9 of the Concept Design Report, LCE 2024)

Parameter	Units	General Limit	Current Water Use Licence Limit
Faecal coliforms	Count per 100 ml	1000	Not specified
E Coli	Count per 100 ml	Not specified	150
COD	mgCOD/l	75	75
pH		5.5-9.5	5.5-9.5
Ammonia (as N)	mgN/l	6.0	6.0
Nitrate (as N)	mgN/l	15	15
Chlorine as Free Chlorine	mg/l	0.25	0.25
Suspended Solids	mg/l	25	25
EC	m/mS	70*	70*
Ortho Phosphate (as P)	mgP/l	10	10
Fluoride	mg/l	1	1
Soap, oil and grease	mg/l	2.5	2.5

2.2 PROCESS UPGRADES RELEVANT TO AQUATIC IMPACTS

2.2.1 UCT Process

According to the Concept Design Report (LCE, June 2024), the effluent standards required by the WULA, as shown in the table above, are of such a nature that an activated sludge treatment process is required. The nitrate effluent standard is 15 mg/l, which requires a configuration that includes nitrification and denitrification. The phosphorus effluent standard is 10 mg/l, which is not a strict limit and can be achieved without an enhanced biological phosphorus removal (EBPR) configuration (depending on the influent). The two processes considered in the design were the Modified Ludzack-Ettinger (MLE) process and the University of Cape Town (UCT) process.

The current capacity of the plant is 8.6 MLD when operating as a UCT process and 10.4 MLD when operating as a MLE process. The ultimate solution was designed as a settled UCT system as this process produces much lower orthophosphate levels which is better for the environment. Given how close the MLE process' orthophosphate concentrations are to the general limit, it is better suited to operate the UCT process when the plant is not overloaded. This process selection is also the preferred method from an aquatic biodiversity perspective.

2.2.2 UV disinfection

An additional process upgrade which has implications for aquatic habitat is the proposed use of UV disinfection as opposed to chlorine disinfection. According to the Concept Design Report of LCE (June 2024), both are proven methods for effectively disinfecting treated wastewater effluent, however, they differ in terms of effectiveness, cost, environmental impact, and operational considerations. According to the report, from an environmental and regulatory standpoint, UV offers more advantages, such as no chemical residuals, and was selected as the preferred process of disinfection be implemented as part of the phase A and B upgrades.

All clarified effluent from the secondary clarifiers will gravitate to the disinfection facility upstream of the maturation ponds to prevent algae from fouling the UV light sleeves. The existing chlorine contact tank will be retained as an optional final disinfection step after the maturation ponds. It is recommended that the maturation ponds be retained as it provides additional disinfection and naturalisation of the effluent, also reducing the TSS concentration and residual chlorine levels before it is discharged to the river. Means to bypass the ponds will be provided. Therefore, the processes selection for the upgrades to the Gwaing WWTW have carefully considered the environmental impacts and are fully supported from an aquatic biodiversity perspective.

2.3 INFRASTRUCTURE UPGRADES RELEVANT TO AQUATIC IMPACTS:

2.3.1 The sludge stockpiles and seepage to maturation ponds

According to the design report, Gwaing WWTW has four maturation ponds of approximately equal size. The total area of the ponds is 44 000 m2. At an approximate depth of 1.5 m, this equates to a volume of 66 000 m3. The maturation pond configuration resembles a horseshoe, with effluent flowing in an anti-clockwise direction. The area between the ponds is being used for sludge stockpiling, which cannot be deemed either a temporary or long-term solution. George Municipality's current sludge disposal method is not compliant with sludge management guidelines with the sludge being stored between the maturation ponds in an unlined area. Since neither the sludge stockpiling area between the ponds, nor the ponds themselves are lined, the nutrients from the sludge seeps into the maturation ponds and the effluent quality is negatively affected.

The sludge produced currently is classified as class B1a (LCE, June 2024). The dewatered sludge from the belt presses has 15-20% dry solids (DS). While this is dry enough to be carted away, it is still too 'wet' for most commercial uses. Composting or fertilizer facilities require drier sludge and new legislation requires that sludge have at least 40% DS before it can be applied to landfills in South Africa. The Western Cape Government's DEADP and Waste Management Directorate has set targets to reduce organic waste to landfills by 50% by 2022 and to ban all organic waste from landfills by 2027. Hence application of sludge to landfills will not be a viable option in the near future.

To make the sludge a more attractive commodity for either the municipal composting facility or private compost and fertilizer manufacturers the sludge needs to be processed further at Gwaing WWTW to achieve a higher dryness (solids content) and/or a classification of A1a.
George Municipality is investigating several options for sludge beneficiations such as primarily composting and/or solar drying for fertilizer production. Regardless of the sludge beneficiation option chosen by GM, there may well be a need for the temporary storage/stockpiling of sludge. It is stated in the Concept Design report that the bunded areas must include impermeable floors and contained stormwater retention so that nutrient-rich runoff does not enter the maturation ponds or stormwater networks.

The 50 MLD ADWF Gwaing WWTW ultimate solution includes WAS and primary sludge dewatered to 15%-20%. If Outeniqua WWTW produces an equal amount of sludge that also requires solar drying at Gwaing WWTW, and an advanced solar drying system is used, an estimated area of 20 000 m² is required for the solar drying facility. Two potential areas for the solar drying plant have been identified as can be seen in Figure 2 (taken from the LCE concept design report).

Figure 3: Two potential sites for the solar drying facility from the Concept Design report (LCE, 2024)

2.3.2 Upgrades to CC and outflow discharge structure

According to the Concept Design Report (LCE 2024), the chlorine contact dosing system and tank is in working condition. The contact tank is however on the upper limit of its hydraulic capacity. Remedial work to the pipework feeding the chlorine contact tank as well as the discharge pipeline is required. The upgrades to the chlorine contact tank are especially relevant to this study as it is near the outlet to the watercourse. Additionally, there has previously been erosion on the hillslope from this structure (although now stabilised and under rehabilitation). According to LCE it is also apparent that the last maturation pond has been overtopped at times when reeds have blocked the outlet structure which resulted in a donga which is being rehabilitated. There are also plans to improve the stormwater management network by directing stormwater to the existing maturation ponds on site since it is located at the lowest point of the site and has sufficient capacity to attenuate the flow, which will assist with the prevention of erosion.

The outflow discharge structure from where water flows into the watercourse, is hydraulically undersized for current peak flow events. These upgrades, proposed as part of Phase A and shown in the following section, will necessitate disturbance to aquatic habitat.

2.4 IMPLEMENTATION AND PHASING

According to the Master Plan compiled by LCEs, all infrastructure was designed with a phased approach in mind. The ultimate capacity of the Master Plan was designed for 50 MLD based on a UCT process. The four phases and their capacities are graphically shown in Figure 3 (taken from Figure 6-3 of the LCE Concept Design report) to align with the population growth based on 4% population growth. The Master Plan is divided into 4 separate phases, namely Phases A, B, C and D. Each phase is described in the sections below as detailed in the Conceptual Design Report (LCE 2024).

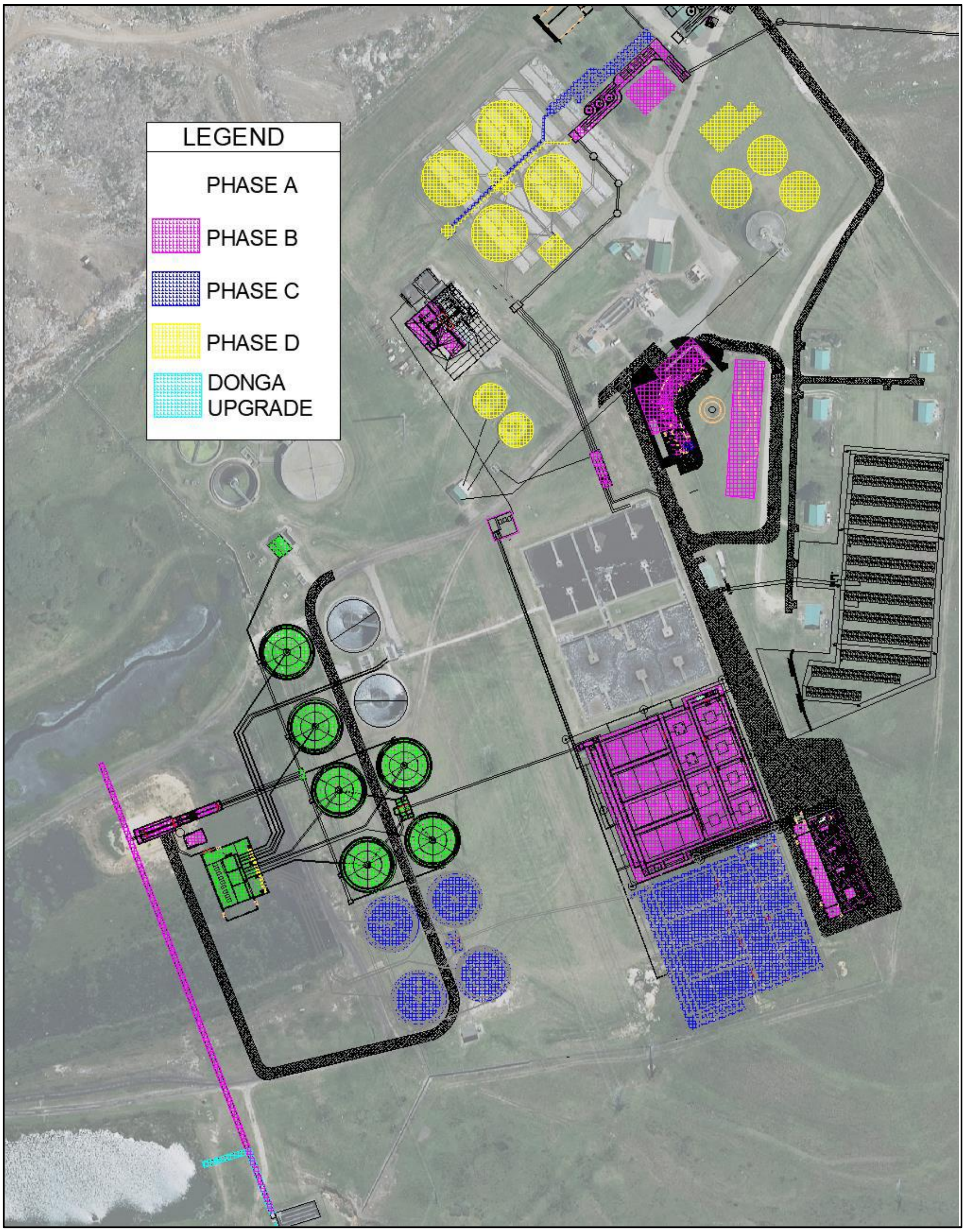

Figure 4: The four phases and their capacities taken from Figure 6-3 of the Concept Design report (2024)

2.4.1 Phase A

This phase includes:

- • Upgrades to the outlet structure
- • 2 additional SSTs for Module A
- • 4 SSTs for Module B (can operate with Reactor A)
- • New RAS Pumpstation
- • New Substation building
- • Electrical Equipment

Capacity achieved:

- • 13.2 MLD ADWF as a Raw UCT process

Gwaing WWTW is currently operating marginally beyond its capacity. The primary purpose of Phase A is to increase the capacity of the plant in the shortest possible time to ensure the works have enough capacity to sufficiently treat wastewater to comply with effluent requirements. The proposed solution is to construct 6 additional SSTs to operate together with the existing Reactor A.

The outlet structure which discharges the final effluent is in a poor condition and is undersized for the current capacity. Included in Phase A of the upgrade will be the construction of a new outlet chamber sufficient for the ultimate solution. The donga and maturation pond outlet channel to the existing chlorine contact channel will be upgraded on a separate contract due to the urgency of restoring the donga. The pipe and channel sizing and positions as part of the donga upgrade contract will be aligned with the Master Plan upgrade. Figure 4 (taken from Figure 6-6 of the Concept Design report) shows the layout of the outlet structure upgrade and the channel from the maturation pond to the chlorine contact channel as part of the donga upgrade.

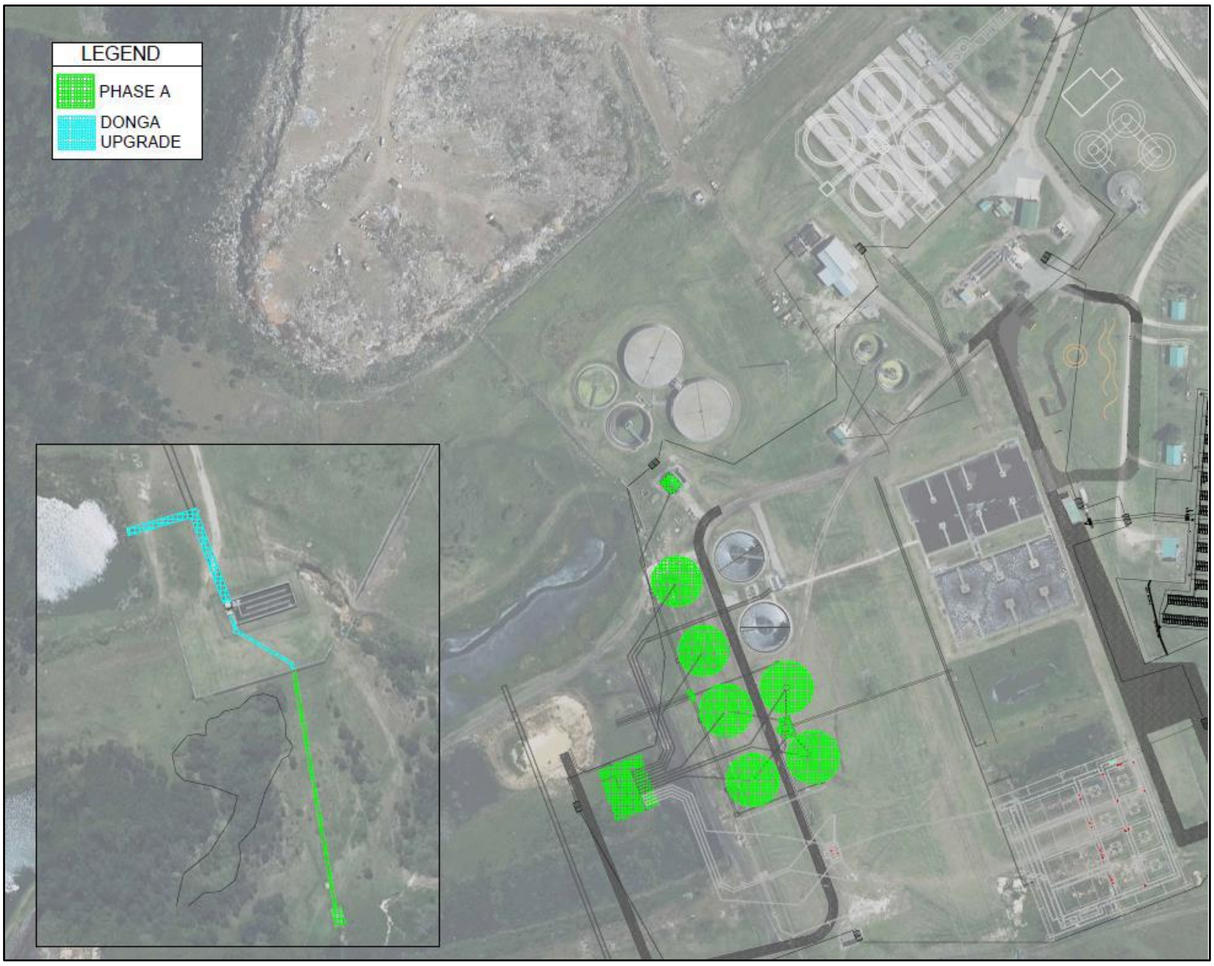

Figure 5: Phase A site layout (taken from Figure 6-6 of the Concept Design report) showing the layout of the outlet structure upgrade

2.4.2 Phase B

Phase B includes:

- • New Inlet Works Train 1
- • Regional Grit and Screenings Facility
- • New biological reactor (Module B)
- • New Blower House and aeration system
- • Service corridor for air header
- • New WAS pumpstation
- • New UV disinfection system
- • Extension to WAS Dewatering Facility
- • New Process Control (Admin) Building
- • Electrical Equipment
- • Potentially sludge storage bunds and/or sludge drying facility
- • New admin building

Capacity achieved:

- • 22 MLD ADWF as Raw UCT process

Phase B will see the construction of a new inlet works, including regional screening and degritting facility, for the washing of screenings and grit from other pumpstations and wastewater treatments works within the Municipal area. An additional reactor (Reactor Module B) will be constructed together with its associated pipework to connect to the SSTs constructed in Phase A. The additional reactor will be aerated with fine bubble diffusers and therefore a blower house will be constructed. UV disinfection and WAS dewatering are also included in the construction of Phase B. Phase B will give an additional capacity of 8.8 MLD from the 13.2MLD achieved in Phase A, resulting in a total capacity of 22 MLD (ADWF).

2.4.3 Phase C

This phase includes:

- • 1 New biological reactor (Module C)
- • Extension of Blower House and aeration system
- • 4 new SSTs (Module C)
- • Additional UV banks (M&E)
- • New Inlet Works Train 2
- • Electrical Equipment

Capacity achieved:

- • 33 MLD ADWF as Raw UCT process

Phase C of the upgrade will be to construct Module C's reactor and SSTs. It is proposed to construct the final reactor and SSTs prior to constructing the PSTs and associated primary sludge handling unit processes as all the ancillary infrastructure for the reactors and SSTs would have been constructed as part of Phase B. This includes the Blower House, RAS pump station and WAS pumpstation. The total capacity of the plant after the Phase C upgrade will be 33 MLD operating a UCT process.

2.4.4 Phase D

This phase includes:

- • 4 New PSTs
- • Primary Sludge Pump Station
- • 2 Gravity Thickeners (repurpose old PSTs)
- 4 Anaerobic Digesters
- Primary Sludge Dewatering Facility
- Electrical Equipment

Phase D of the upgrades will be the final phase of the Master Plan. The phase will see the construction of the four PSTs, a primary sludge pumpstation and three additional anaerobic digestors. The existing PSTs will be refurbished and used as gravity thickeners for the primary sludge. Phase D will increase the plant's capacity from 33 MLD to 50 MLD, operating a UCT settled process.

3 RELEVANT LEGISLATION

The protection of water resources is essential for sustainable development and therefore many policies and plans have been developed, and legislation promulgated, to protect these sensitive ecosystems. The proposed project must abide by the relevant legislative requirements. Table 2 below shows an outline of the environmental legislation relevant to the project.

Table 2: Relevant environmental legislation

Legislation	Relevance
South African Constitution 108 of 1996	The constitution includes the right to have the environment protected
National Environmental Management Act 107 of 1998	Outlines principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state. Chapter 1(4r) states that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. Section 24 of NEMA requires that the potential impact on the environment, socio-economic conditions and cultural heritage of activities that require authorisation, must be investigated and assessed prior to implementation, and reported to the authority.
Environmental Impact Assessment (EIA) Regulations	The 2014 regulations have been promulgated in terms of Chapter 5 of NEMA and were amended on 7 April 2017 in Government Notice No. R. 326. In addition, listing notices (GN 324-327) lists activities which are subject to an environmental assessment.
The National Water Act 36 of 1998	The proposed project requires water use authorisation in terms of Chapter 4 and Section 21 of the National Water Act No. 36 of 1998, and this must be secured prior to the commencement of activities. Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water.
Conservation of Agricultural Resources Act (Act 43 of 1983)	The Conservation of Agricultural Resources Act (CARA) is to provide for the conservation of the natural agricultural resources by the maintenance of production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants.
National Environmental Management: Biodiversity Act No. 10 of 2004	This is to provide for the management and conservation of South Africa's biodiversity through the protection of species and ecosystems; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits.

4 TERMS OF REFERENCE

- Contextualization of the study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information (including but not limited to the South African Inventory of Inland Aquatic Ecosystems (SAIIAE), vegetation, CBAs, Threatened ecosystems, any Red data book information, NFEPA data, broader catchment drainage and protected areas).
- Desktop delineation and illustration of all watercourses within and surrounding the study area utilising available site-specific data such as aerial photography, contour data and water resource data.
- Prepare a map demarcating the respective watercourses or wetland/s, within the study area. This will demonstrate, from a holistic point of view the connectivity between the site and the surrounding regions, i.e. the hydrological zone of influence while classifying the hydrogeomorphic type of the respective water courses / wetlands in relation to present land-use and their current state. The maps depicting demarcated waterbodies will be delineated to a scale of 1:10 000, following the methodology described by the DWS.
- A risk/screening assessment of the identified aquatic ecosystems to determine which ones will be impacted upon and therefore require ground truthing and detailed assessment.
- Ground truthing, identification, delineation and mapping of the aquatic ecosystems in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*.
- Classification of the identified aquatic ecosystems in accordance with the, 'National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al.* 2013) and WET-Ecoservices (Kotze et al. 2009).
- Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland and riparian habitats.
- Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project. Impacts are described in terms of their extent, intensity, and duration. The other aspects that must be included in the evaluation are probability, reversibility, irreplaceability, mitigation potential, and confidence in the evaluation.
- All direct, indirect, and cumulative impacts for each alternative will be rated with and without mitigation to determine the significance of the impacts.
- Recommend actions that should be taken to avoid impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas or ecological processes.
- Rehabilitation guidelines for disturbed areas associated with the proposed project and monitoring.

5 APPROACH AND METHODS

This study followed the approaches of several national guidelines with regards to wetland/ riparian assessment. See Appendix 1. The following approach to the aquatic habitat assessment is undertaken:

5.1 DESKTOP ASSESSMENT METHODS

The contextualization of the study area was undertaken in terms of important biophysical characteristics and the latest available aquatic conservation planning information (i.e. existing data for coastal management lines, NFEPA identified rivers and wetlands, critical biodiversity areas (WBSP 2017), estuaries, vegetation units, ecosystem threat status, catchment boundaries, geology, land uses, etc.) in a Geographical Information System (GIS). A South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was established during the National Biodiversity Assessment of 2018 (Van Deventer *et al.* 2018). The SAIIAE offers a collection of data layers pertaining to ecosystem types and pressures for both rivers and inland wetlands. National Wetland Map 5 includes inland wetlands and estuaries, associated with river line data and many other data sets within the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) 2018. It is imperative to develop an understanding of the regional drainage setting and longitudinal dynamics of the watercourses and the coastal dynamic. The conservation planning information aids in the determination of the level of importance and sensitivity, management objectives, and the significance of potential impacts.

Following this, desktop delineation and illustration of all watercourses within the study area was undertaken utilising available site-specific data such as aerial photography, contour data and water resource data. Digitization and mapping were undertaken using QGIS 3.28 GIS software. These results, as well as professional experience, allowed for the identification of sensitive habitat that could potentially be impacted by the project and therefore required ground truthing and detailed assessment.

5.2 BASELINE ASSESSMENT METHODS

A site assessment was conducted on the 26th of March 2024 to confirm desktop findings, gather additional information, and define the boundaries of the aquatic habitat. General observations were made with regards to the vegetation, fauna and current impacts. The identified aquatic ecosystems were classified in accordance with the '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009). Information generated from a previous assessment for development of the neighbouring farm portion in 2017 was also utilised.

Infield delineation was undertaken with a hand-held GPS for mapping of any potentially affected aquatic ecosystems, in alignment with standard field-based procedures in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and*

Delineation of Wetlands and Riparian Areas. The delineation is based upon observations of the landscape setting, topography, vegetation and soil characteristics.

Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats was undertaken utilising:

- Qualitative Index of Habitat Integrity (IHI) tool adapted from Kleynhans, 1996 – PES
- DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS

Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland habitat was undertaken utilising:

- The health/condition or Present Ecological State (PES) of the wetland was assessed using the Level 2 WET-Health assessment tool Version 2 (Macfarlane *et al.* 2020), which is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of wetland vegetation.
- The WET-Ecoservices tool (Kotze et al., 2020) is utilised to assess the goods and services that the individual wetlands under assessment provide, thereby aiding informed planning and decision-making. Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).

5.3 IMPACT ASSESSMENT METHODS

The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance is determined. Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring. Unknown parameters are given the highest score as significance scoring follows the Precautionary Principle. The methodology to determine the significance ratings of the potential environmental impacts and risks associated with the alternatives was provided by Sharples Environmental Services cc as well as the impact table template for completion by the specialist.

Cumulative impacts affect the significance ranking of an impact because the impact is taken in consideration of both onsite and offsite sources. For example, pollution making its way into a river from a development may be within acceptable national standards. Activities in the surrounding area may also create pollution which does not exceed these standards. However, if both onsite and offsite pollution activities take place simultaneously, the total pollution level may exceed the standards. For this reason, it is important to consider impacts in terms of their cumulative nature.

5.4 Mitigation and Monitoring

Actions are thereafter recommended to prevent and mitigate the identified impacts on aquatic habitat, in alignment with the mitigation hierarchy, as well as any measures necessary to restore disturbed areas or ecological processes. No-Go Areas will be determined, and any necessary monitoring protocol will be developed.

6 ASSUMPTIONS AND LIMITATIONS

Within the realm of EIA specialist assessments, there are often assumptions and limitations, which can influence the determination of specialist outcomes. Sometimes these can result in the project being fatally flawed, however frequently these are simply gaps of knowledge that will not have a significant impact on the findings of the specialist report. Therefore, specialists proceed and list the known assumptions and limitations associated with the project, such as these outlined below:

- Aquatic ecosystems vary both temporally and spatially. Once-off surveys such as this can miss certain ecological information due to seasonality, thus limiting accuracy and confidence.
- Layouts and designs were provided by the client.
- While disturbance and transformation of habitats can lead to shifts in the type and extent of aquatic ecosystems, it is important to note that the current extent is reported on here.
- All soil/vegetation/terrain sampling points were recorded using a Garmin Montana Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- Conditions on the day were clear and sunny, and no significant rainfall had been recently recorded in the area. The full extent of the site was walked, and a detailed inspection of the wetland near the outlet structure was undertaken. Access to the Gwaing River was across difficult terrain in terms of gradient and dense vegetation, however the riparian zone was sufficiently delineated beyond the river channel.
- Infield soil and vegetation sampling was only undertaken within a specific focal area around the proposed activities, while the remaining watercourses were delineated at a desktop level with limited accuracy.
- No detailed assessment of aquatic fauna/biota (e.g. fish, invertebrates, microphytes, etc.) was undertaken, and not deemed necessary.
- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or indicator wetland/riparian species.
- The scope of work did not include water quality sampling and the water quality characteristics were inferred from data provided.
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar projects. The degree of confidence is considered high.

7 DESKTOP ASSESSMENT OF THE STUDY AREA

The desktop/ screening study was informed by the available datasets relevant to water resources, as well as historic and the latest aerial imagery, to develop an understanding of the fluvial processes of the study area. A significant amount of the latest spatial data has been provided through the products of the 2018 National Biodiversity Assessment (NBA). The NBA is the primary tool for monitoring and reporting on the state of biodiversity in South Africa. It is used to inform policies, strategies and actions in a range of sectors for managing and conserving biodiversity more effectively. The desktop study was followed by the detailed site assessment. The general biophysical characteristics of the study area are described below.

7.1 CLIMATE

George experiences a temperate oceanic climate, classified as Cfb under the Köppen-Geiger climate classification. This type of climate is characterised by mild temperatures and evenly distributed precipitation throughout the year. The average annual temperature in George is approximately 16.5°C. During the summer months, from December to February, the weather is warm, with average daytime temperatures ranging from 20°C to 25°C. Winters, from June to August, are mild, with average temperatures ranging from 10°C to 18°C.

George receives an average annual rainfall of about 700 to 900 mm, making it one of the wetter areas in the Western Cape. Rainfall is relatively evenly distributed throughout the year, with a slight peak during the autumn and spring months. This level of precipitation is significantly higher than the national average for South Africa, which is about 450 mm per year. Consequently, George has more consistent water availability. The evaporation rate is lower than in many other parts of South Africa due to its mild temperatures and higher humidity levels. This helps to retain more of the precipitation, further contributing to the area's relatively abundant water resources compared to other regions in the country.

The study area is primarily drained through surface runoff, with stormwater flowing westward towards the Gwaing River. The natural drainage patterns across the site have been modified due to previous construction activities. It is located on the raised coastal platform which, at the coast, rises steeply from sea level to elevations > 100 m. The rivers are deeply incised into this coastal platform, their catchment areas being relatively small.

7.2 GEOLOGY AND SOILS

According to the geology map 3322 CD George, the study area is underlain by Gneissic Granite from the Maalgaten Formation, part of the George Pluton. This geological formation consists of high-grade metamorphic rocks that are known for their hardness and durability. Such rocks typically produce soils with low permeability due to their dense and compact nature.

According to the geotechnical report undertaken by Terra Geotechnical (2024), groundwater seepage was observed in three test pits across the site. This seepage is classified as a perched groundwater table, characterised by slow to moderate flow. It is primarily found within the fill material, pedogenic horizon, and upper transported soils. A perched groundwater table occurs when an impermeable layer, such as a dense granite layer or clay-rich horizon, prevents water from moving deeper into the aquifer. Instead, the water flows laterally through the overlying soil layers. This type of geology often results in shallow groundwater that can contribute to surface runoff and localised wetness.

The site also shows that all exposed soil horizons generally maintain slightly moist to moist conditions. Ferricrete nodules, indicative of pedogenic processes, were detected at various shallow depths across the site. These nodules suggest fluctuating water tables or soil moisture evaporation. The natural soils in the area are also noted to be moist in their undisturbed state, reflecting the consistent moisture retention in these geological conditions. Overall, the on-site soils, influenced by the underlying granite, exhibit low permeability, and the variability in bedrock depth suggests that the perched water table could be encountered at varying depths throughout the site.

7.3 VEGETATION

The national vegetation map (SANBI 2018 VEGMAP) shows the site of the Gwaing WWTW as located within the Garden Route Granite Fynbos vegetation unit. According to Mucina and Rutherford (2006), this unit is characterised by a unique assemblage of plant species and ecological features associated with the underlying granite geology of the Garden Route region. The Garden Route Granite Fynbos is classified as Critically Endangered B1(i) due to various threats including habitat loss due to development, invasive species, and climate change. The vegetation type is narrowly distributed with high rates of habitat transformation.

The upgrades are being undertaken within the same boundaries as the existing WWTW which has already been transformed from the natural vegetation. The surrounding hillslopes and valleys contain some indigenous vegetation but are largely infested with alien invasive plant species such as Bugweed and Black Wattle.

7.4 DRAINAGE NETWORK

The site is located within the DWS Quaternary Catchment K30B and falls within the Gouritz Coastal Water Management Area (Figure 6). The Gwaing River is the major river system in the catchment with tributaries such as the Malgas and Camfersdrift Rivers. The site falls within the Southern Coastal Belt Ecoregion which is described by Kleynhans et al. (2005) as an area of hills and mountains with moderate to high relief and surrounding plains. The area is characterised by gently undulating topography on the coastal plateau between the Outeniqua Mountains and the ocean. According to the Freshwater Biodiversity Information System

(FBIS), the reach of the Gwaing River near the site is situated in the perennial, Upper Foothills geomorphological zone of the river profile (DWAF, 2006).

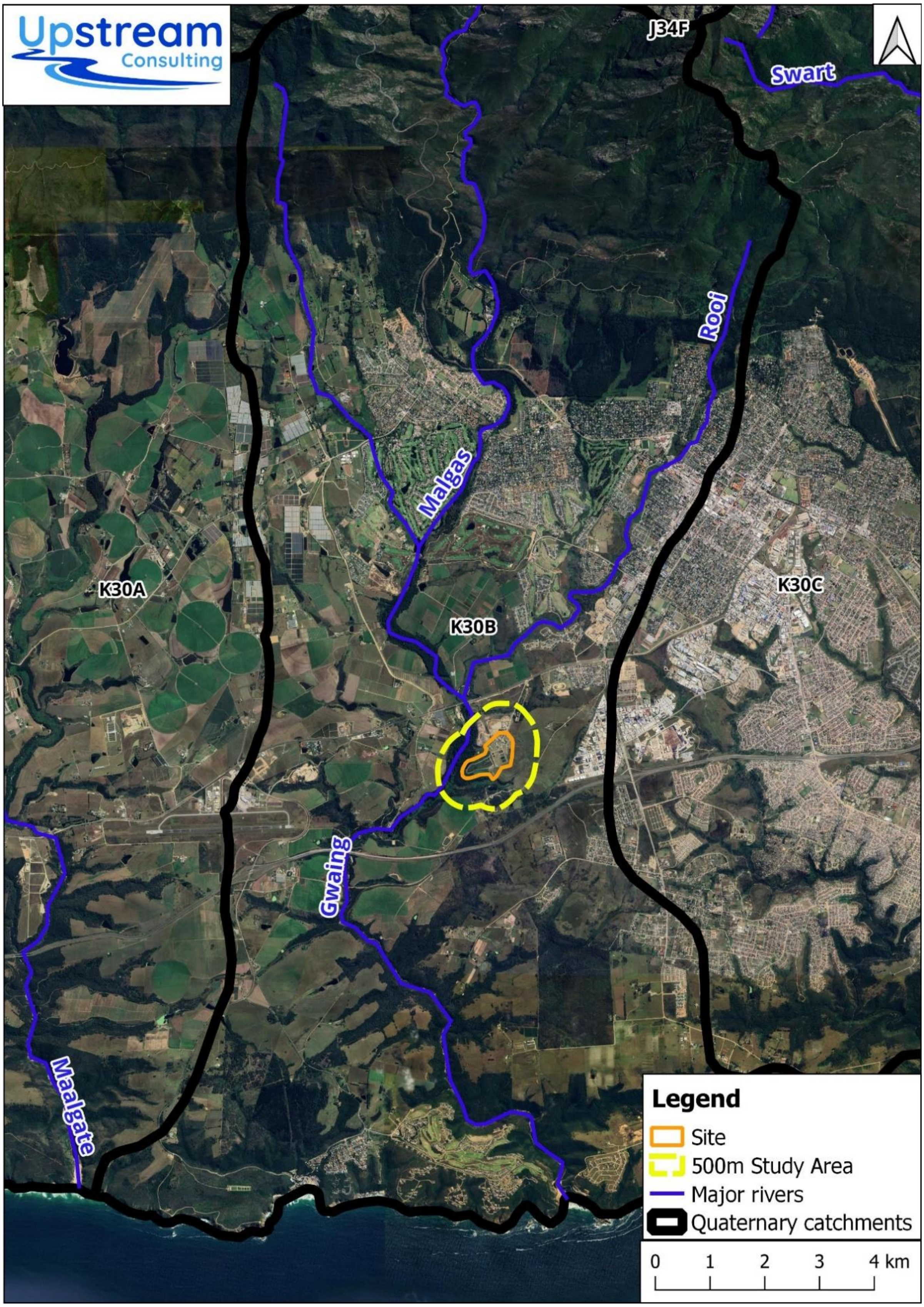

Figure 6: Map of the site in relation to the Gwaing River in quaternary catchment K30B

7.5 Strategic Water Source Areas

The study area falls within the Outeniqua Strategic Water Source Area for surface water (Le Maitre *et al.* 2018). Refer to Figure 7. A Strategic Water Source Areas (SWSA) is where the water that is supplied is considered to be of national importance for water security. Surface water SWSAs are found in areas with high rainfall and produce most of the runoff. Groundwater SWSAs have high groundwater recharge and are located where the groundwater forms a nationally important resource. There are 22 national-level SWSAs for surface water (SWSA-sw) and 37 for groundwater (SWSA-gw). The SWSA-sw in South Africa, Lesotho and Swaziland occupy 10% of the land area and generate 50% of the mean annual runoff. They support at least 60% of the population, 70% of the national economic activity, and provide about 70% of the water used for irrigation.

Treated effluent discharge into Strategic Water Source Areas (SWSAs) has several significant impacts. The effluent often contains elevated levels of nutrients like nitrogen and phosphorus, which can lead to eutrophication. This process causes harmful algal blooms, reduced oxygen levels, and disruptions in aquatic ecosystems, affecting the water quality. Additionally, treated effluent may introduce chemical contaminants such as pharmaceuticals, heavy metals, and industrial pollutants. These substances can accumulate in water and sediments, posing risks to aquatic life and potentially entering the human food chain.

Changes in water quality due to effluent discharge can alter aquatic habitats, making them less suitable for locally indigenous species. This can lead to a decline in sensitive species and an increase in tolerant or invasive species, reducing biodiversity and altering ecosystem dynamics. Many SWSAs host endemic and sensitive species that are adapted to specific water conditions. The introduction of contaminants and changes in nutrient levels can negatively impact these, potentially causing population declines or local extinctions.

The discharge of treated effluent can compromise water quality in SWSAs, reducing the availability of clean water, which is especially concerning in regions already facing water scarcity. Moreover, the additional stress from effluent discharge exacerbates the challenges posed by climate change, such as altered precipitation patterns and increased evaporation rates, making water resources even more precarious.

Addressing these challenges requires a combination of advanced treatment technologies, stricter regulations, pollution prevention strategies, and public engagement. Protecting SWSAs is crucial for ensuring the long-term sustainability and resilience of South Africa's water resources.

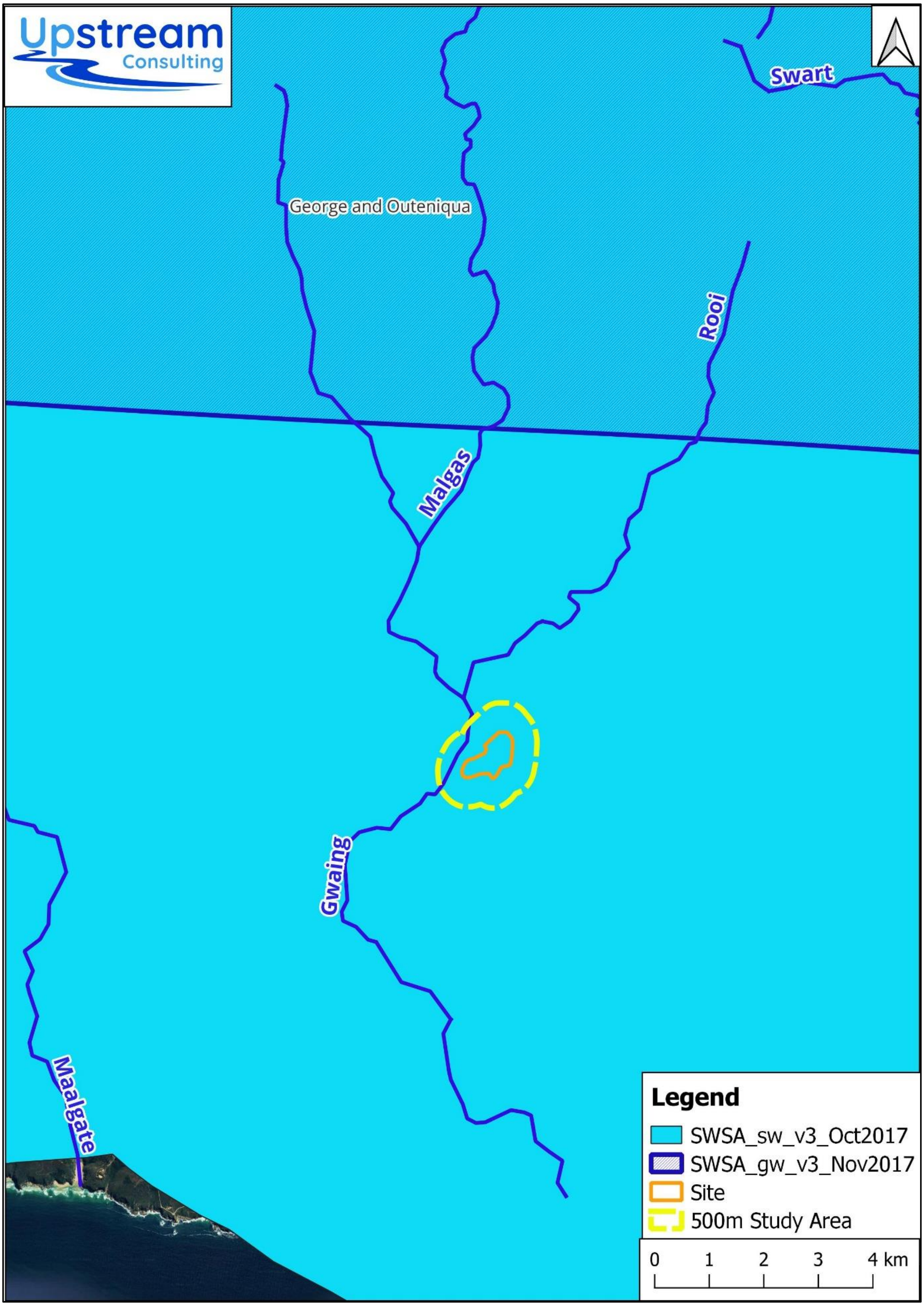

Figure 7: Map of the site in relation to SWSAs

7.6 South African Inventory of Inland Aquatic Ecosystems

A significant amount of the latest spatial data has been provided through the products of the 2018 National Biodiversity Assessment (NBA). The NBA is the primary tool for monitoring and reporting on the state of biodiversity in South Africa. It is used to inform policies, strategies and actions in a range of sectors for managing and conserving biodiversity more effectively. A South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was established during the 2018 National Biodiversity Assessment (Van Deventer et al. 2018). The SAIIAE offers a collection of data layers pertaining to ecosystem types and pressures for both rivers and inland wetlands.

7.6.1 River data

The NBA 2018 Rivers Map is a GIS layer which summarises the river condition, river ecosystem types, flagship and free-flowing river information (Van Deventer *et al.* 2019). The river lines data set is associated with the National Wetland Map 5 (NWM5) issued with the SAIIAE. The GIS layer of origin is the 1:500 000 rivers data layer that DWAF coded for geomorphological zonation, with added data from the Chief Directorate Surveys and Mapping's (CDSM) 1:50 000 rivers GIS layer, and information generated during the NFEPA project in 2011.

The NBA 2018 Rivers data only identifies the perennial Gwaing River. Refer to Figure 8. However, the 1:50 000 cadastral NGI river line data show an additional five non-perennial drainage lines within the 500m radius study area. The nation river inventory shows that the Gwaing River was classed within the 'C' PES category (Moderately Modified) in the 1999 determinations, however, it has deteriorated in health and the 2018 NBA classes the river in the 'D' PES category as it is Largely Modified from the natural reference state. The NBA 2018 data also indicates that this river type is Critically Endangered and Poorly Protected.

7.6.2 Wetland data

The National Wetland Map 5 (NWM5) includes inland wetlands and estuaries, associated with river line data and many other data sets. The Gwaing River, and two watercourses (one north and another south of the WWTW), are mapped as channelled valley bottom wetland habitat by the NWM5. Refer to Figure 8. It is shown to be in a poor present ecological state. The wetland falls within the Eastern Fynbos-Renosterveld Bioregion (Valley-bottom). This wetland type is listed as poorly protection and critically endangered.

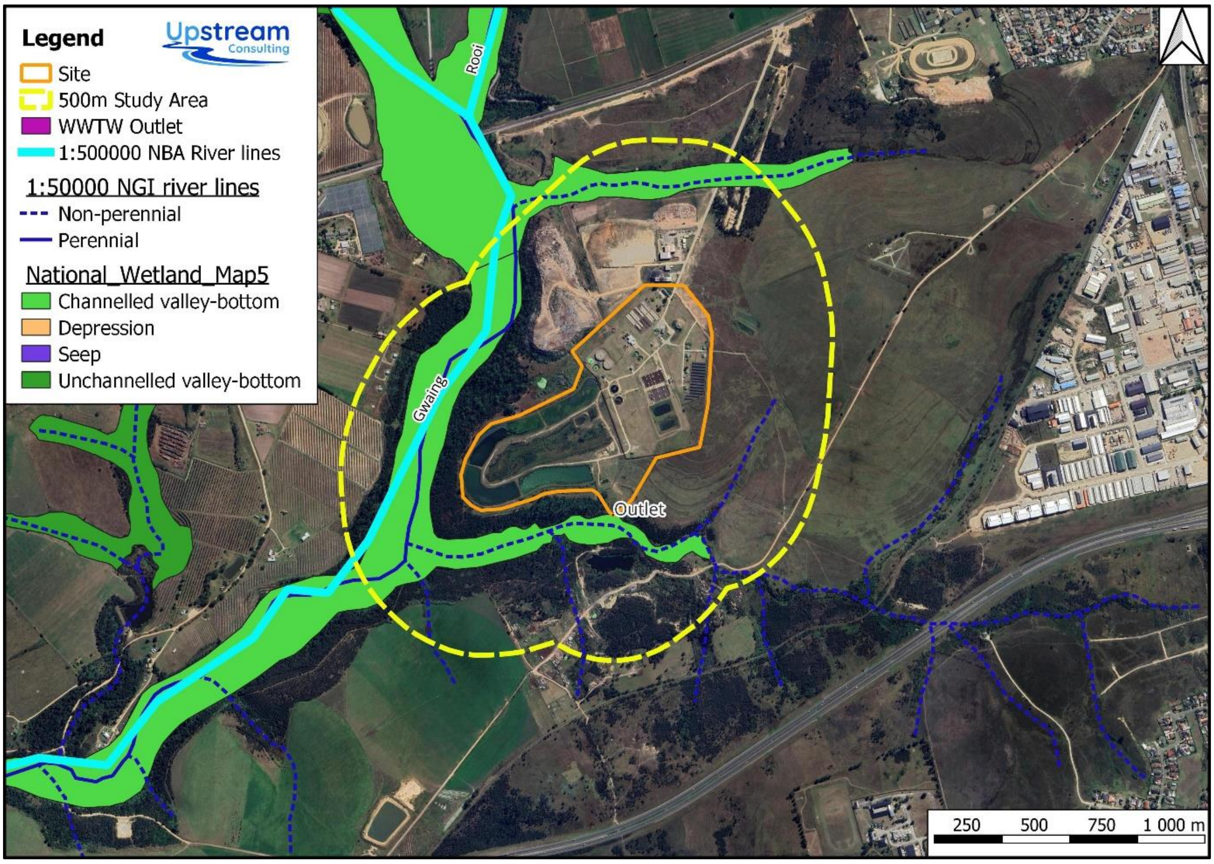

Figure 8: The project site in relation to the national river and wetland inventories (CSIR, 2018)

7.7 CONSERVATION CONTEXT

The Western Cape Biodiversity Spatial Plan (WCBSP) identifies biodiversity priority areas, Critical Biodiversity Areas, Ecological Support Areas (ESAs) and Other Natural Areas (ONA), which, together with Protected Areas (PA), are important for the persistence of a viable representative sample of all ecosystem types and species, as well as the long-term ecological functioning of the landscape as a whole. The primary purpose of a map of CBAs and ESAs is to guide decision-making about where best to locate development. CBA's are required to meet biodiversity targets. According to the WCBSP, these areas have high biodiversity and ecological value and therefore must be kept in a natural state without further loss of habitat or species.

Figure 9 shows that the site is not located upon any biodiversity priority areas, CBA nor ESAs. However, the watercourse downslope of the WWTW outlet structure is classified as CBA 1 wetland habitat, as is the Gwaing River downstream.

No endemic or conservation worthy aquatic species (Listed or Protected) were observed within the site, but the wetland habitats downslope may contain such species. Although, due to the highly modified condition of the area, it is likely that the majority of the aquatic species are disturbance tolerant.

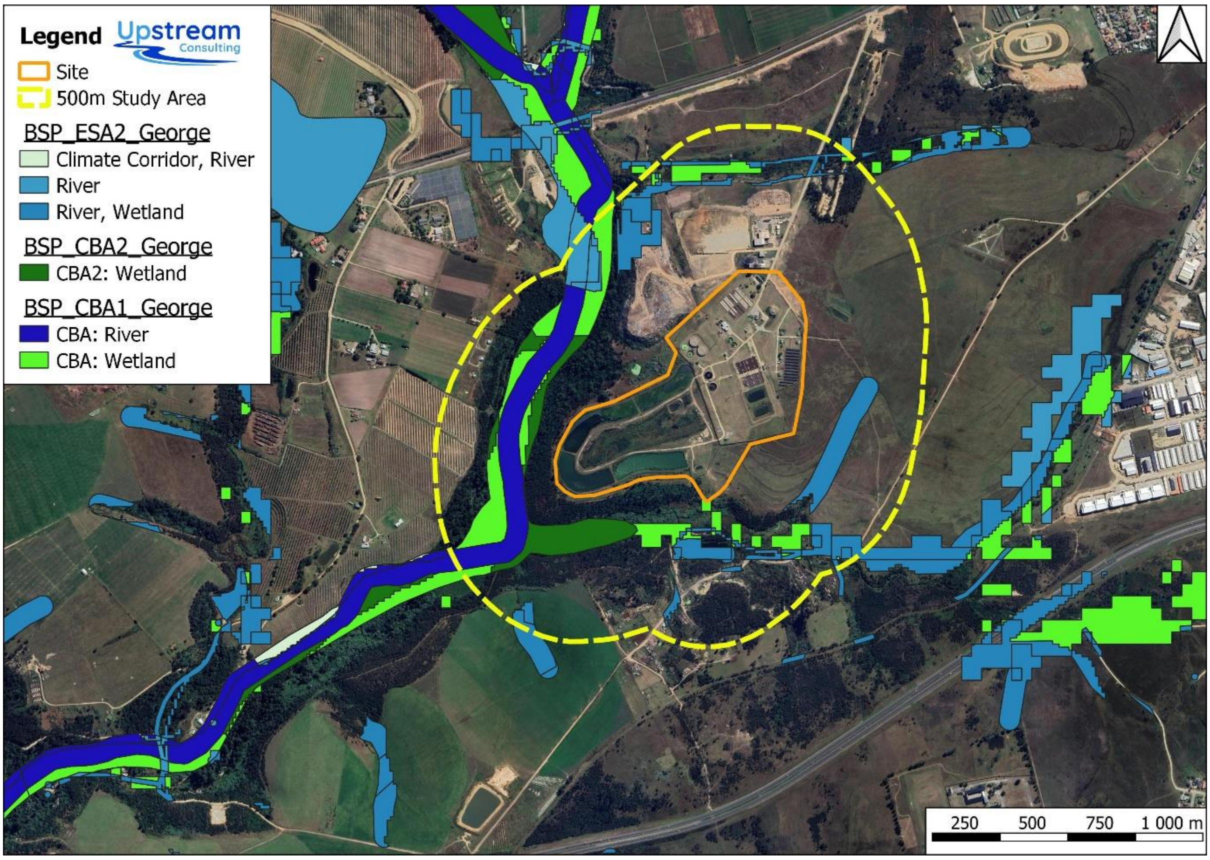

Figure 9: Map of the site in relation to aquatic biodiversity priority areas identified in the WCBSP (2017)

BSP 2017 Reasons

Summary 1:	Critically Endangered Vegetation Variant (0.29), Threatened SA Vegetation Type (0.3), Threatened Vertebrate (8.1), Water resource protection (4.83)
Feature 1:	Bontebok Extended Distribution Range
Feature 2:	Garden Route Granite Fynbos (CR)
Feature 3:	Watercourse protection- Southern Coastal Belt
Feature 4:	Wolwedans Grassy Fynbos (Vlok variant- CR)

According to the National Freshwater Ecosystem Priority Atlas (NFEPA; Nel *et al*., 2011) the sub-quaternary is classified as a Fish Support Area. This is defined as:

"Fish sanctuaries are sub-quaternary catchments that are required to meet biodiversity targets for threatened and near threatened fish species indigenous to South Africa. Fish sanctuaries in sub-quaternary catchments associated with a river reach in good condition (A or B ecological category) were selected as FEPAs; the remaining fish sanctuaries became fish support areas. Fish support areas also include sub-quaternary catchments that are important for migration of threatened and near threatened fish species. River reaches in fish support areas need to be maintained in a condition that supports the associated populations of threatened fish species which need not necessarily be an A or B ecological category."

Fish species of conservation significance that are meant to occur in the Gwaing River are *Sandelia capensis*, *Galaxias zebratus, and Pseudobarbus afer*. The river is also home to the Longfin Eel (Anguilla mossambica), a migratory and near-threatened species. These eels spawn in the ocean but mature in freshwater systems, meaning they need access to both habitats. Consequently, the Gwaing River serves as a crucial migratory route for A. mossambica and other fish species. For the fish indicated to survive and reproduce successfully good water quality which includes high clarity and low nutrients is important.

Downstream habitat of significant ecological importance includes the estuary at the river mouth. The Gwaing River estuary is defined in the 2018 National Biodiversity Assessment (SANBI, 2019) as a small, temporarily closed estuarine system located within the warm temperate biogeographic region on the southern Cape coastline. The size of the estuary, as defined by the estuarine functional zone (EFZ), is approximately 10.6 ha, extending over a length of approximately 1.4 km. Although the Gwaing WWTW is located upstream, there is potential for impacts to affect the estuary. The 2019 Gwaing River Estuary Management Plan specifically states that an issue that requires attention is the water quality impacts from the WWTW as well as agricultural run-off.

7.8 Historic Context

Almost half (49.5%) of the George LM has been transformed, of which 22.9% is under intensive agriculture and 14.2% consists of plantations. The site and surrounding even have been subjected to land use cover changes for many decades. There is no natural habitat remaining at the WWTW. Google satellite imagery shows that the WWTW was in operation prior to the construction of the adjacent landfill site. The drainage lines surrounding the site have been disturbed by agricultural practices and road infrastructure. Historic imagery also shows the increasing infestation of alien invasive tree species over the past decade.

In the recent past, poor stormwater management from the WWTW resulted in gully erosion, referred to as a ‘donga’ in the engineering report, from the chlorine contact tank to the southern valley bottom near the outlet structure. Refer to Figure 10. This area has since been under rehabilitation to stabilise the slope and prevent future erosion.

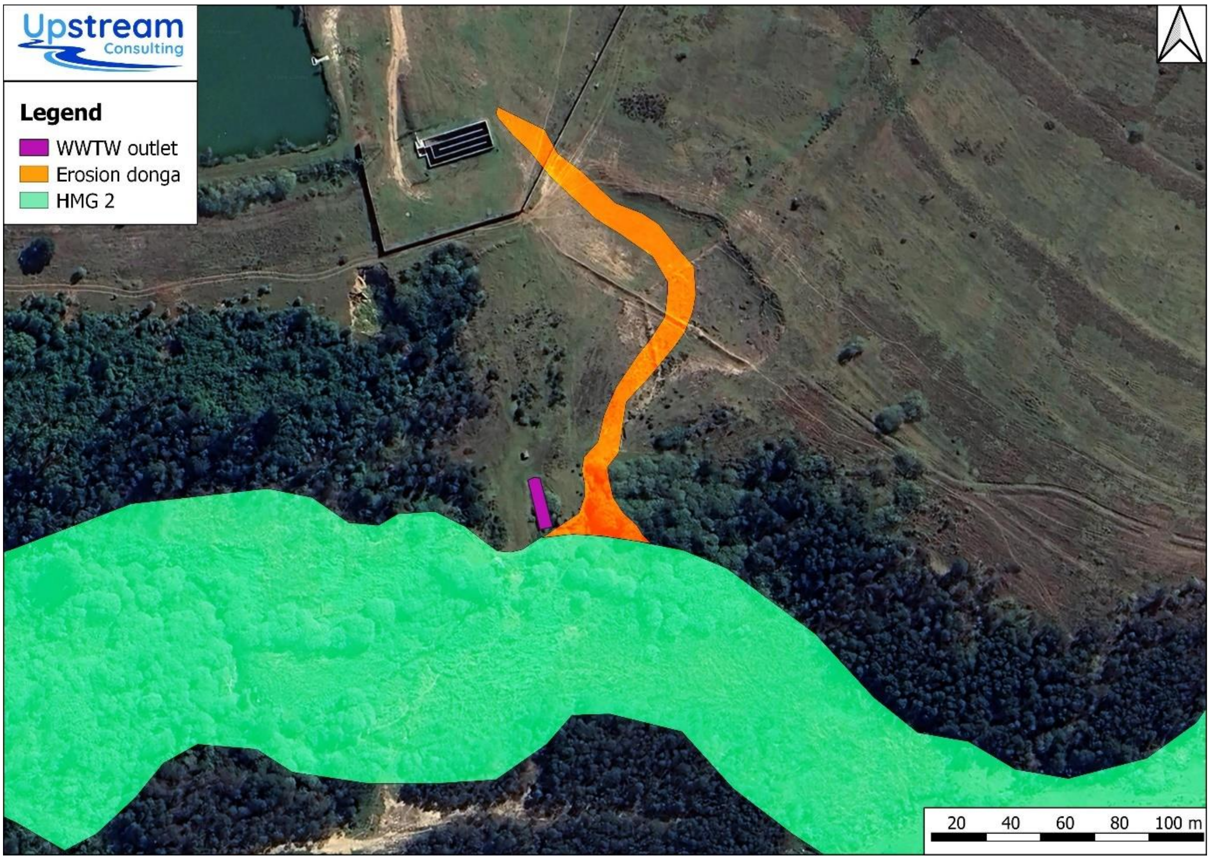

Figure 10: Map of the repaired erosion donga by the CC tank of the WWTW

8 RESULTS

The aquatic habitats within a 500 metre radius of the proposed development were identified and mapped on a desktop level utilising available data. In order to identify the wetland/river types, using Kotze *et al.* (2009) and Ollis *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. Following the desktop findings, the infield site assessment (conducted on the 26th of March 2024) confirmed the location and extent of these systems. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project. The findings are detailed in this section below.

8.1 DELINEATION AND CLASSIFICATION

Following the contextualisation of the study area with the available desktop data, a site visit was conducted to ground truth the findings and delineate the aquatic habitat and map it within the 500m radius of the development area. The additional information collected in the field allowed for the development of an improved baseline aquatic habitat delineation map (Figure 10).

Five (5) watercourses were identified and mapped within a 500m radius of the proposed development. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project and required further assessment. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the project and position the system is located in the landscape.

Due to the topography of the site resulting in surface runoff in a south westerly direction, and location of the WWTW outlet, it was determined that only the southern watercourse (mapped as HGM 2) has potential to be directly impacted by the upgrades (Figure 11). However, there is also potential for the downstream section of the Gwaing River (mapped as HGM 1) to be indirectly impacted by the project. The other watercourses identified within the 500m radius of the site are unlikely to be impacted by any of the proposed activities and were therefore not assessed further.

The affected watercourses were classified by hydrogeomorphic (HGM) type, using Kotze *et al*. (2009; 2020), Grenfell *et al.* (2019), and Ollis *et al.* (2013). It was determined that the unnamed watercourse south of the WWTW outlet (referred to as HGM 2), can be classified as a channelled valley bottom wetland. And although the Gwaing River would have supported vast wetland habitat in its natural state, it has been significantly modified from the reference condition, and is presently typical of a riparian ecosystem.

Figure 10 shows the watercourses in relation to the Gwaing WWTW and the 500m radius study area. Figure 11 shows the HGM 2 wetland impacted by the discharge of effluent from the WWTW, and the location of outlet structure requiring upgrading relative to the wetland boundary.

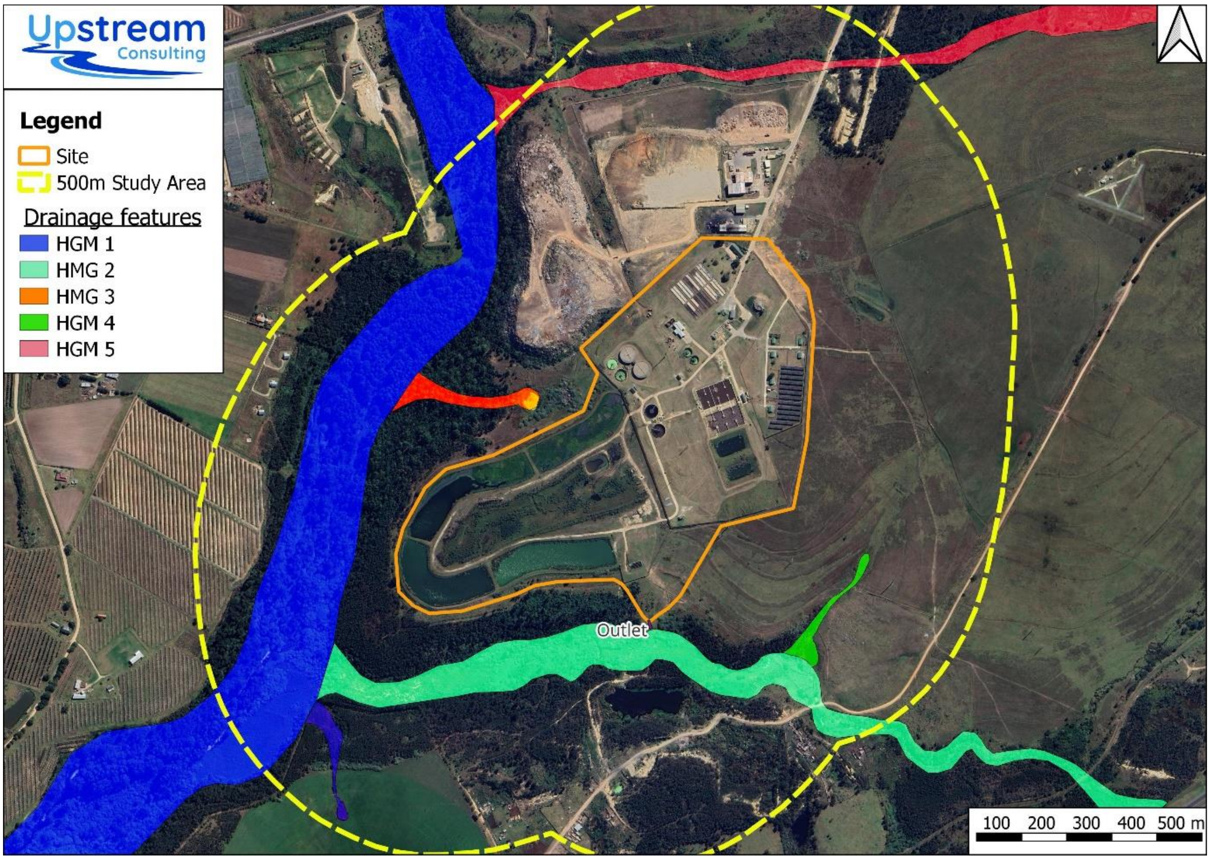

Figure 11: Map of the aquatic habitat identified within the 500m radius study area

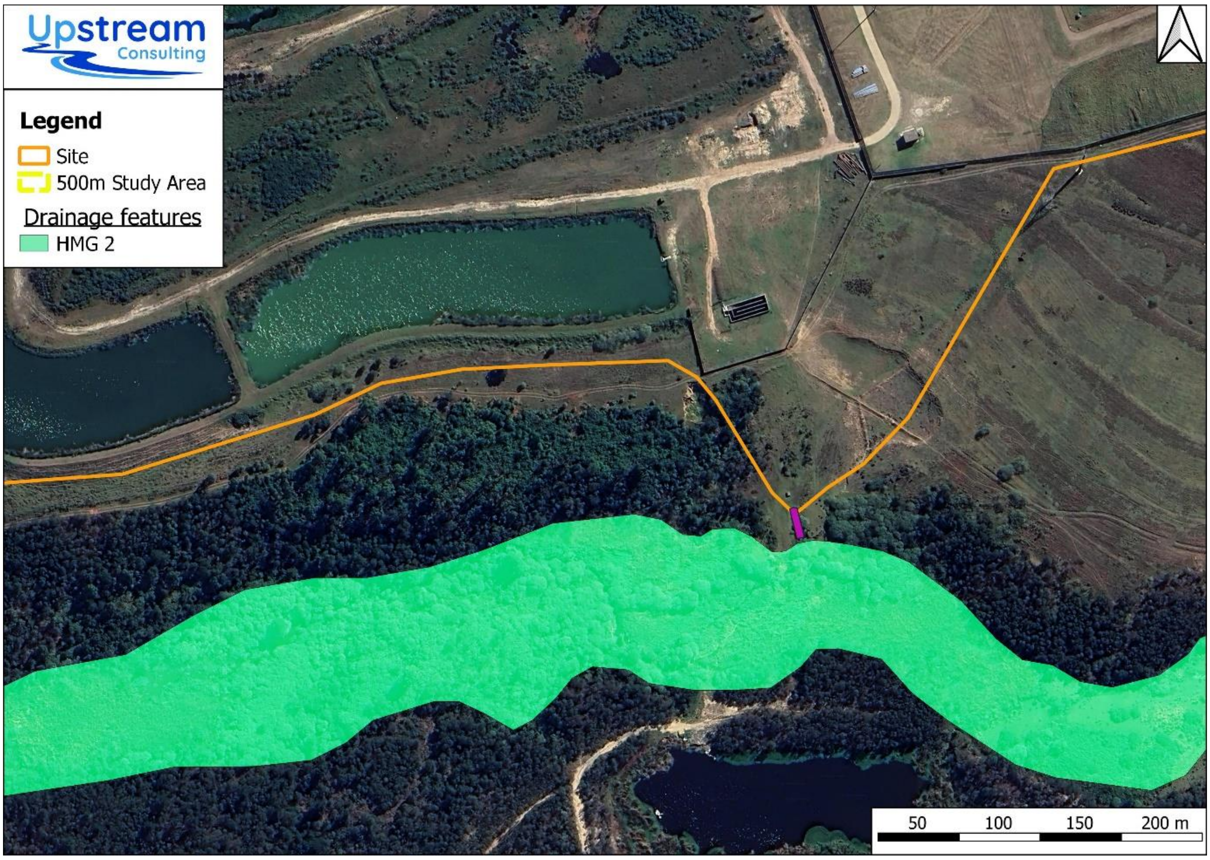

Figure 12: Map of the HGM 2 wetland downslope of the Gwaing WWTW discharge outlet structure

8.2 DESCRIPTION OF AFFECTED AQUATIC HABITAT

8.2.1 HGM 1 – Gwaing River

The Gwaing River originates in the Outeniqua Mountains and flows southwest towards the Indian Ocean, covering an approximate length of 20 km. The study area is within the upper foothills geomorphic reach and has a perennial flow regime. There is some remaining channelled valley wetland habitat remaining, but the channel has become incised, and alien invasive plants have encroached into the riparian area (such as very large Eucalyptus sp., black wattle and bugweed trees).

The water quality of the Gwaing River is influenced by a variety of natural and anthropogenic factors. As a vital freshwater resource, its quality has direct implications for the health of local ecosystems and agricultural productivity. The water quality is subject to various pressures from both natural and human activities. The poor water quality of the river is discussed in the following sections.

The river reach assessed falls within the 'D' ecological category for present ecological state (PES) as it is in a Largely Modified condition, but it has a High ecological importance and sensitivity (EIS). The Gwaing River is of significant ecological importance due to its role in sustaining biodiversity and providing ecosystem services. It serves as a critical water source for both the natural environment and human use, supporting agriculture, recreation, and urban water supply. Despite its ecological value, the Gwaing River faces several threats, including pollution from agricultural runoff, urban development, and invasive alien plant species. Climate change poses additional challenges, potentially altering the river's flow patterns and impacting its ecosystems.

Approximately 12km downstream of the study area the river enters the Gwaing River Estuary at its mouth. The estuary is a small temporarily closed estuary that lies within a steep valley incised into the coastal plain and is about 1.4 km long. According to the Gwaing River Estuary Management Plan (2019), the Mean Annual Runoff (MAR) to the estuary has been slightly reduced by 8% to 35.09 x 106 m3 from its natural state and nutrient enrichment from golf courses, agriculture, and sewage spills is expected.

8.2.2 HGM 2 – Unnamed channelled valley bottom wetland

The HGM 2 wetland occupies the valley south of the Gwaing WWTW. Water flows through an incised channel in a westerly direction to the Gwaing River. The upper reaches are severely degraded and have little remaining habitat. The downstream habitat is disturbed but intact. The seasonal and temporary zones have been subjected to soil disturbance and vegetation clearance for grazing, resulting in alien invasive plant encroachment, such as kikuyu grass and bugweed trees. However, the permanent zone is robustly vegetated with indigenous reeds (dense *Phragmites australis* beds) and retains a high level of ecological functioning. Other indigenous wetland plant species identified on site were *Zantedeschia aethiopica, Typha capensis, Cliffortia odorata, Cyperus textillis,* and *Juncus effusus.*

The significant habitat loss in the upper reaches, and alien invasive plant infestation throughout the system, results in an overall 'D' (poor) Present Ecological State (PES) score (Table 3). It is recommended that the management objective for the wetland be to improve the system though alien plant removal and reducing contaminants from surrounding land uses.

The wetland supplies important regulatory and supporting ecosystem services such as stream flow regulation, pollutant assimilation and the provision of water (Table 3). However, towards the eastern portion the wetland becomes increasingly degraded and ultimately transformed. Additionally, the water is severely contaminated by urban and agricultural activities. Therefore, while there are portions of HGM2 of high ecological value, such as at the confluence with the Gwaing River, the upper reach of the wetland is critically modified (Figure 12).

Plate 1: Photograph of the reach of HGM 2 wetland nearest to the Gwaing WWTW

Plate 2: Photograph of the outlet structure discharging effluent into a channel towards the wetland

Table 3: WET -EcoServices assessment summary

ECOSYSTEM SERVICE		Present State: Supply	Present State: Demand	Present State: Importance Score	Present State: Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1,5	1,5	0,7	Very Low
	Stream flow regulation	2,5	4,0	3,5	Very High
	Sediment trapping	2,4	2,0	1,9	Moderate
	Erosion control	2,3	2,1	1,8	Moderate
	Phosphate assimilation	2,5	4,0	3,0	High
	Nitrate assimilation	2,4	4,0	2,9	High
	Toxicant assimilation	2,9	4,0	3,4	Very High
	Carbon storage	3,3	2,7	3,2	High
	Biodiversity maintenance	2,3	4,0	2,8	High
PROVISIONING SERVICES	Water for human use	3,0	4,0	3,5	Very High
	Harvestable resources	2,5	0,3	1,2	Low
	Food for livestock	1,5	2,0	1,0	Low
	Cultivated foods	2,1	0,0	0,6	Very Low
CULTURAL SERVICES	Tourism and Recreation	0,1	0,0	0,0	Very Low
	Education and Research	0,3	0,0	0,0	Very Low
	Cultural and Spiritual	0,0	0,0	0,0	Very Low

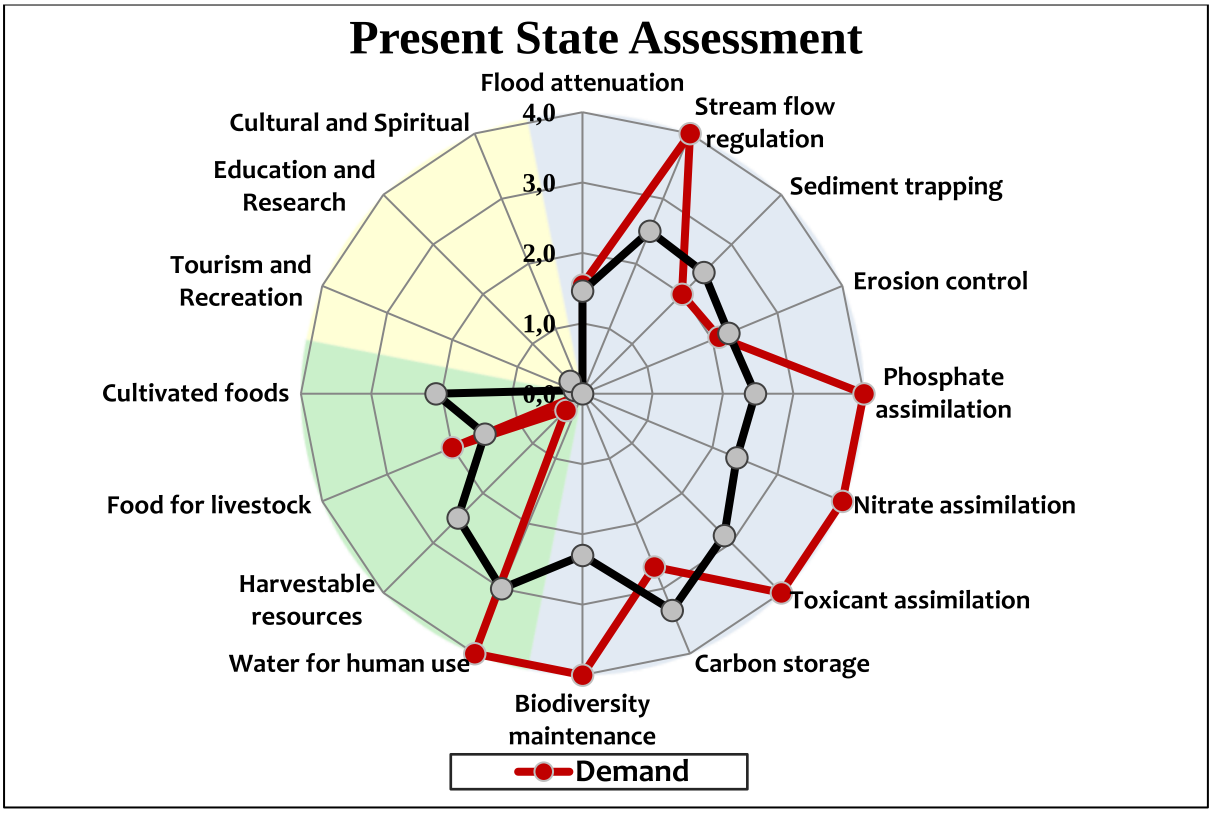

Figure 13: Spider diagram summarising the Ecosystem Service Scores

8.3 AQUATIC BUFFER ZONES

An aquatic impact buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels (Macfarlane and Bredin, 2016). Aquatic buffer zones are designed to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions and have therefore been adopted as a standard measure to protect water resources and associated biodiversity.

However, for this project, aquatic buffer zones are not applicable. The upgrades are confined to existing infrastructure or transformed land within the current boundary of the Gwaing WWTW. Therefore, determining an aquatic buffer zone is unnecessary. The only potential for physical habitat disturbance is at the outlet structure. It is recommended that any upgrades to this infrastructure avoid encroaching further into the wetland. Since the outlet is already on the wetland boundary, establishing a buffer zone would not be practical. It is more practical to adopt a No-Go Area around the wetland habitat by the outlet structure.

8.4 WATER QUALITY

The George Municipality laboratory services provided water quality monitoring data relevant to the Gwaing WWTW and two testing stations, one upstream and one downstream, on the Gwaing River. For the purposes of this assessment, only the final effluent measurements were analysed relative to (a) the river, (b) the General Limits of the water use license, and (c) the South African Water Quality Guidelines for Aquatic Ecosystems.

It was determined that the effluent from the Gwaing WWTW is typically within the General Limits of the General Authorisation for discharging water into a river. This is a good indication of compliance and the performance from the WWTW. However, meeting the standards of a water use license does not necessarily equate to no impacts upon aquatic habitat. The effluent water will never be the same as the river water it enters, and the discharge water will therefore always result in some change to river water characteristics. The scale, magnitude, and ultimate significance, of this impact upon the river water quality depends on the difference in constituents and their levels. Therefore, the water quality monitoring data provided was also compared to the upstream and downstream results and the South African Water Quality Guidelines for Aquatic Ecosystems.

The discussion of water quality is based in a ‘snapshot’ of measurements (from averages in April 2024) to provide an indication of quality. Ideally, for accurate interpretation of the water quality results, daily samples should be taken by an independent laboratory for at least 4 weeks, to get a good indication of concentrations. A brief analysis of measurements is of limited use and shouldn’t be used to draw conclusions on the water quality, but the results can provide insight regarding the current impacts.

Based on the snapshot investigation it would seem that the effluent from the Gwaing WWTW is not significantly impacting the water quality of the Gwaing River or downstream aquatic habitat. However, it is advisable that additional testing be conducted by an independent laboratory for comparison with relevant variables within the South African Water Quality Guidelines for Aquatic Ecosystems and not just the General Limits of the license.

8.4.1 Faecal Coliforms and Escherichia coli

The GM laboratory data only shows results for E. coli measurements, and not faecal coliforms. Faecal coliforms and Escherichia coli (E. coli) are both important indicators of microbial water quality, but they differ in their specificity and what they indicate about water contamination. E. coli is generally preferred due to its specificity and closer association with health risks. Therefore, since the E. coli levels are below 130 counts per 100ml it is not deemed as necessary to test Faecal coliforms (Table 3). The data shows that the E. coli count in the effluent from the Gwaing WWTW is typically compliant and within general limits and recommended guideline values.

It is interesting to note that the Gwaing River E. coli levels are high and indicative of pollution from surrounding and upstream land uses. The results indicate that the effluent discharged from the WWTW is not the cause for the elevated E. coli levels in the river. It is important to note however, that the data assessed was only for the April 2024 averages but provides a snapshot of the situation.

Table 4: The GM Laboratory water quality results for E. coli in relation to the limits set in the water use license (General limits) and South African Guidelines for Recreational Use

Constituent	GM Laboratory measurements for the Gwaing WWTW			General limits	Water Quality Guidelines for Recreational Use (DWAF, 1996)	
	Outlet	Upstream	Downstream		Full contact	Intermediate contact
E. coli (per 100ml)	77,6	1840,25	1433,5	-	0 - 130	0 - 1000
Faecal coliforms (per 100ml)	-	-	-	1000		

8.4.2 Total Residual Chlorine (TRC), Free Chlorine, and Chloride

The terms Total Residual Chlorine (TRC), Free Chlorine, and Chloride refer to different substances in water chemistry, each with distinct characteristics and implications for water quality. Total Residual Chlorine is the sum of all chlorine species present in the water, including free chlorine and combined chlorine (chloramines and other chlorine compounds). Free Chlorine refers specifically to the chlorine available in the form of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-), which are the primary active disinfectants. Chloride is a negatively charged ion (Cl^-) that forms when chlorine gains an electron. While TRC is generally more comprehensive for assessing the impacts of WWTW discharge into rivers, free chlorine measurements are also crucial for understanding acute toxicity and disinfection effectiveness.

Each provides unique and important information:

- Total Residual Chlorine (TRC):
  - Provides insight into the overall chlorine burden in the river.
  - Helps identify potential long-term impacts on aquatic ecosystems and compliance with environmental regulations.
- Free Chlorine:
  - Offers immediate information about the toxicity of the water.
  - Essential for assessing acute effects on aquatic organisms and verifying the effectiveness of disinfection processes.
- Chloride:
  - Indicates salinity levels, which can have significant ecological and water quality implications.
  - Helps track pollution sources and understand broader environmental impacts.

The municipal data shows that the Chlorine Free in the final effluent (on average in April 2024) is within the GA General Limits (Table 3). This criterion is however not measured within the Gwaing River. The water quality measurements provided by the municipality include the testing of Chloride (as mg/l Cl) for the outlet water, and both upstream and downstream testing stations. However, this criterion is not in the General Limits to be tested for under the GA nor the Target Water Quality Guidelines. The results therefore cannot be compared with any legislated standards or guidelines; however, it can be noted that the measurement at the outlet works is only slightly below the river water quality parameters. The municipal data does not contain results for Total Residual Chlorine, a criterion within the SA Water Quality Guidelines for Aquatic Ecosystems, which should be tested for in future monitoring. Therefore, it is with limited confidence that one can state that the chlorine components in the effluent water is not impacting the river. But the snapshot analysis does indicate that the effluent quality is typically within GA limits for free chlorine.

Table 5: The GM Laboratory water quality results for chlorine in relation to the limits set in the water use license (General limits) and South African Guidelines for Aquatic Ecosystems

Parameter and unit of measurement	GM Laboratory measurements for the Gwaing WWTW			General Limit per GA	South African Water Quality Guidelines for Aquatic Ecosystems		
	Final effluent	Upstream	Downstream		TWQR	Chronic effect	Acute effect
Chloride as mg/l Cl	106	120	122	-	-	-	-
Chlorine Free (mg/L)	0,16	Untested	Untested	0,25	-	-	-
Total Residual Chlorine (µg/L)	Untested	Untested	Untested	-	0,2	0,35	5

8.4.3 Ammonia

Un-ionized ammonia (NH_3) and ammonia as nitrogen (NH_3-N) are related but distinct terms used in water quality and environmental chemistry. Un-ionized ammonia (NH_3) refers specifically to the toxic form of ammonia, while ammonia as nitrogen (NH_3-N) encompasses the total ammonia content (NH_3 and NH_4^+) expressed as nitrogen. When determining the impact of wastewater treatment works (WWTW) discharge into rivers, both un-ionized ammonia (NH_3) and ammonia as nitrogen (NH_3-N) are important parameters to measure, but each provides different insights. While un-ionized ammonia (NH_3) is crucial for assessing acute toxicity to aquatic life, ammonia as nitrogen (NH_3-N) offers a more comprehensive measure of the total ammonia impact from WWTW discharges.

The municipality tests for ammonia as nitrogen (NH_3-N) in the discharged effluent, as well as both up and downstream of the Gwaing WWTW in the river (Table 4). The results from April show that the effluent quality for this constituent is typically well-within the General Limits of the water use license. The laboratory does not test for un-ionised ammonia and therefore the results cannot be compared to the SA Water Quality Guidelines for Aquatic Ecosystems. However, as mentioned above, testing for total ammonia is a better measure for the WWTW.

Table 6: The GM Laboratory water quality results for ammonia in relation to the limits set in the water use license (General limits) and South African Guidelines for Aquatic Ecosystems

		GM Laboratory measurements for the Gwaing WWTW				Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996)		
Constituent	**Unit**	**Outlet**	**Upstream**	**Downstream**	**General limits**	**TWQR**	**CEV**	**AEV**
Ammonia as N	mg/L	1,87	1,2405	1,91075	6	-	-	-
Un-ionised ammonia	µg/L	Untested	Untested	Untested	-	7	15	100

8.4.4 Nitrogen and Phosphorus

Testing for nitrogen and orthophosphate in rivers receiving effluent from wastewater treatment works (WWTW) is essential for understanding nutrient pollution and its ecological impacts. These tests help in preventing eutrophication, which protects aquatic life and maintains water quality. The ‘snapshot ’investigation of the results from the George Municipality Laboratory shows that the nitrogen and ortho-phosphate concentrations in the effluent water are typically within the General Limits of the Water Use License. However, when compared to the South African Guidelines for Aquatic Ecosystems, the Nitrogen levels are slightly elevated and can result in eutrophic water.

The Phosphorus levels are not tested by the Municipality, and it was therefore not possible to compare with the Guidelines for Aquatic Ecosystems. Both total phosphorus and orthophosphate testing are important in water quality monitoring of effluent from WWTW and its impact on rivers. Total phosphorus provides a comprehensive view of all phosphorus forms, making it better for long-term monitoring and regulatory compliance. Orthophosphate indicates the bioavailable portion, making it better for assessing immediate ecological impacts and the risk of eutrophication. Using both tests together can provide a more complete understanding of phosphorus pollution and its effects on river ecosystems.

Table 7: The water quality results for nitrogen and ortho-phosphates in relation to the limits set in the water use license (General limits) and South African Guidelines for Aquatic Ecosystems

Constituent	**Unit**	**GM Laboratory measurements for the Gwaing WWTW**			**General limits**	**Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996)**			
		Outlet	**Upstream**	**Downstream**		**Oligotrophic**	**Mesotrophic**	**Eutrophic**	**Hypertrophic**
Nitrogen	mg/L	3,3426	1,2675	1,4925	15	< 0,5	0,5 - 2.5	2,5 - 10	> 10
Phosphorus	µg/L				-	< 5	5 - 25	25 - 250	> 250
Ortho - Phosphate	mg/L	1,3954	0,58275	1,93275	10	-	-	-	-

8.4.5 Other constituents

The constituents in Table 7 are grouped as there are no criterion for these parameters in the South African Guidelines for Aquatic Ecosystems (1996). However, some are required to be tested by the water use license for compliance monitoring and may also impact downstream water quality if irregular to the natural river waters. All of the parameters tested in Table 7 (as the average in April 2024) are compliant with the limits set in the Gwaing WWTW water use license.

The only outliers with regards to river water comparison are alkalinity (which is more than that found in the river waters), and COD (which is less than the characteristics of the river water). High alkalinity levels in discharge water can have both positive and negative impacts when entering a river. The positive impacts include increased buffering capacity and pH stabilization, which protect against acidification. However, high alkalinity can also promote eutrophication and algal blooms, and harm sensitive species. Low COD levels in discharge water are typically beneficial when entering a river. They indicate reduced organic pollution, lower oxygen demand, and fewer nutrients that could lead to eutrophication. This results in improved water quality and healthier aquatic ecosystems.

Table 8: The water quality results for additional parameters in relation to the limits set in the water use license (General limits)

Parameter	Outlet	Upstream	Downstream	License limits
Alkalinity as mg/l CaCO3	130	56	71	-
COD (mg/L)	26	49	41	75
Electrical Conductivity (mS/m)	63	40	50	70
pH	7,15	7,20	7,18	5.5 - 9.5
Settleable solids (mL)	<1	<1	<1	-
Suspended solids (mg/L)	12	13	30	25
Oil or Grease	<1			2,5
Temperature (°C)	21,2	21,6	21,5	-

9 POTENTIAL IMPACTS

Aquatic ecosystems are particularly vulnerable to human activities and these activities can often result in irreversible damage or longer term, cumulative changes. After reviewing the proposed activities and locations for upgrading the WWTW, and conducting in-field assessment, it was determined that the only realistic potential impacts from the project are associated with the construction at the outlet structure (as it is in close proximity to the HGM 2 wetland) and the increase in effluent to be discharged from the WWTW in the operational phase.

There are no immediate impacts associated with the No Go Alternative. However, it is highly likely that, should the plant not receive upgrades, the effluent will become non-compliant due to the expected population growth and result in negative impacts upon aquatic biodiversity.

9.1 IMPACTS FROM UPGRADING THE OUTLET STRUCTURE

The construction activities a required to upgrade the outlet structure may result in a disturbance or loss of aquatic vegetation and habitat due to the proximity of the HGM 2 wetland. This refers to the direct physical destruction or disturbance of aquatic habitat caused by earthworks, vegetation clearing, and encroachment and colonisation of habitat by invasive alien plants.

Mitigation, such as demarcating a no-go area during construction, can prevent any direct impacts to aquatic habitat. It is also important that other eroded areas in this vicinity be repaired, and stormwater is managed appropriately in future to prevent further erosion on this hill slope. Refer to Figure 14. Any erosion of the hillslope and/or at the outlet structure will result in sedimentation of the wetland.

Ineffective site stormwater management, particularly in periods of high runoff, can lead to soil erosion from confined flows. Formation of rills and gullies from increased concentrated runoff. This increase in volume and velocity of runoff increases the particle carrying capacity of the water flowing over the surface. Where soil erosion problems and bank stability concerns initiated during the construction phase are not timeously and adequately addressed, these can persist into the operational phase of the development project and continue to have a negative impact on downstream water resources in the study area.

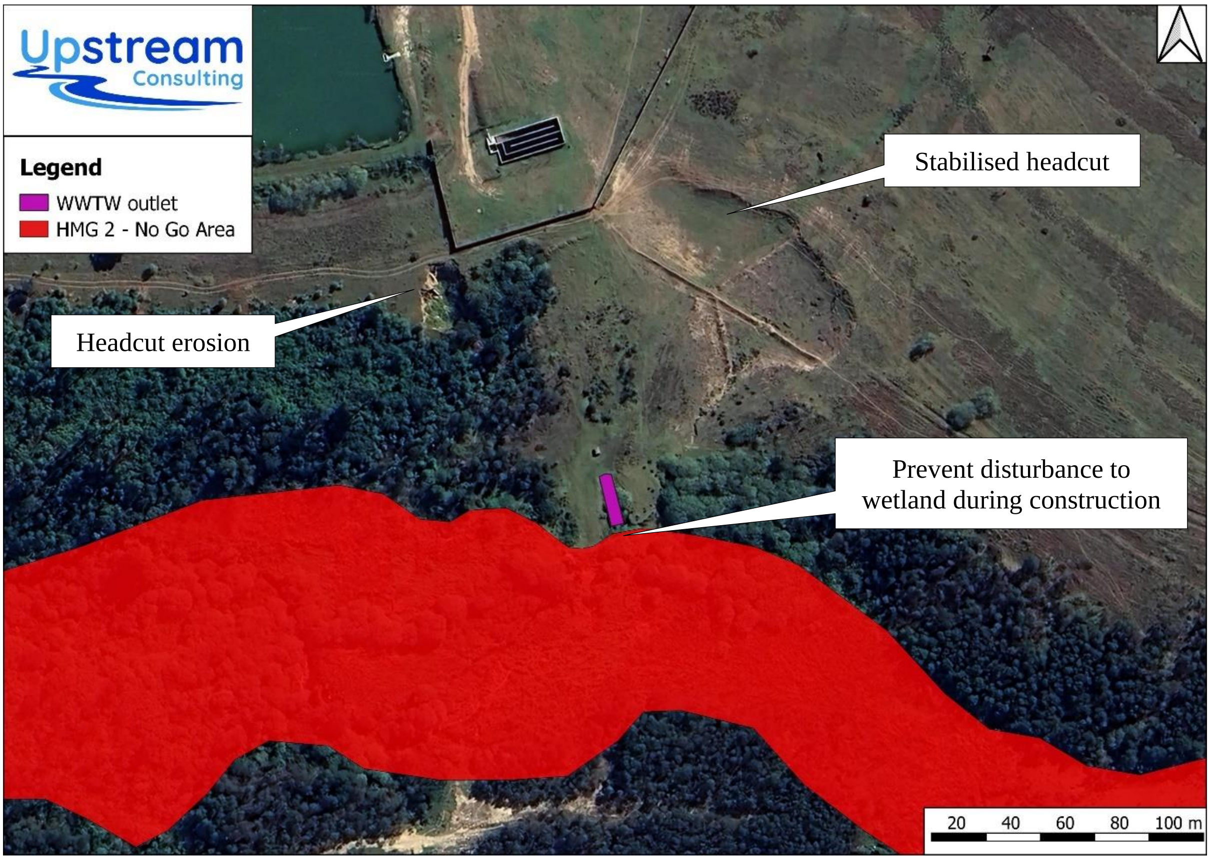

Figure 14: Map indicating the HGM 2 wetland as a No-go Area when upgrading the outlet structure

During construction of the upgraded outlet there are a number of potential pollution inputs into the aquatic systems (such as hydrocarbons and raw cement). These pollutants alter the water quality parameters such as turbidity, nutrient levels, chemical oxygen demand and pH. These alternations impact the species composition of the systems, especially species sensitive to minor changes in these parameters. Hydrocarbons including petrol/diesel and oils/grease/lubricants associated with construction activities (machinery, maintenance, storage, handling) may potentially enter the nearby watercourse by means of surface runoff or through dumping by construction workers. However, this impact is deemed as easily preventable.

9.2 IMPACTS RELATED TO THE DISCHARGE OF EFFLUENT

The discharge of treated effluent from wastewater treatment works (WWTW) into rivers can have several ecological, chemical, and physical impacts. The degree of impact depends on the quality of the treated effluent, the volume of discharge, the capacity of the river to assimilate the effluent, and the sensitivity of the river's ecosystem.

9.2.1 Altered water characteristics (quality)

The ecological impacts include the potential for nutrient enrichment (eutrophication) and the alteration of aquatic communities (biodiversity loss from changes in water quality and the encroachment of alien invasive plant species). Physio-chemical impacts can result from discharges altering the pH, temperature, and oxygen levels of the river, impacting the solubility and toxicity of other pollutants and affecting the health of aquatic organisms. Additionally, treated effluent may contain trace amounts of pharmaceuticals, hormones, and heavy metals that can have sub-lethal or chronic effects on aquatic organisms.

However, with specific regards to the Gwaing WWTW discharge water quality effect on the Gwaing River, it has been determined that the river water quality is already poor and significantly modified due to other anthropogenic activities, not necessarily the WWTW effluent. Additionally, the brief investigation into the George Municipality's water quality monitoring results indicates that the discharge water is of fair quality and compliant with the General Standards of the water use license.

Should the upgrades not be undertaken, then the increasing pressure from population growth is more than likely going to result in poor quality effluent entering the watercourses. The upgrades are necessary to maintain compliance with the water use license.

9.2.2 Increased water inputs (quantity)

Increasing the water supply to a river from a wastewater treatment plant (WWTP) can have a variety of ecological impacts, both positive and negative. Positive impacts include:

- Dilution of Pollutants: Additional water can dilute existing pollutants in the river, reducing concentrations of harmful substances and improving overall water quality.
- Flow Maintenance: In dry periods or in rivers with reduced flow, increased discharge from WWTPs can help maintain adequate flow levels, supporting aquatic habitats and species.
- Improved Oxygen Levels: Higher flows can increase aeration, raising dissolved oxygen levels and benefiting fish and other aquatic organisms that require oxygenated water.
- Habitat Creation: Increased water flow can create new or enhance existing habitats, supporting a greater diversity.

The negative impacts result from hydrological alterations which lead to flow regime changes and erosion. Significant increases in water discharge can alter the natural flow regime, potentially disrupting the life cycles of aquatic organisms adapted to specific flow conditions.

Increased water flow can cause erosion of riverbanks and disturb sediment balance, impacting habitats and water quality. The hydrological impacts indirectly result in biological impacts such as species composition changes and the altered conditions may provide opportunities for invasive species to establish and outcompete indigenous species.

However, in the context of this project, it must be recognised that the discharge of effluent is an existing impact, which has become part of the wetland and river flow dynamics. Regarding the Gwaing River, the increase may pose additional risks from erosion, but the channel has already incised to bedrock in many locations. Invasive species already dominate in most reaches. Also, considering that the river has reduced flow from the natural condition (Gwaing River Estuary Management Plan, 2019), the increase in water input will not significantly change the flow regime. The positive impacts listed above may out-weigh the negatives in the case of the Gwaing River. However, the HGM 2 wetland must be protected from increased deterioration from increased inputs. Without mitigation it is likely to erode further.

9.3 CUMULATIVE IMPACTS

Cumulative impacts on the environment can result from broader, long-term changes and not only as a result of a single activity. They are rather from the combined effects of many activities overtime. In relation to an activity, cumulative impact means *"the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may be significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities"* (NEMA EIA Reg GN R982 of 2014).

Watercourses are set apart from many other ecosystem types by the degree to which they integrate with and are influenced by the surrounding landscape, or catchment. The physical, chemical and biological characteristics of any watercourse are determined almost entirely by the nature of its catchment and the activities, human and natural, that take place in it (Davies and Day 1998). Widespread land use conversion at a catchment scale can dramatically alter the flow rates, water quality and sediment regimes of watercourses.

The watercourses in the Gwaing WWTW area have all been modified to some degree by anthropogenic activities and none are in pristine ecological health. However, the remaining wetland habitat is providing refuge for biota, and supplies regulatory ecological services which benefit society. Therefore, no further deterioration or loss of aquatic habitat should be allowed.

The impacts of the Gwaing WWTW must not be viewed in isolation. The Gwaing river is the largest system in the catchment and supports a significant amount of habitat, including the estuarine habitat at the coast, and acts as an important ecological corridor. Sedimentation can result in changes to estuary mouth closure dynamics. Changes to flow regime and nutrient loads can lead to increased alien invasive species encroachment downstream. Water quality changes can affect the estuarine biota. The area is mapped as a SWSA for surface water and therefore it is critical that the water resources are not polluted. All the impacts studied in this assessment have the potential to become cumulatively more significant. However, the population growth in the area cannot be ignored and the implications of not upgrading the WWTW are far worse than those which can be planned for and mitigated against.

10 IMPACT ASSESSMENT

The significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed. The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance is determined. The direct and indirect impacts associated with the project are grouped into four encapsulating impact categories where associated or interlinked impacts are grouped. Therefore, the potential impacts assessed, including cumulative impacts, were:

- Impact 1: Disturbance to aquatic habitat and biota
- Impact 2: Increased water inputs leading to changes to the hydrological regime
- Impact 3: Changes to hydrological regime that could also lead to sedimentation and erosion
- Impact 4: Changes to water quality characteristics

10.1 SIGNIFICANCE

The impact significance of the proposed project was determined for each potential impact, direct and indirect for each phase. Refer to impact summary tables in the section below.

It was determined that, after mitigation, the project is of Low negative significance to aquatic biodiversity. There is potential for positive impacts and risk avoidance. Therefore, from an aquatic perspective, the proposed project is deemed as acceptable. The No-Go Alternative was determined to have no new impacts upon aquatic biodiversity but may have negative future implications.

The mitigation of negative impacts on biodiversity and ecosystem goods and services is a legal requirement for authorisation purposes and must take on different forms depending on the significance of the impact and the specific area being affected. Mitigation requires the adoption of the precautionary principle and proactive planning that is enabled through a mitigation hierarchy. Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining significant residual negative impacts on biodiversity (DEA 2013). Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Standard management measures should be implemented to ensure that any on-going activities do not result in a decline in water resource quality.

Mitigation measures related to the impacts associated with the activities are intended to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMP). The monitoring of the activities is essential to ensure the mitigation measures are implemented. Therefore, compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. Monitoring should focus on adherence to the No-Go area, preventing erosion and pollution.

10.2 Impact Tables

The potential impacts of the project are provided in Tables 9 - 12 which show that after mitigation, it will have Low impact significance. The methodology to determine the significance ratings of the potential environmental impacts and risks associated with the alternatives was provided by Sharples Environmental Services cc as well as the impact table template for completion.

Table 9: Impact 1 – Disturbance of aquatic habitat biota

PHASE:	Construction (at outlet structure)	
Potential impact and risk:	Disturbance of aquatic habitat biota from clearance of vegetation, earthworks, and further invasive alien plant infestation, which can result in further deterioration in freshwater ecosystem integrity, and a reduction in the supply of ecosystem services.	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Local and long-term	None
Magnitude of impact or risk:	Low	
Probability of occurrence:	Probable	
Degree to which the impact may cause irreplaceable loss of resources:	Marginal loss	
Degree to which the impact can be reversed:	Barely Reversible	
Indirect impacts:	Probable	
Cumulative impact prior to mitigation:	Medium	
Significance rating of impact prior to mitigation	Low	
Degree to which the impact can be avoided:	High	
Degree to which the impact can be managed:	High	
Degree to which the impact can be mitigated:	Can be mitigated	
Proposed mitigation:	• A construction method statement must be compiled and available on site. It must consider the no go area and include methods to avoid unnecessary disturbance and prevent material being washed downslope into the wetland.	Duty of Care- Alien clearing and pollution control

	• Any contractor found working within No-Go areas must be fined as per fining schedule/system setup for the project. • It is the contractor's responsibility to continuously monitor the area for newly established alien species during the contract and establishment period, which if present must be removed. Removal of these species shall be undertaken in a way which prevents any damage to the remaining indigenous species and inhibits the re-infestation of the cleaned areas. Any use of herbicides in removing alien plant species is required to be investigated by the ECO before use. • Where vegetation has been cleared in the buffer and open ground in the riparian area has resulted it is recommended that cover components be reinstated appropriately. Only indigenous species are to be considered. • Monitoring by an independent ECO during construction in the outlet area.	
Residual impacts:	Negligible	
Cumulative impact post mitigation:	Low	
Significance rating of impact after mitigation	Low	None

Table 10: Impact 2 – Changes to the hydrological regime

PHASE:	Operation	
Potential impact and risk:	Increase in water inputs resulting in changes to hydrological form and function. The impact can result in further deterioration in freshwater ecosystem integrity, and a reduction in the supply of ecosystem services.	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Regional and permanent	None
Magnitude of impact or risk:	Medium	
Probability of occurrence:	Definite	
Degree to which the impact may cause irreplaceable loss of resources:	Partial loss	
Degree to which the impact can be reversed:	Partly Reversible	
Indirect impacts:	Probable	
Cumulative impact prior to mitigation:	Medium	
Significance rating of impact prior to mitigation	Medium	
Degree to which the impact can be avoided:	Low	

Degree to which the impact can be managed:	High	
Degree to which the impact can be mitigated:	Can be barely mitigated	
Proposed mitigation:	Effective stormwater management is imperative to reduce volumes. Re-use of effluent water will reduce the volume of water entering the drainage network from the WWTW and therefore reducing hydrological changes to the HGM2 wetland and Gwaing River (however small). The following options are discussed in the Concept Design report: • Effluent from the Gwaing WWTW can in future be pumped to neighbouring industries or golf courses for non-potable use. Alternatively, it can be further treated together with the effluent from Outeniqua WWTW before it is pumped to the Garden Route Dam as part of an indirect potable reuse scheme. • Effluent will be recycled and pressurized on-site in a wash water ring main for various uses including irrigation, reducing the potable water demand of the WWTW. Other measures which can assist to mitigate this impact include: • Controlled Discharges: Regulating the timing and volume of discharges can help mimic natural flow regimes and reduce hydrological disruptions, especially during flood events. • Habitat Restoration: Restoring and protecting natural habitats can enhance the river's resilience to changes in water flow and quality. The project will need to comply with all regulations of the National Water Act (Act 36 of 1998), including the protection of downstream users, and minimise any potential ecological impacts upon water resources.	Duty of Care- Alien clearing and pollution control
Residual impacts:	Low	
Cumulative impact post mitigation:	Mow	
Significance rating of impact after mitigation	Low	None

Table 11: Impact 3 – Sedimentation and erosion

PHASE:	Construction and operation	
Potential impact and risk:	From discharge water: Changes to hydrological regimes that could also lead to sedimentation and erosion. From hillslope erosion and erosion at outlet: Concentrated stormwater flow paths and altered flow patterns causing increased erosion and sedimentation as the disturbed soils are carried by unmanaged surface runoff down slope. These impacts can result in the deterioration of aquatic ecosystem integrity and a reduction/loss of habitat for flora & fauna.	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Regional and long-term	None
Magnitude of impact or risk:	High	
Probability of occurrence:	Probable	
Degree to which the impact may cause irreplaceable loss of resources:	Partial loss	
Degree to which the impact can be reversed:	Partly	
Indirect impacts:	Probable	
Cumulative impact prior to mitigation:	Medium	
Significance rating of impact prior to mitigation	Medium	
Degree to which the impact can be avoided:	Medium	
Degree to which the impact can be managed:	High	
Degree to which the impact can be mitigated:	Can be mitigated	
Proposed mitigation:	• Efficient site stormwater management • Stabilise any erosion features upslope of watercourses and do not concentrate flows into wetland • Prevent erosion at outlet and design upgraded structure accordingly • Do not encroach into wetland habitat with excavations or drains • The volume and velocity of water must be reduced through discharging the surface flow at multiple locations surrounding the WWTWs. Effective stormwater management must include effective stabilisation of exposed soil. • Sedimentation must be minimised with appropriate measures. Any construction causing bare slopes and surfaces to be exposed to the elements must include measures to protect against erosion using covers, silt fences, sandbags, earthen berms etc.	Duty of Care- Alien clearing and pollution control

	• All stockpiles must be protected and located in flat areas where run-off will be minimised and sediment recoverable. • Construction must have contingency plans for high rainfall events during construction.	
Residual impacts:	Low	
Cumulative impact post mitigation:	Low	
Significance rating of impact after mitigation	Low	None

Table 12: Impact 4 –Changes to water quality

PHASE:	Construction and operation	
Potential impact and risk:	Water contamination of wetland during outlet upgrades in construction phase. Altered water quality from discharging more treated effluent from WWTW in operational phase.	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Regional and permanent	None
Magnitude of impact or risk:	High	
Probability of occurrence:	Improbable	
Degree to which the impact may cause irreplaceable loss of resources:	Partial loss	
Degree to which the impact can be reversed:	Partly Reversible	
Indirect impacts:	Probable	
Cumulative impact prior to mitigation:	High	
Significance rating of impact prior to mitigation	Medium -High	
Degree to which the impact can be avoided:	Low	
Degree to which the impact can be managed:	High	
Degree to which the impact can be mitigated:	Can be partly mitigated	
Proposed mitigation:	• Ensure that the WWTW complies with all relevant water quality standards and regulations. Regular inspections and audits by regulatory authorities can enforce compliance and identify any areas needing improvement. • Habitat restoration of the HGM 2 wetland through alien plant eradication and halting erosion. • Using the recommended settled UCT system from Concept Design Report, as this process produces much lower orthophosphate levels. • Upgrading the treatment processes. For example, the use of ultraviolet	Duty of Care- Alien clearing and pollution control

	(UV) disinfection, as recommended in Concept Design report, will assist with effluent water quality management. • The reuse of the effluent, recommended above, will also contribute to mitigating against cumulative water quality change impacts. • The Department of Water Affairs regional office should be notified, as soon as possible, of any significant chemical spill or leakage to the environment where there is the potential to contaminate surface water or groundwater. • Effluent Standards: Enforcing stricter effluent discharge standards and regular monitoring can ensure that only high-quality effluent is released into SWSAs, minimizing negative impacts on water quality and ecosystem health. • Implement continuous monitoring systems to regularly check the quality of the treated effluent • Establish strict maintenance protocols to ensure that all treatment equipment and infrastructure are functioning optimally, preventing any bypass or failure in the treatment process. • Develop and implement emergency response plans to address accidental discharges or treatment failures. This includes having backup systems in place and protocols for immediate action to contain and mitigate any potential impacts on the river. • provide incentives for WWTWs that consistently meet or exceed water quality standards. • Require industrial facilities to pretreat their wastewater before discharging it into municipal systems, reducing the load of contaminants entering the WWTW. • Improve sludge management to reduce the amount of sludge stockpiles on unlined ground.	
Residual impacts:	Low	
Cumulative impact post mitigation:	Medium	
Significance rating of impact after mitigation	Low	None

11 CONCLUSION

The aquatic habitats within a 500 metre radius of the proposed development were identified and mapped on a desktop level utilising available data. In order to identify the wetland/river types, using Kotze et al. (2009) and Ollis et al. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. Following the desktop findings, the infield site assessment (conducted on the 26th of March 2024) confirmed the location and extent of these systems. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project.

Five (5) watercourses were identified and mapped within a 500m radius of the proposed development. Due to the topography of the site resulting in surface runoff in a south westerly direction, and location of the WWTW outlet, it was determined that only the southern watercourse (mapped as HGM 2) has potential to be directly impacted by the upgrades. However, there is also potential for the downstream section of the Gwaing River (mapped as HGM 1) to be indirectly impacted by the project. The other watercourses identified within the 500m radius of the site are unlikely to be impacted by any of the proposed activities and were therefore not assessed further. The affected watercourses were classified by hydrogeomorphic (HGM) type, using Kotze et al. (2009; 2020), Grenfell et al. (2019), and Ollis et al. (2013). It was determined that the unnamed watercourse south of the WWTW outlet (referred to as HGM 2), can be classified as a channelled valley bottom wetland. And although the Gwaing River would have supported vast wetland habitat in its natural state, it has been significantly modified from the reference condition, and is presently typical of a riparian ecosystem.

After reviewing the proposed activities and locations for upgrading the WWTW, and conducting in-field assessment, it was determined that the only realistic potential impacts from the project are associated with the construction at the outlet structure (as it is in close proximity to the HGM 2 wetland) and the increase in effluent to be discharged from the WWTW in the operational phase.

There are no immediate impacts associated with the No Go Alternative. However, it is highly likely that, should the plant not receive upgrades, the effluent will become non-compliant due to the expected population growth and result in negative impacts upon aquatic biodiversity.

It was determined that, after mitigation, the project is of Low negative significance to aquatic biodiversity. There is potential for positive impacts and risk avoidance. Therefore, from an aquatic perspective, the proposed project is deemed as acceptable. Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Monitoring should focus on adherence to the No-Go area, preventing erosion and pollution.

12 REFERENCES

BROMILOW, C. 2001. Problem Plants of South Africa: a Guide to the Identification and Control of more than 300 invasive plants and other weeds. Briza Publications, Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 1999a. Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems Version 1.0, Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 2005. A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas. Edition 1, September 2005. DWAF, Pretoria.

KLEYNHANS, C.J., 1996. Index of Habitat Integrity (IHI).

KLEYNHANS, CJ, THIRION, C AND MOOLMAN, J (2005). A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Department of Water Affairs and Forestry, Pretoria, South Africa.

KOTZE, D.C., MARNEWECK, G.C., BATCHELOR, A.L., LINDLEY, D.S. AND COLLINS, N.B. 2009. WET-Ecoservices: A technique for rapidly assessing ecosystem services supplied by wetlands.

LAWRENCE, D.P., 2007. Impact significance determination - Designing an approach. Environmental Impact Assessment Review 27: 730 - 754.

LE MAITRE, D.C., SEYLER, H., HOLLAND, M., SMITH-ADAO, L., NEL, J.L., MAHERRY, A. AND WITTHÜSER, K. (2018) Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater. Report No. TT 743/1/18, Water Research Commission, Pretoria.

NAIMAN, R.J., AND H. DECAMPS. 1997. The ecology of interfaces -- riparian zones. Annual Review of Ecology and Systematics 28:621-658

MUCINA, L. AND RUTHERFORD, M. C. (EDS) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

POOL-STANVLIET , R., DUFFELL-CANHAM, A., PENCE, G. AND SMART, R. (2017). The Western Cape Biodiversity Spatial Plan Handbook. Stellenbosch: Cape Nature.

ROGERS KH. 1995. Riparian Wetlands. In: Wetlands of South Africa, Cowan GI (ed). Department of Environmental Affairs and Tourism: Pretoria.

VAN GINKEL, C.E., GLEN, R.P., GORDAN-GRAY, K.D., CILLIERS, C.J., MUASYA AND VAN DEVENTER, P.P., 2011. Easy identification of some South African Wetland Plants. WRC Report No. TT 459/10

APPENDIX 1 –DETAILED METHODOLOGY

For reference the following definitions are as follows:

- **Drainage line**: A drainage line is a lower category or order of watercourse that does not have a clearly defined bed or bank. It carries water only during or immediately after periods of heavy rainfall i.e. non-perennial, and riparian vegetation may not be present.
- **Perennial and non-perennial:** Perennial systems contain flow or standing water for all or a large proportion of any given year, while non-perennial systems are episodic or ephemeral and thus contains flows for short periods, such as a few hours or days in the case of drainage lines.
- **Riparian**: the area of land adjacent to a stream or river that is influenced by stream-induced or related processes. Riparian areas which are saturated or flooded for prolonged periods would be considered wetlands and could be described as riparian wetlands. However, some riparian areas are not wetlands (e.g. an area where alluvium is periodically deposited by a stream during floods but which is well drained).
- **Wetland**: 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 under normal circumstances supports or would support vegetation typically adapted to life in saturated soil (Water Act 36 of 1998); land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al*., 1979).
- **Water course**: as per the National Water Act means -
  (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

12.1 WETLAND DELINEATION AND HGM TYPE IDENTIFICATION

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005a). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

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

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.

- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

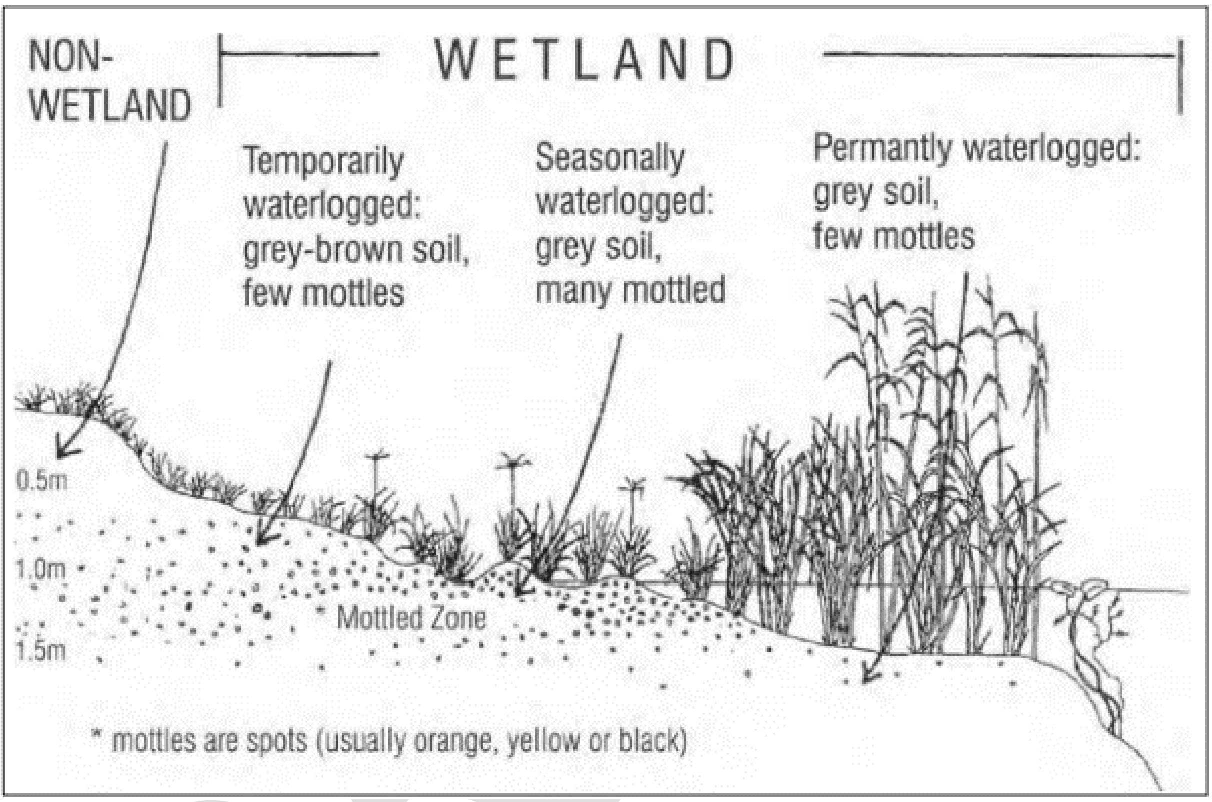

Figure A12.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

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

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table A12.1a)

A12.1a: Soil Wetness Indicators in the various wetland zones

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

Table A12.1b: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands

Vegetation	Temporary Wetness Zone	Seasonal Wetness Zone	Permanent Wetness Zone
Herbaceous	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants.
Woody	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).
Symbol	Hydric Status	Description/Occurrence	
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas	
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas	
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)	
D	Dryland species	Almost always grow in drylands	

In order to identify the wetland types, using Kotze *et al*. (2009) and Ollie *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. These have been defined based on the geomorphic setting of the wetland in the landscape (e.g. hillslope or valley bottom, whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Figure A12.1b).

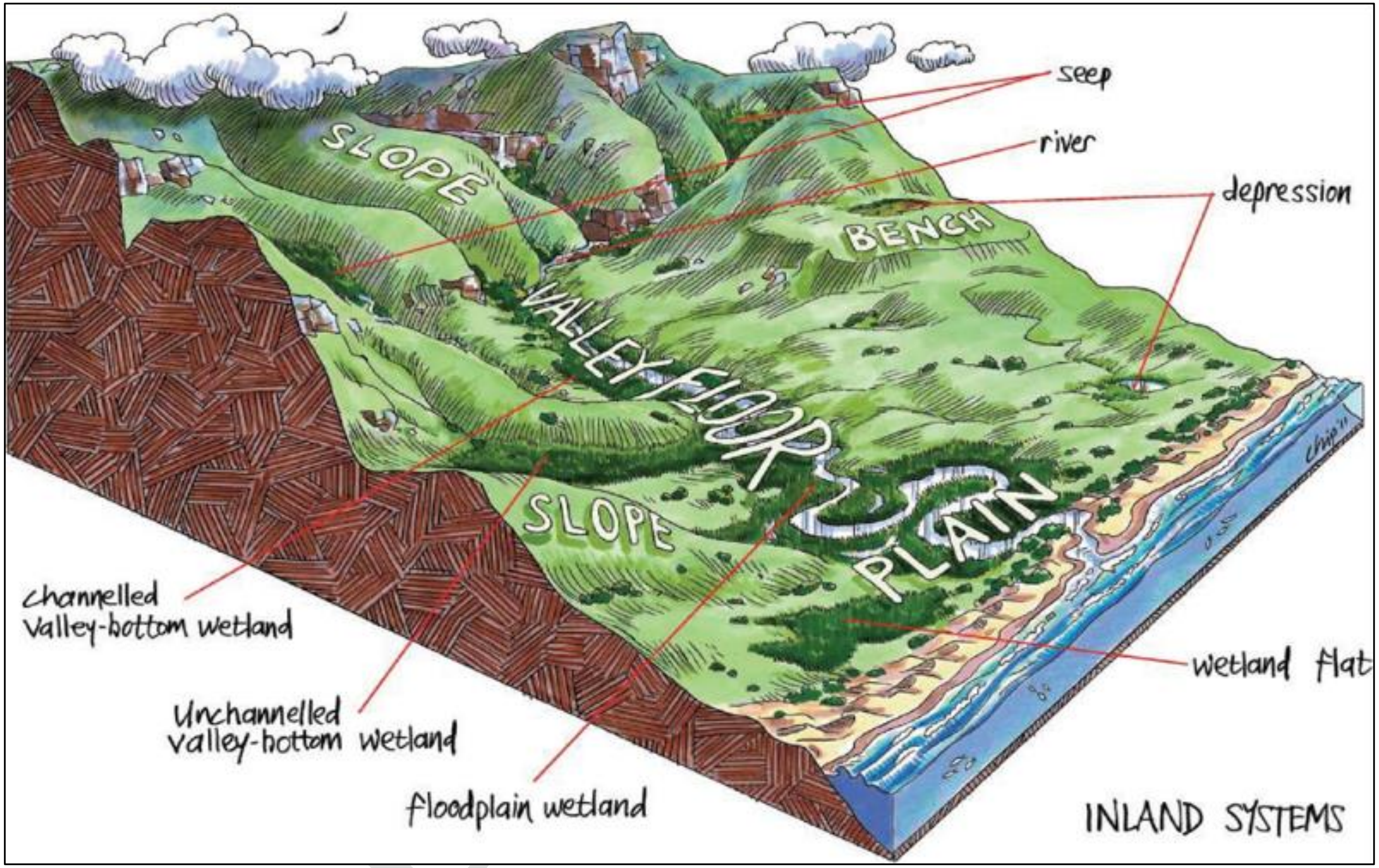

Figure A12.1b: Illustration of wetland types and their typical landscape setting (From Ollie et al. 2013)

12.2 Delineation of Riparian Areas

Riparian zones are described as "the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas" i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (Figure 12.2a). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

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

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

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

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

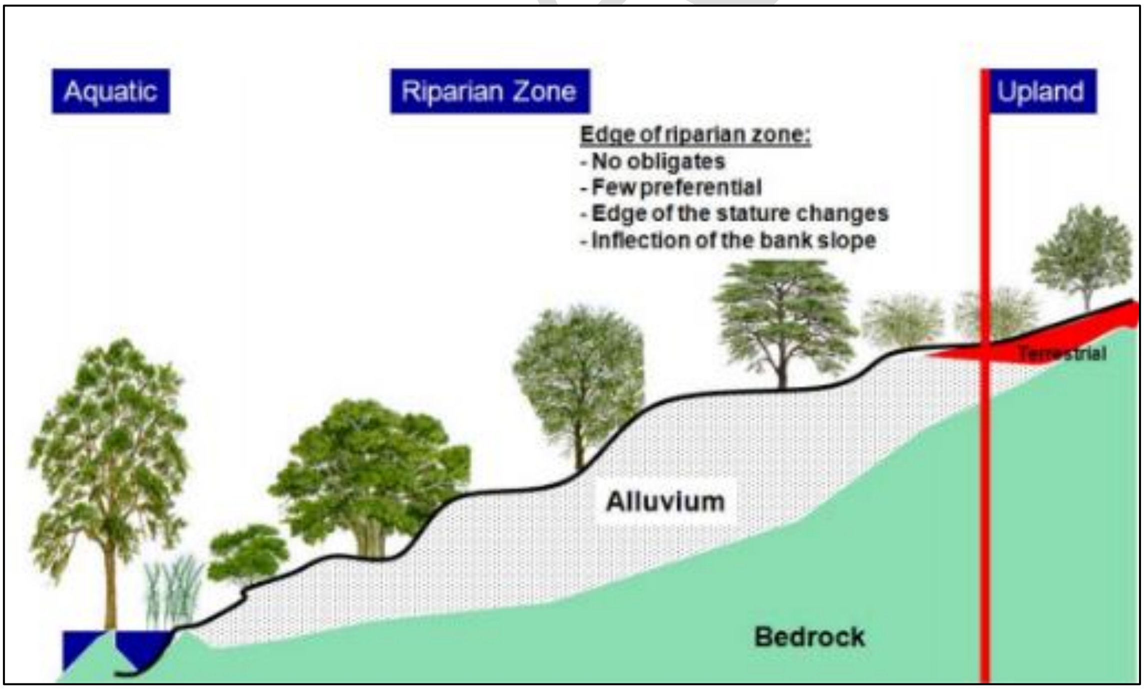

Figure A12.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).

12.3 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland.

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

Hydrology is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland.
Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).
Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (Table A12.2a).

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table A12.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

Table A12.2a: Guideline for interpreting the magnitude of impact on integrity

Impact Category	Description	Score
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Table A12.2b. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

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

12.4 WETLAND FUNCTIONAL IMPORTANCE (GOODS AND SERVICES)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 20 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table A12.4a) - that is, the benefits provided to people by the ecosystem.

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

Table A12.4a: Ecosystem services assessed by WET-Ecoservices

12.5 PRESENT ECOLOGICAL STATE (PES) – RIPARIAN

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

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table A1.1) according to the following metrics:

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

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

Table A1.1: The rating scale for each of the various metrics in the assessment

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

4.5 - 5.0	Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table A1.2).

Table A1.2: The habitat integrity PES categories

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

12.6 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh et al., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table A1.3).

The scores assigned to the criteria in Table A1.3 were used to rate the overall EIS of each mapped unit according to Table A1.4, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane et al., 2008).

***Table A1.3: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided*.**

Ecological Importance and Sensitivity assessment (Rivers)		
Determinants		Score (0-4)
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0,5
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0,0
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	0,5
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1,5
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1,0
	Refugia (4=Very high - 1=marginal/low)	1,5
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1,0
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	1,0
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2
MEDIAN OF DETERMINANTS		1,00
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		LOW, EC=D

Table A1.4: The ratings associated with the assessment of the EIA for riparian areas

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

APPENDIX 2- SPECIALIST CV

CURRICULUM VITAE

Debra Jane Fordham

Cell: 0724448243
Email: debrajanefordham@gmail.com
Date of birth: 26th August 1987
Country of origin: South Africa
ID Number: 8708260094081

Professional profile

Debbie is a registered ecologist (119102), with over 8 years of working experience, largely specialising in aquatic ecology. She has authored over 80 reports and applications and she constantly contributes to the scientific and local community. Most of her projects involve (as a minimum) in-depth wetland and river field delineation (including soil investigations via augering, vegetation identification, and classifying the hydrological characteristics), laboratory analysis (such as water quality and sediment analysis), classification, characterisation, ecological health and ecosystem functioning assessments (using the latest available tools), as well as impact rating, buffer determinations, mitigation recommendations and detailed rehabilitation plans. She is highly proficient using GIS software to incorporate accurate spatial analysis and visual aids (No Go Area maps etc.) into her reports.

Debbie holds a M.Sc. degree in Environmental Science from Rhodes University, by thesis, entitled: The geomorphic origin and evolution of the Tierkloof Wetland, a peatland dominated by Prionium serratum in the Western Cape. She is a member of scientific organisations such as the Society of Wetland Scientists (SWS), the South African Wetland Society (SAWS), the Southern African Association of Geomorphologists (SAAG), and the International Association for Impact Assessment (IAIAsa). Debbie is registered with SACNASP in the field of Ecological Science (Reg Number: 119102).

Tertiary Education

- M.Sc. Environmental Science (Rhodes University):
  Master of Science thesis entitled: The geomorphic origin, evolution and collapse of a peatland dominated by Prionium serratum: a case study of the Tierkloof Wetland, Western Cape.
- BA Hons. Environmental Science (Rhodes University):
  Honours dissertation: The status and use of Aloe ferox. Mill in the Grahamstown commonage, South Africa.
  Courses: Wetland Ecology, Environmental Water Quality /Toxicology, Biodiversity, Non-Timber Forest Products (NTFPs) and Rural Livelihoods, Environmental Impact Assessment (EIA), Statistics

- BA - Environmental Science and Geography (Rhodes University)

Work Experience:

- Ecological specialist (2022/03/01 – present)
- Sharples Environmental Services cc (2016/08/10 – 2022/03/01)

Position: Aquatic Ecologist and WULA Manager

- KSEMS Environmental Consulting (2015/08/10 - 2016/07/31)

Position: Wetland specialist

- AGES EC (Pty) Ltd (2014/10/01 – 2015/08/10)

Position: Aquatic Ecologist and WULA Manager

- Environmental Impact Management Services (2014/02/04-2014/02/07)

Position: Environmental consultant

- Rhodes University Alumni Relations (2010/04/01 – 2010/12/17)