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AQUATIC BIODIVERSITY IMPACT ASSESSMENT

for the proposed

BIOSOLIDS BENEFICIATION FACILITY (BBF) AT GWAING WASTEWATER TREATMENT WORKS, GEORGE LOCAL MUNICIPALITY

DATE: 14 May 2025

PREPARED FOR:

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EXECUTIVE SUMMARY

Upstream Consulting was appointed to undertake an aquatic biodiversity impact assessment to provide specialist input on the proposed construction of a Biosolids Beneficiation Facility (BBF) at the Gwaing Wastewater Treatment Works (WWTW), located in the George Local Municipality. The BBF is a component of broader infrastructure upgrades aimed at transforming the WWTW into a Water Resource Recovery Facility (WRRF), with improved sludge handling and resource recovery.

The assessment focused on identifying and characterising aquatic ecosystems potentially affected by the development. Fieldwork confirmed the presence of a small artificial wetland within the BBF footprint, originating from past excavations. No natural wetlands or sensitive aquatic habitats were found within the project footprint, and no rare or endangered species were recorded.

The proposed BBF will result in the permanent loss of this artificial wetland. However, this impact is of low ecological significance and does not warrant formal wetland offsets. To compensate and achieve a net gain, rehabilitation is recommended on the downstream HGM2 wetland reach affected by erosion and invasive species.

With the implementation of these mitigation measures, including stormwater management and rehabilitation, the residual impact of the project on aquatic biodiversity is rated as Low. The development of the BFF is thus deemed acceptable from an aquatic ecological perspective.

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:…14 May 2025………

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1 INTRODUCTION

Debbie Fordham of Upstream Consulting has been appointed by Sharples Environmental Services CC to conduct an aquatic biodiversity impact assessment for the Gwaing biosolids beneficiation facility (BBF), which will form part of an extension of the existing Wastewater Treatment Works (WWTW) in George Municipality. An aquatic specialist impact assessment was undertaken for the proposed upgrades on existing infrastructure at the WWTW and the report entitled 'Aquatic Biodiversity Impact Assessment for the proposed upgrading of the Gwaing Wastewater Treatment Works, George Local Municipality' by Debbie Fordham of Upstream Consulting (dated 27 July 2024), should be read in conjunction with this report.

1.1 BACKGROUND

George Local Municipality appointed Lukhozi Consulting Engineers (Pty) Ltd (LCE) to create a Master Plan to guide future upgrades at the Gwaing WWTW. 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. Sludge beneficiation in the form of composting or fertilizer production is envisioned as one of the key strategies. Two potential locations for an advanced solar drying facility were identified in the Concept Design Report but not investigated further.

The need for improved sludge handling was identified in the 2024 Aquatic Biodiversity Impact Assessment report for the upgrades at the WWTW, which recommended the following mitigation measures:

- Improve sludge management to reduce the amount of sludge stockpiles on unlined ground.
- All stockpiles must be protected and located in flat areas where run-off will be minimised and sediment recoverable.

Since the aquatic biodiversity impact assessment of the proposed upgrades to the WWTW infrastructure (Upstream Consulting, 2024), a formal proposal for the biosolids beneficiation facility (BBF) has been developed and requires addition assessment for potential impacts upon aquatic biodiversity.

1.2 LOCATION

This facility is planned as part of the wider mixed-use Gwayang Precinct Plan proposed by the George Municipality. The proposed BBF area, amounting to 5.9 ha, is divided between four proposed erven, numbered 57, 59, 61, and 63 on the Gwayang Mixed Development Layout. The project area is highly transformed, within a municipal service zone, and is adjacent to the existing WWTW and landfill. The area has been extensively modified over decades from agriculture and development.

Figure 1 illustrates the site location and the 500-meter radius study area, in relation to the Gwaing WWTW and the R102 road.

Figure 2 shows the concept layout plan for the proposed BFF on vacant land east of the Gwaing WWTW.

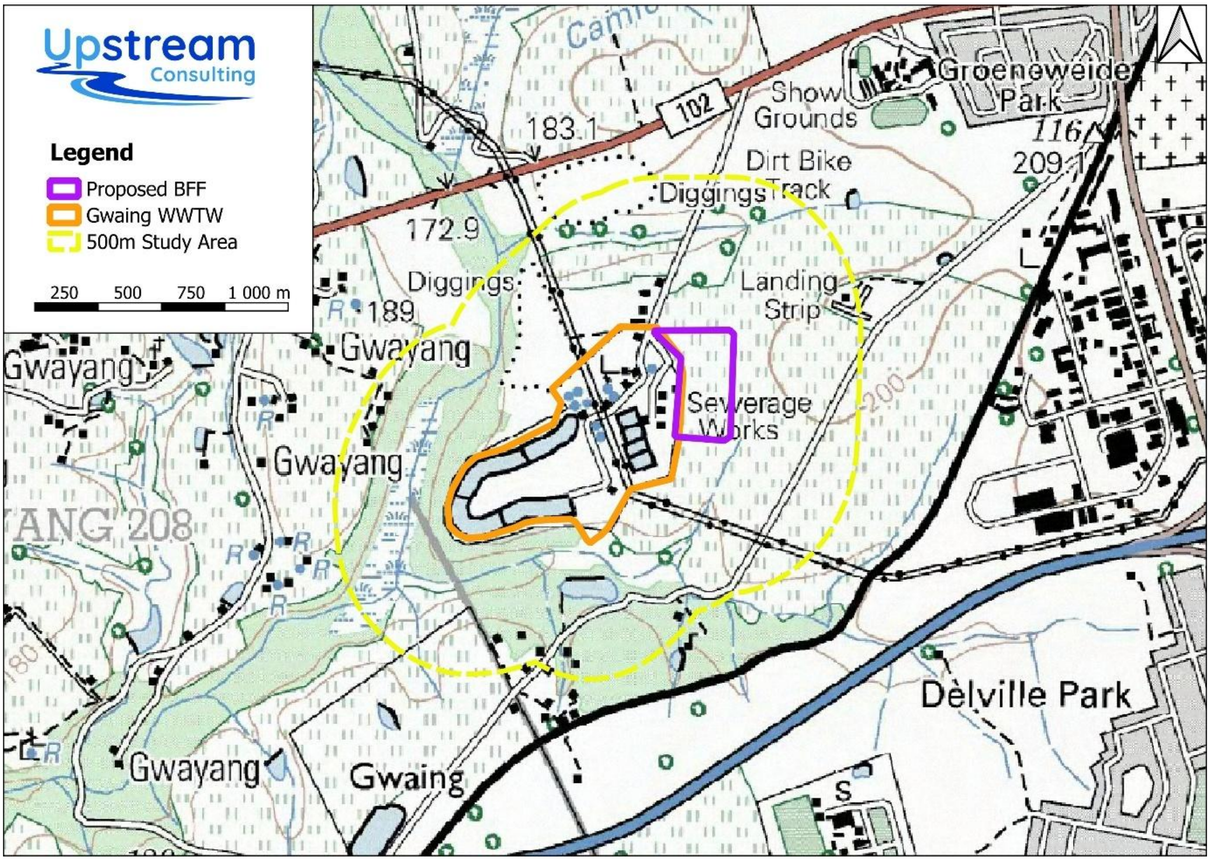

Figure 1: Topo-cadastral map showing the location of the site and 500m radius study area

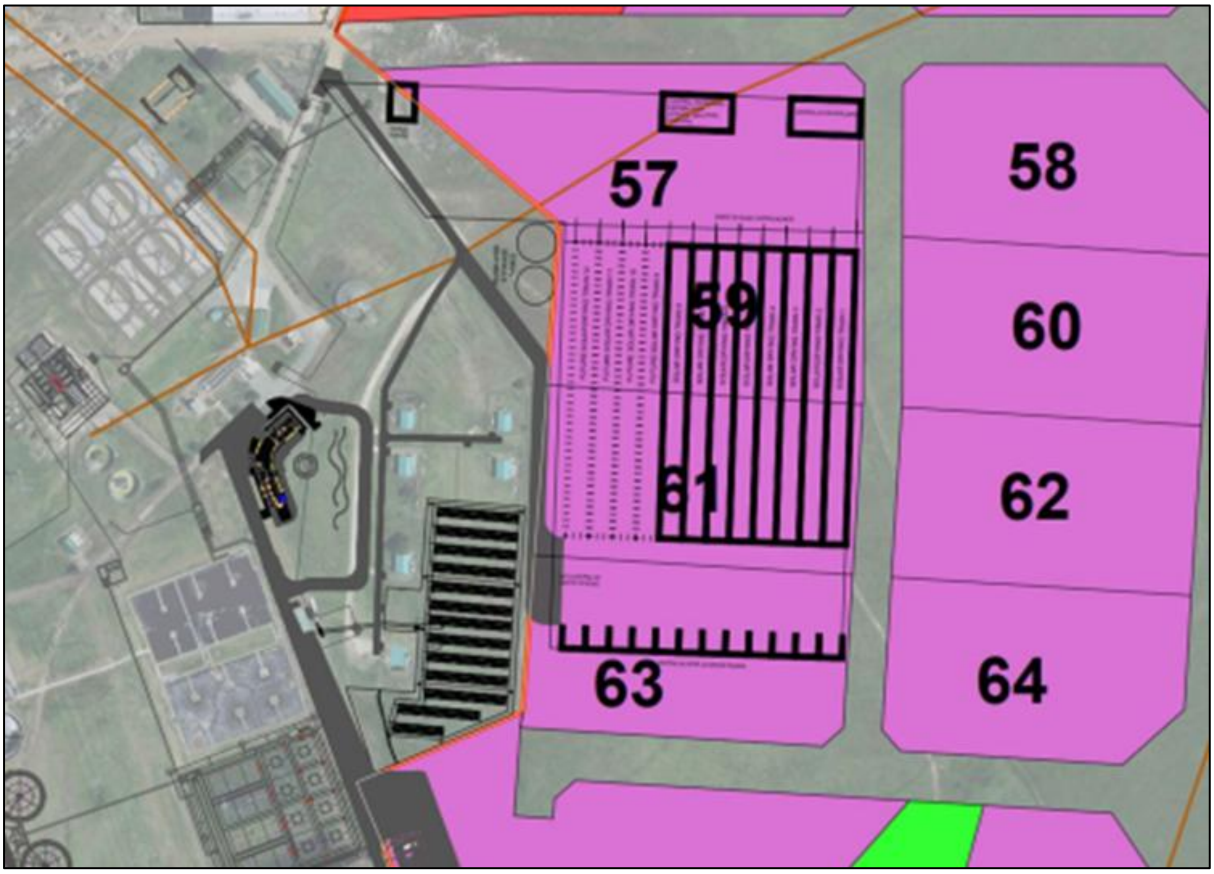

Figure 2: Proposed location for the BFF on the eastern border of the Gwaing WWTW

1.3 PROJECT DESCRIPTION

According to the concept 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.

According to the new concept design report the BBF will consist of:

- Guard House
- Perimeter fencing and access gate
- Approximately 30 000 m² of concrete slabs for the various stages of sludge stockpiling, solar drying, composing and sludge handling. This includes the areas under translucent roof sheeting for solar drying.
- Approximately 13 000 m² in plan view of translucent roof sheeting (‘greenhouse’) structures.
- One 18m x 36m shed with a clear height of 4.5m and without any columns inside the building for the sludge granulation plant.
- A second building of similar footprint for the packaging plant and distribution depot. This building is to include offices, ablution and a canteen for the operating staff of approximately 6 people.
- Movable precast concrete walls placed on slabs to demarcate separated process areas and to prevent contamination of treated sludge by raw sludge.
- Access Roads
- Rainwater collection and storage from all roof structures
- Stormwater collection and drainage from concrete slabs with pipeline to Gwaing WWTW inlet works.

Figure 3 below shows the proposed BFF layout footprint provided for assessment.

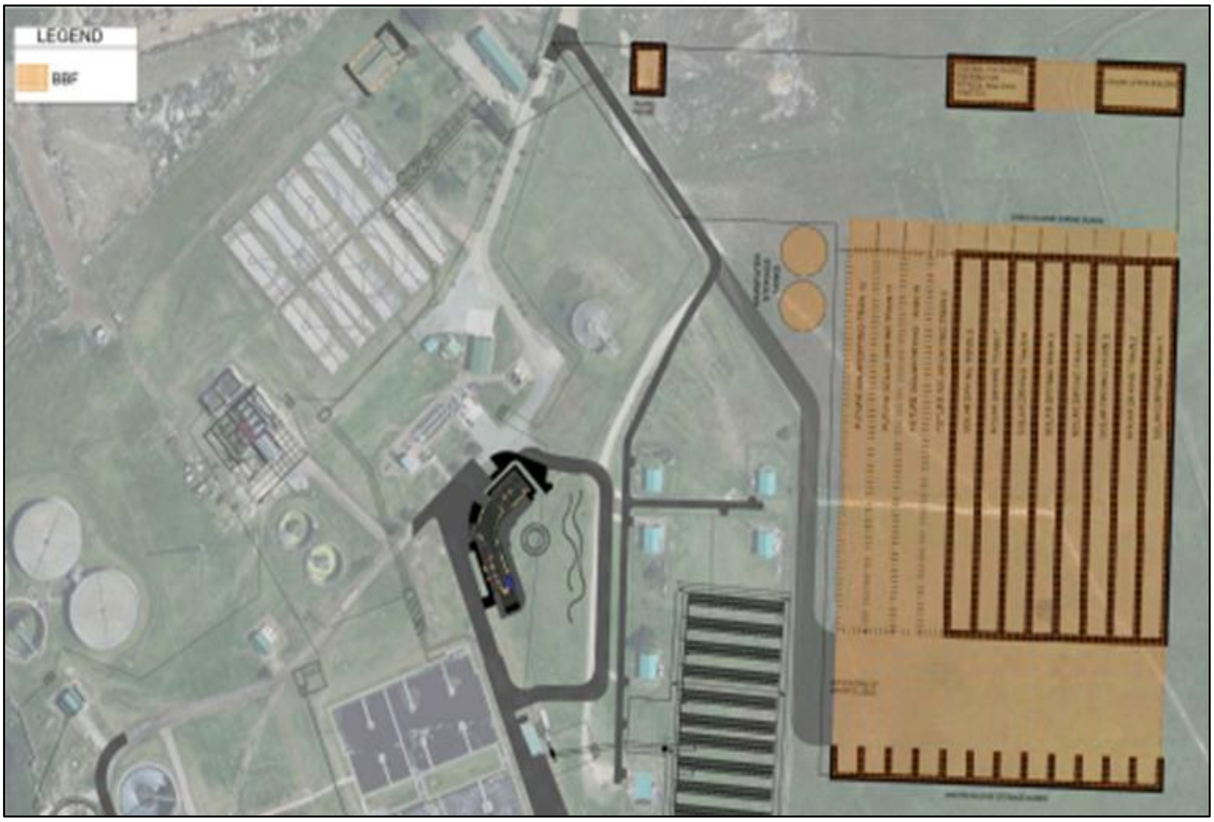

Figure 3: Proposed BFF footprint and conceptual layout plan

2 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 1 below shows an outline of the environmental legislation relevant to the project.

Table 1: 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.
The Water Services Act (WSA) 108 of 1997	The WSA mandates the Minister responsible for water and sanitation to prescribe compulsory national norms and standards in accordance with Sections 9 and 10 of the Act. The National norms and standards for domestic water and sanitation services (GN R. 982 of 2017; DWS, 2017) set out the national norms and standards for levels of water services, including sanitation, which will be applicable from 2017 until the Minister requests another revision. According to section 6.2.4 of the norms and standards, wastewater sludge management must adhere to the Guidelines for the utilisation and disposal of wastewater sludge
National Environmental Management: Waste Act (Act no. 59 of 2008)	Wastewater sludge falls in the definition of waste under NEMWA and therefore the waste regulations, norms and standards must be considered in sludge management, especially when disposal is the preferred management option. The NEMWA norms and standards applicable to sludge storage and disposal are: • National norms and standards for the storage of waste (GN R. 926 of 2013); and • National norms and standards for the assessment of waste for landfill disposal (GN R.635 of 2013).

3 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.

4 APPROACH AND METHODS

The study followed the same approach and methods detaioed within the 2024 impact assessment report for the WWTW upgrades. Refer to 2024 report and see Appendix 1.

5 ASSUMPTIONS AND LIMITATIONS

The same assumptions and limitations from the previous report apply. The site assessment for the BFF site was undertaken on the 25th of April 2025, following significant rainfall, and the confidence level is deemed as high.

6 DESKTOP ASSESSMENT OF THE STUDY AREA

The aquatic impact assessment report for the upgrades within the WWTW (Upstream Consulting, 2024) provided a detailed description with maps of desktop findings. In order to avoid unnecessary repetition, only the desktop findings relevant to the specific BFF site, or those which differ from the WWTW site already covered, are reported below.

6.1 SOUTH AFRICAN INVENTORY OF INLAND AQUATIC ECOSYSTEMS

There are no watercourses mapped within the proposed BFF site by the national river and wetland inventory. There is a 1:50 000 cadastral NGI river line depicted on the southeastern site boundary. The National Wetland Map 5 (NWM5) shows no wetlands within or near the BFF site. Refer to Figure 4.

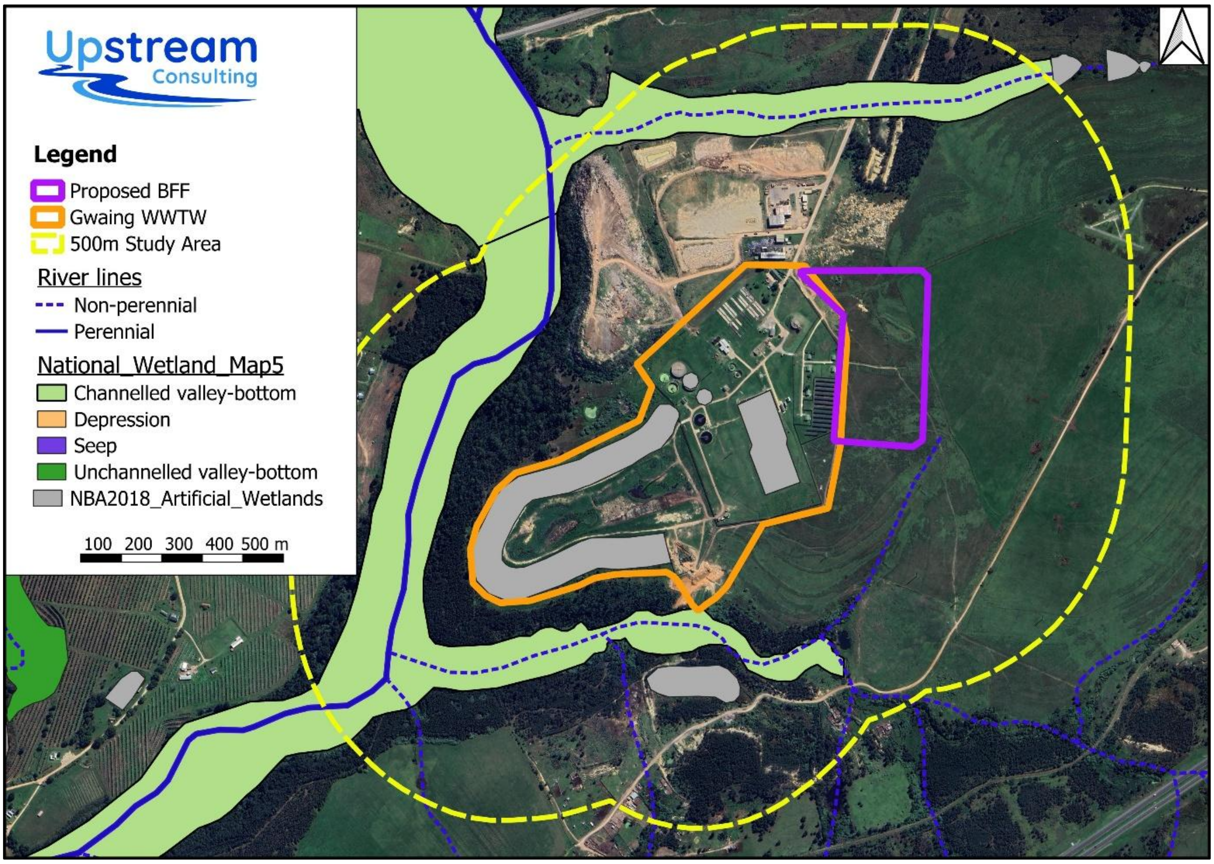

Figure 4: The BFF site in relation to the national river and wetland inventories (CSIR, 2018)

6.2 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.

Figure 5 shows that the site is not located upon any biodiversity priority areas, CBA nor ESAs. However, the drainage line located south of the BFF is classified as ESA 2 aquatic habitat.

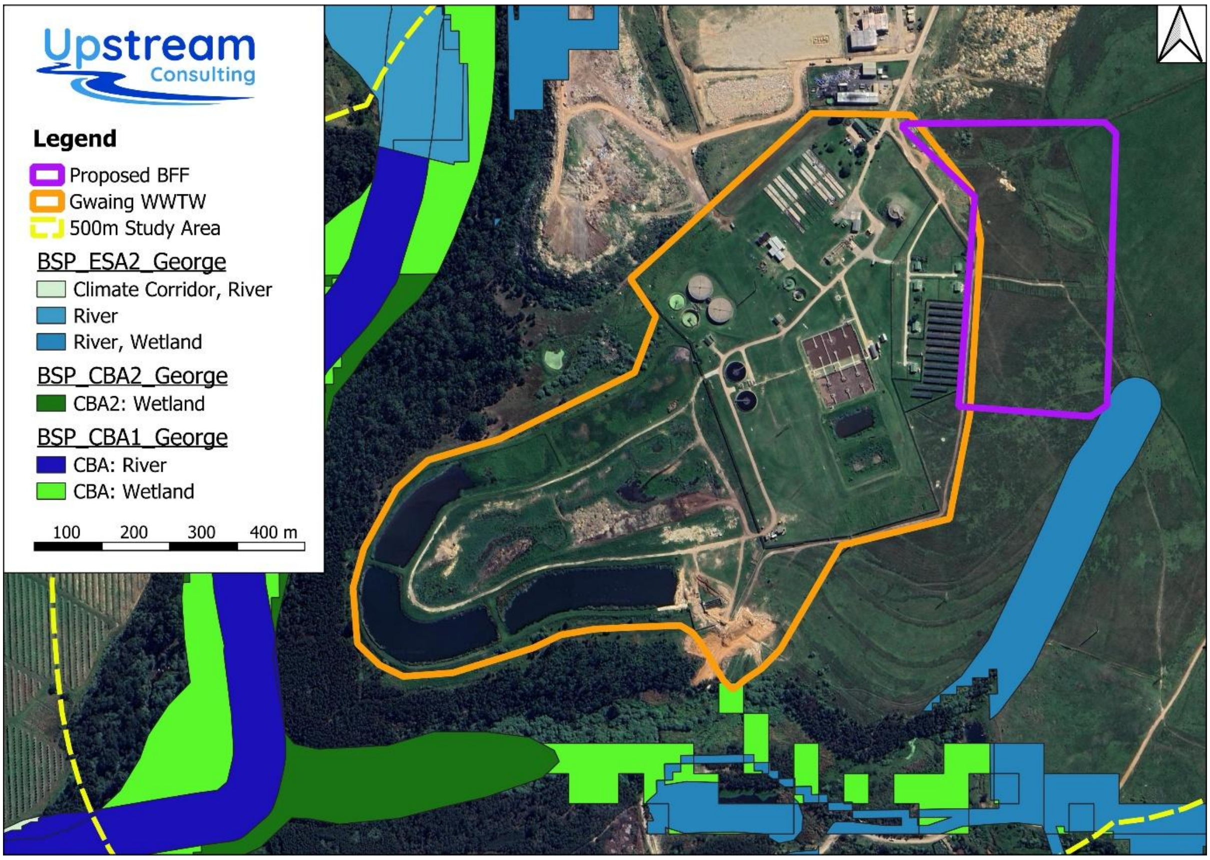

Figure 5: The site in relation to aquatic biodiversity priority areas identified in the WCBSP (2017)

6.3 HISTORIC CONTEXT

In the aquatic sensitivity assessment of the Gwayang Precinct Plan, conducted in May 2024 by Confluent Environmental (Pty) Ltd, entitled 'Mixed Use Development for RE/464 Gwayang Industrial Park, George', a small area in the BFF locality is described as "*historical natural wetland now excavated*". It is indicated by an arrow on historic Google imagery in Section 3.4 – Artificial Wetlands. Refer to Figure 6. However, it is important to note that this area was seemingly not groundtruthed by the Confluent aquatic specialist, as shown by the fieldwork map of GPS tracks taken from the Gwanyang Precinct Plan report. Refer to Figure 7.

In this assessment, a comprehensive groundtruthing exercise was undertaken which found only a small pocket of artificial wetland within an old excavation. All evidence indicates that this artificial wetland originated from a small livestock drinking pond excavated into the perched water table (Figure 8), which later was modified into the old sludge ponds (Figure 9). It is disputed that this site ever contained natural wetland habitat. It is argued to be a result of past excavations (Figure 10).

3.4 Artificial Wetlands

Historical irrigation with wastewater from the WWTW creates what can appear to be wetlands in some of the fields (Figure 13). However, irrigation has ceased for approximately 5 years and areas that were previously irrigated now show no indication of wetland features.

Figure 13. Periodic irrigation of wastewater from the WWTW on agricultural fields. Arrow indicates historical natural wetland now excavated.

Figure 6: Excerpt from the Confluent 2024 aquatic assessment of the Gwayang Precinct Plan indicating artificial wetland on the BFF site on Google imagery

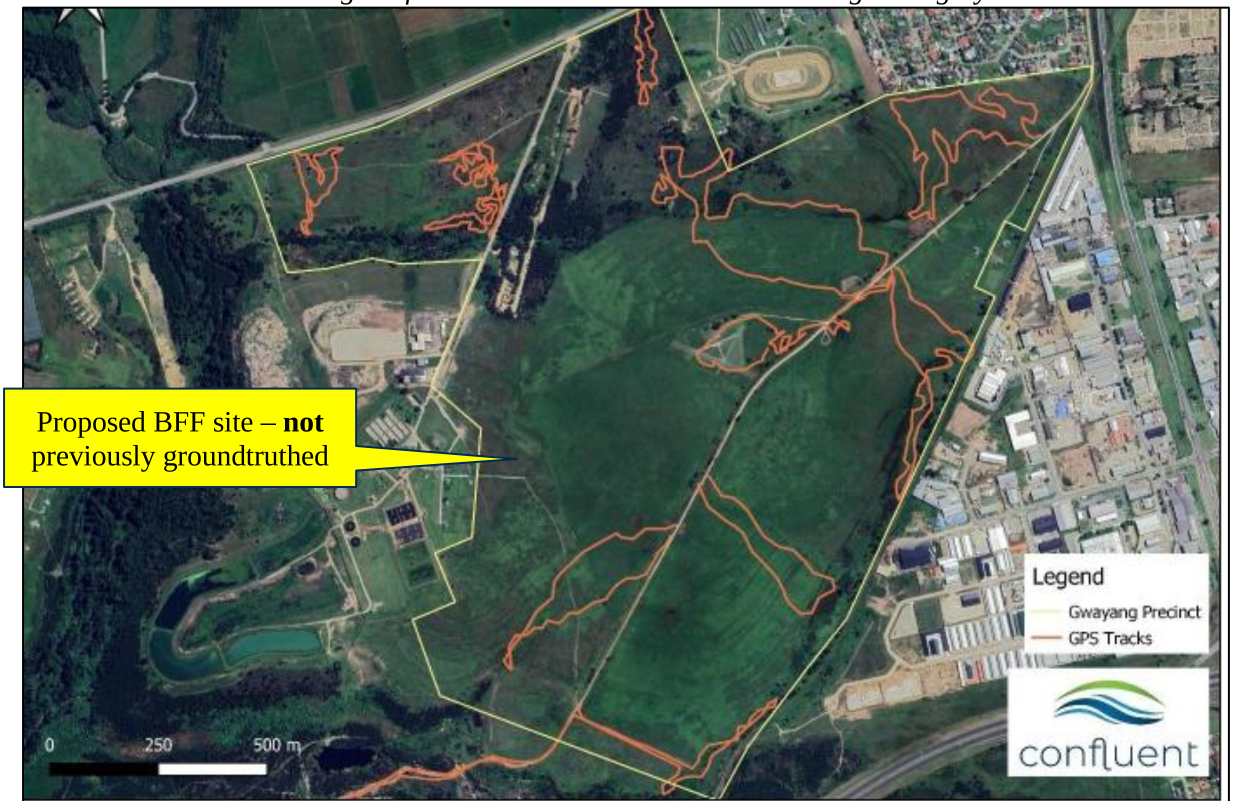

Figure 11. Property boundary showing GPS track walked during different dates for the site visit.

Figure 7: Excerpt from the Confluent 2024 aquatic specialist assessment report showing that the BFF site was not groundtruthed during the fieldwork.

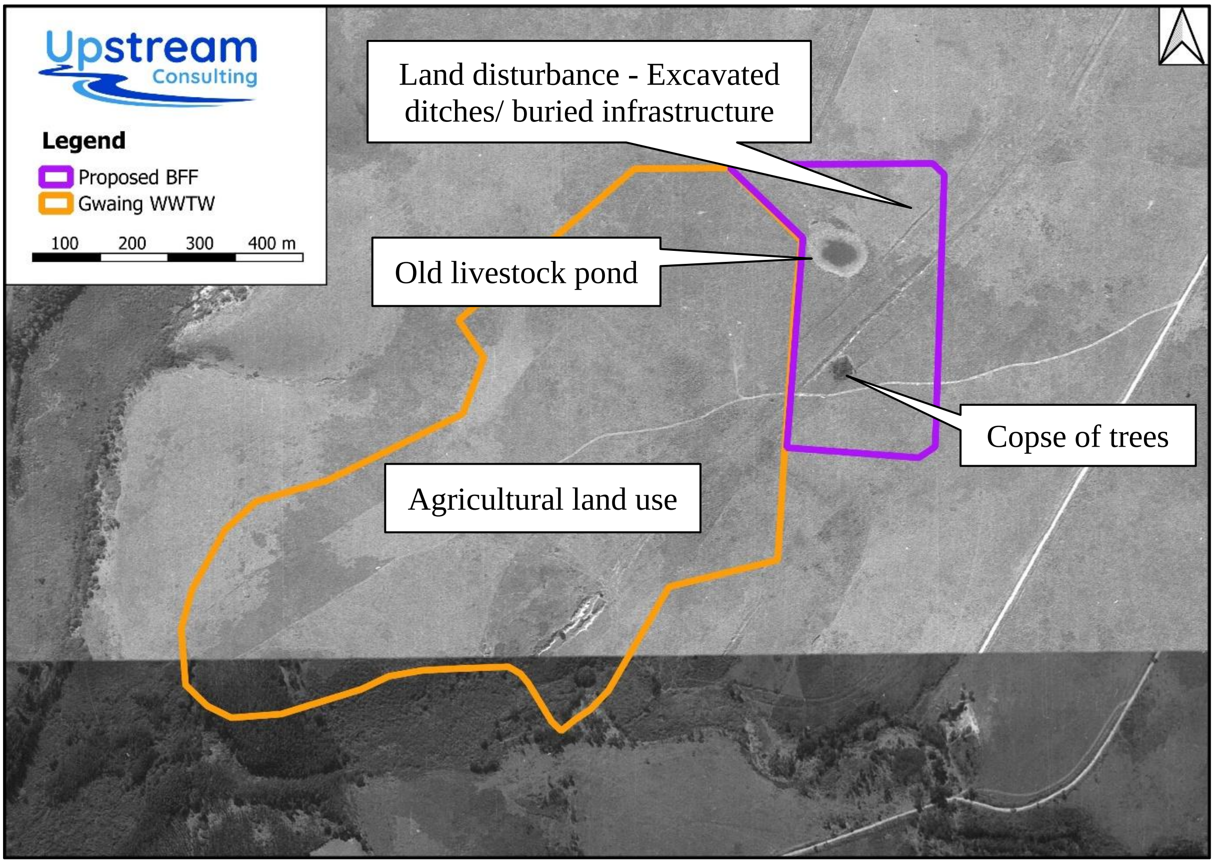

Figure 8: Historic aerial photography of the site in 1957

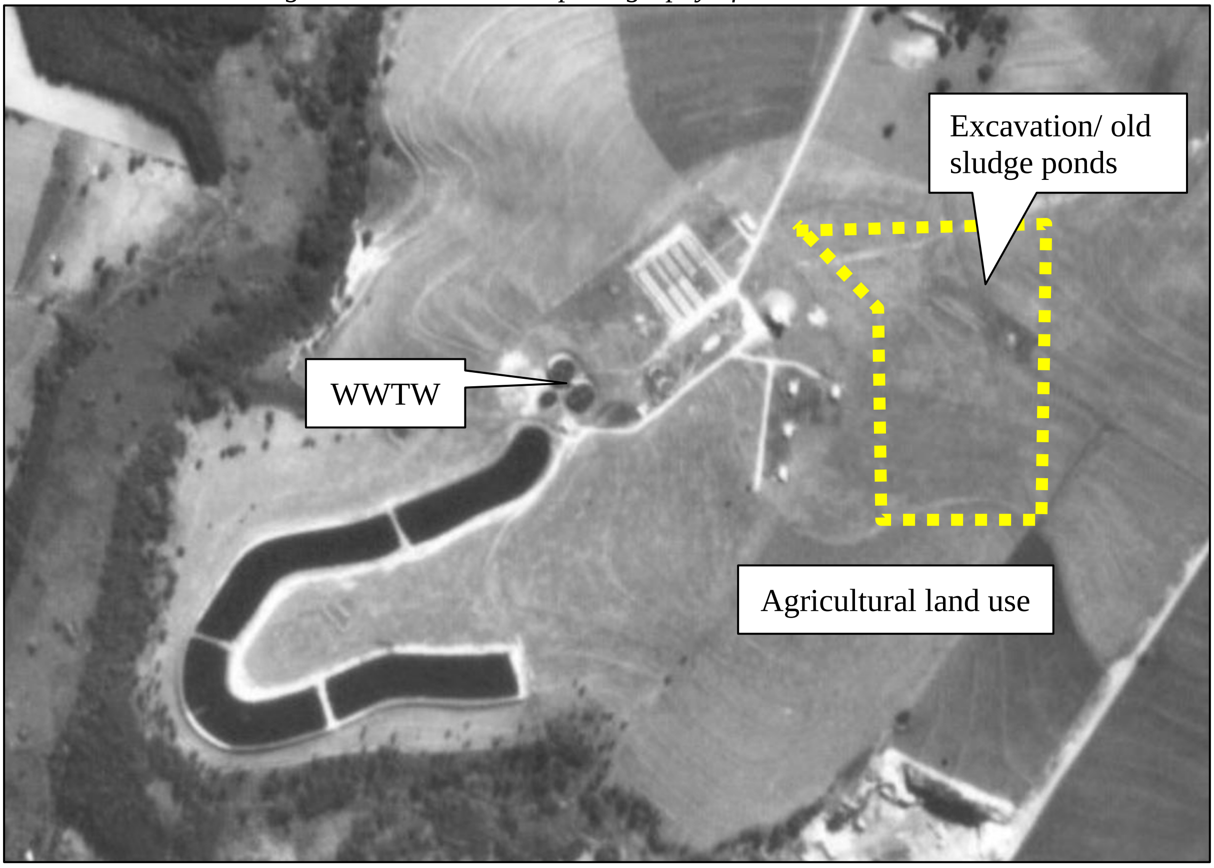

Figure 9: Historic aerial photography of the Gwaing WWTW in 1979

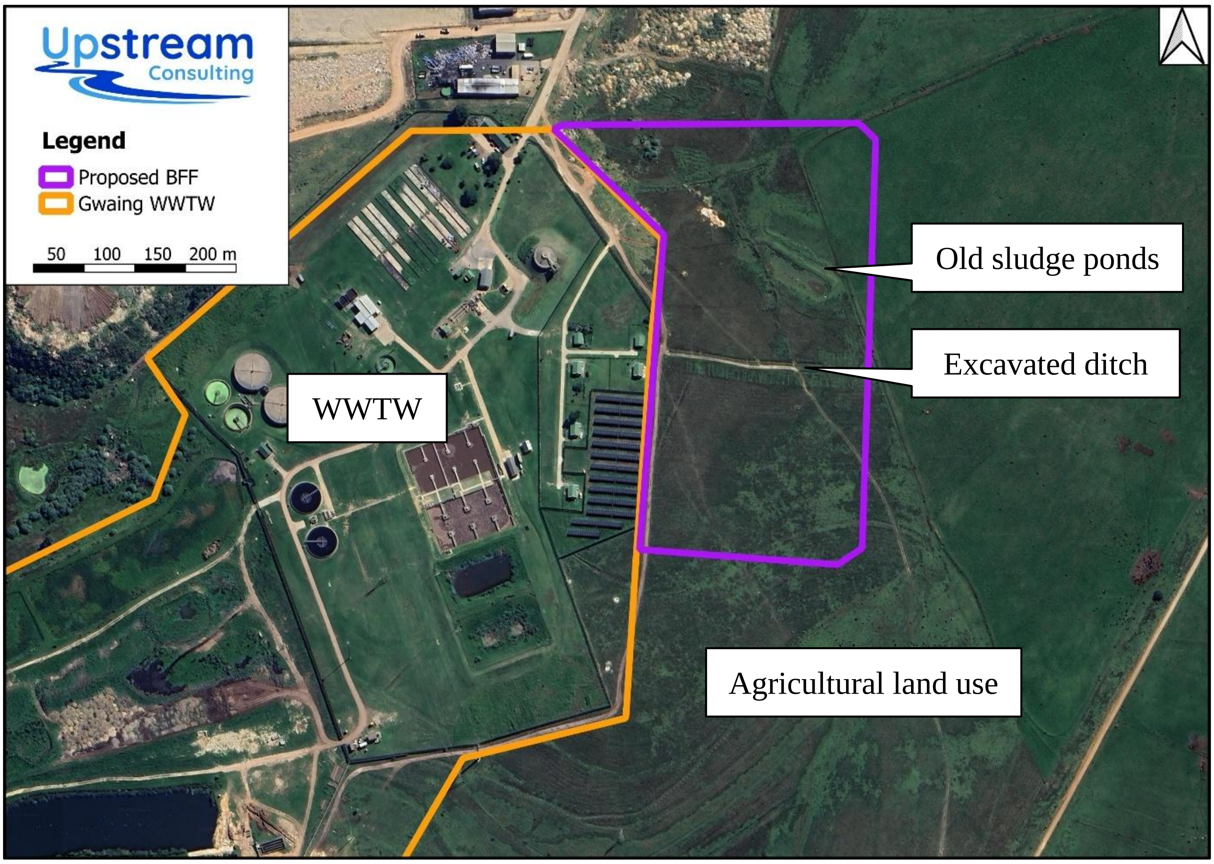

Figure 10: Google Satellite Imagery of the site dated 11/3/2025

7 RESULTS

The aquatic habitats within a 500 metre radius of the proposed project 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 and the 25th of April 2025) 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.

7.1 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 11).

Five (5) watercourses were identified and mapped within a 500m radius of the proposed upgrade works. An artificial wetland was identified and delineated within excavations on the BBF site. 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 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 WWTW upgrades. Less likely, but still possible, is for the HGM 4 watercourse (located south of the BFF site) to be indirectly impacted by construction upslope. However, it is definite that the artificial wetland formed in the old excavations on the BFF site will be directly impacted. 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.

Figure 11 shows the watercourses in relation to the 500m radius study area. Figure 12 shows the artificial wetland within the proposed BFF site.

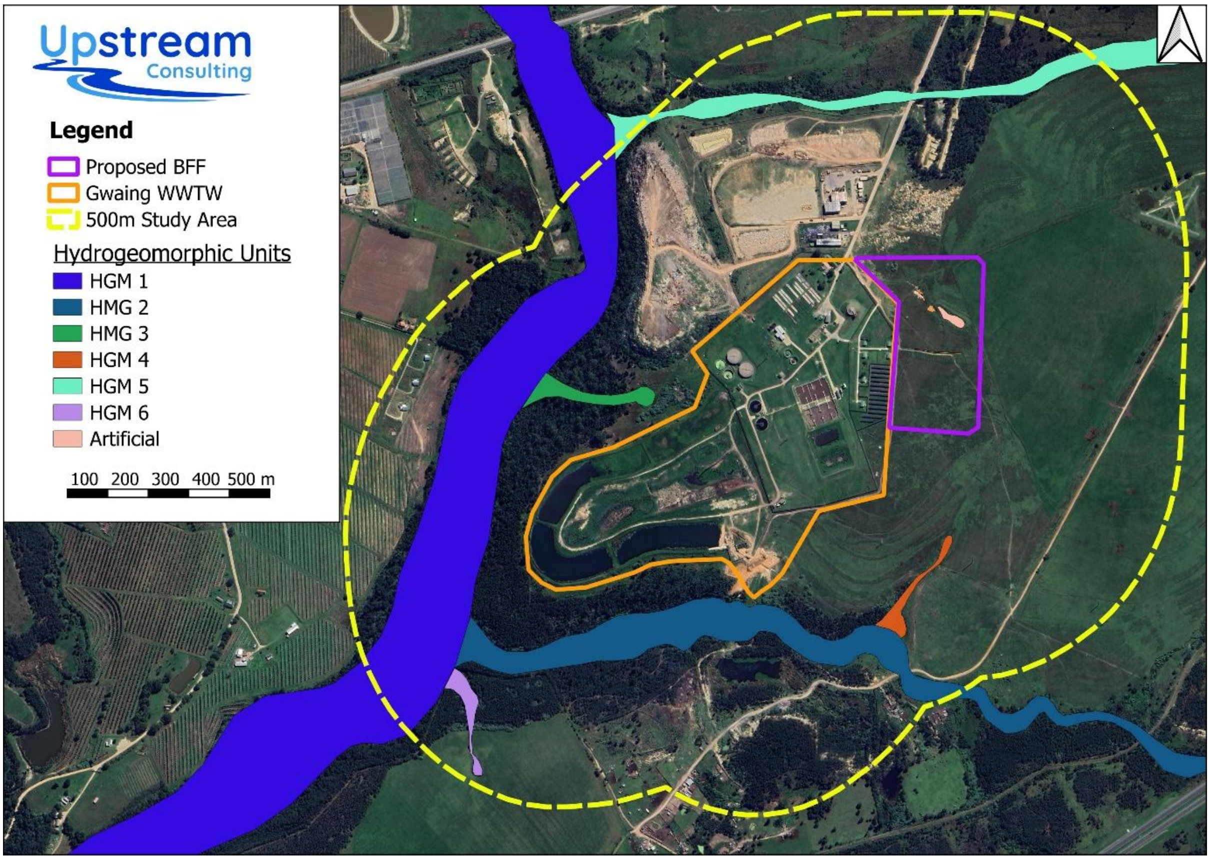

Figure 11: Map of the aquatic habitat identified within the 500m radius study area

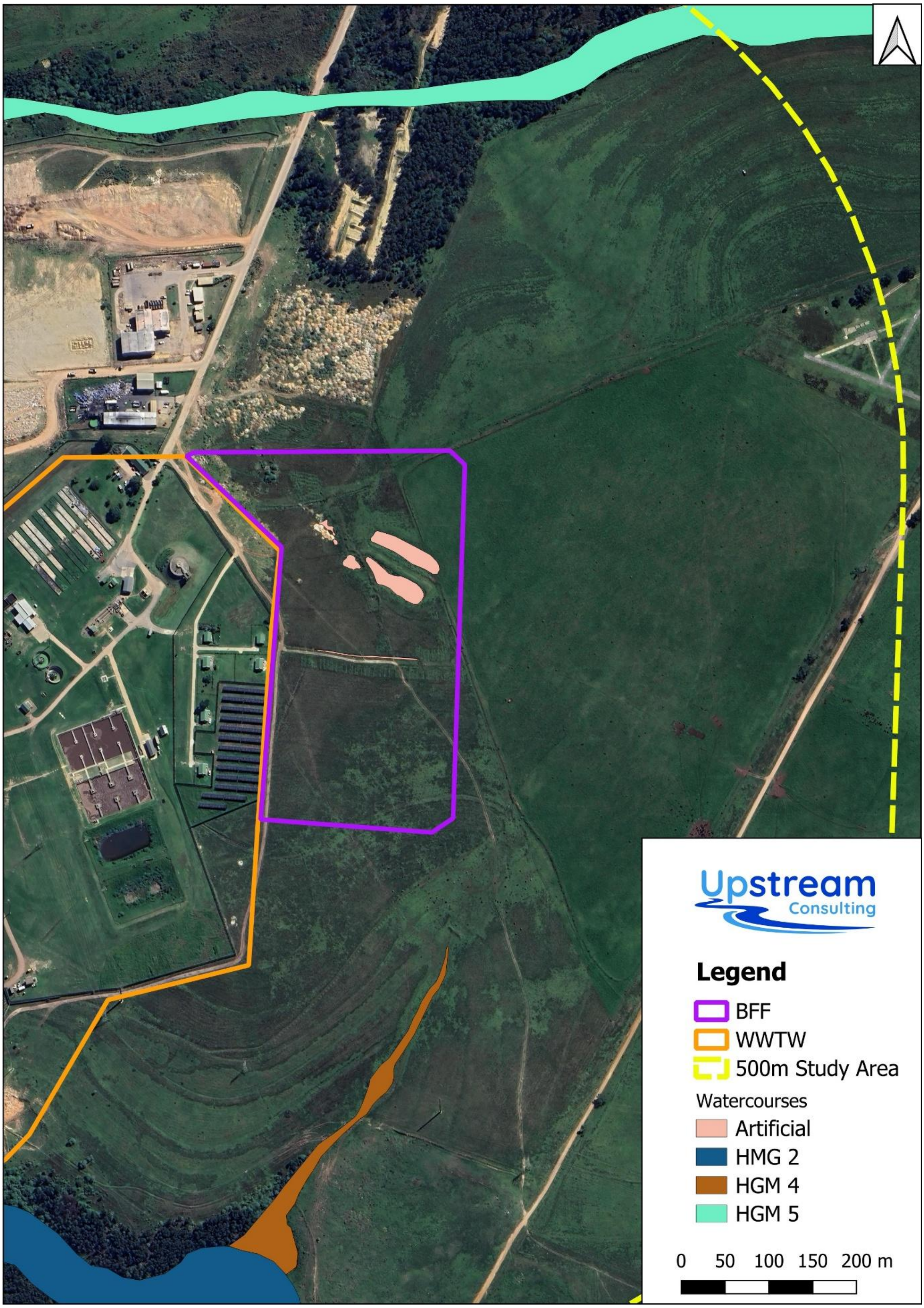

Figure 12: Map of the artificial wetland formed in old excavation at the proposed BFF site

7.2 DESCRIPTION OF AFFECTED AQUATIC HABITAT

The watercourses potentially affected by the upgrades to the WWTW infrastructure have already been assessed in the 2024 report. Therefore, to avoid repetition, only the artificial wetland on the BFF site, and HGM 4 to the south, are described below.

7.2.1 Artificial wetland

The site proposed for the BFF is located upon a relatively flat hilltop and slopes gently towards both the north and south. Past excavations and land surface disturbances upon this level plateau (probably undertaken for old sludge ponds, drainage ditches, buried infrastructure, or simply soil material) have resulted in numerous small, artificial depressions. Over time, wetland characteristics have developed due to prolonged soil saturation from digging into the perched water table. These wetland areas are not connected to the drainage network and soil augering throughout the site determined that there are no natural wetlands.

Although site assessment took place after a heavy rainfall event, there were only very small areas inundated within the depression. The site is intensely grazed and trampled but there are obligate plant species in these depressions, which have adapted to the seasonally saturated soils.

These artificial depressions do not support sensitive aquatic habitat. No rare, endangered, nor endemic species were observed, and none are expected to occur.

Plate 1: Artificial wetland formed in a shallow excavation

Plate 2: Obligate wetland plant species established in an excavated ditch

Plate 3: Soil mottling, indicating hydric conditions within the old, excavated area, characteristic of wetlands

7.2.2 HGM 4

The southern portion of the BFF site slopes more steeply towards the HGM 4 drainage, which joins the tributary to the Gwaing in the valley bottom. HGM 4 can be classified as a 1st order ephemeral stream. However, the upper reach is critically modified by agricultural activity and supports very little aquatic habitat.

HGM 4 is more than 100m away from the proposed BFF and therefore, provided stormwater runoff is managed appropriately, it is unlikely to be impacted by the project.

Plate 4: Looking south from the BFF site to the head of the HGM 4 drainage line located > 100m away

8 RESULTS

The impacts upon aquatic biodiversity as a result of the upgrades proposed at the Gwaing WWTW were discussed and assessed within the 2024 report. Therefore, only impacts relating to the proposed BFF are described below.

8.1 POTENTIAL IMPACTS

In order to construct the BFF in this location (and it is understood that other locations have been investigated but are not deemed suitable), the artificial wetland within the site will need to be infilled and lost. This is a direct negative impact upon aquatic biodiversity; however, it is of low cumulative significance.

The construction of the facility will positively reduce the impacts of the existing sludge stockpile on the Gwaing River from seepage. Therefore, while a small area of low sensitivity, artificial wetland will be lost, the construction of the facility will remove a source of pollutants to the mainstem river system.

8.2 OFFSET INVESTIGATION

The construction of the BFF will result in the direct loss of the very small artificial wetland (0.465ha). Loss of any wetland area is undesirable from an ecological perspective. Where wetlands are lost or degraded as a result of development impacts then some level of compensation should be considered.

In order to assess the need for any formal compensation, such as offsets, a wetland offset investigation was undertaken to determine if such an approach is required to mitigate the residual impacts of loss of the artificial depression. It determined that due to the negligible size and importance of the excavation there would not in fact be any remaining significant residual negative impacts on biodiversity.

The potential loss of the wetland area was assessed using the DWS Wetland Offset Calculator (as developed by McFarlane *et al* (2014) and included in the 2017 Draft National Offset Guidelines (GN 276 of March 2017)) to determine the wetland targets that would need to be achieved by any wetland offset. The offset calculations include consideration of wetland condition, extent, existing buffer condition, likely wetland condition in a development context, wetland importance in local, regional and bioregional conservation plans and the impacts of development on so-called wetland functionality. The offset calculation is based on the loss of 0.465 ha of artificial depression wetland. A summary of the wetland offset targets for the artificial wetland area to be lost is provided in Table 2 below.

It was determined that no functional wetland offsets are required. The small, artificial depression does not provide significant ecological functions at any scale and therefore there is a negligible loss. The same result was calculated for species conservation offset targets as there are no species of conservation concern within, or supported by, the artificial wetland.

The loss of the artificial wetland will not influence any biodiversity conservation targets or compromise water resource protection in any way, or on any scale. There is no need for wetland offsets to be implemented. However, compensation is encouraged to achieve a net gain. Any activities to improve nearby watercourses, such as the Gwaing River,and/ or the tributary by the WWTW Discharge outlet, would be an example of such voluntary compensation for wetland loss.

It is therefore recommended as a mitigation measure in this report that the scope of works for the project also include the financial provisioning and implementation of rehabilitation of the incision of the wetland below the WWTW discharge outlet and eradication of the alien invasive tree and shrub species (i.e. Black Wattle and Bugweed) in this reach.

Table 3 shows a summary of the assessment of wetland gains associated with rehabilitation of the HGM2 system at the discharge outlet (erosion control and alien plant clearing). It is clear from the offset investigation and calculations in the tables below, that the gains to aquatic biodiversity, after mitigation, outweigh the loss of the small artificial wetland area.

Table 2: Summary of wetland offset calculations for artificial excavation wetland

Determining wetland offset targets			
Wetland Functionality Targets			
Impact Assessment	**Prior to development**	Wetland size (ha)	**0,465**
		Functional value (%)	**20**
	Post development	Functional value (%)	**0**
		Change in functional value (%)	**20**
	Key Regulating and Supporting Services Identified		**Small area of intermittent innundation in artificial depression providing temporary habitat for wetland biota, but very limited, and not supporting any rare or endanged species.**
	Development Impact (Functional hectare equivalents)		**0,1**
Offset calculation	**Offset Ratios**	Triggers for potential adjustment in exceptional c	**None**
		Functional Importance Ratio	**1,0**
	Functional Offset Target (Functional hectare equivalents)		**0,1**
Further considerations	**Have other key Provisioning or Cultural Services Identified that require compensation?**		**No**
	Additional compensatory mechanisms proposed	The artificial depression does not have any key provisioning or cultural services associated with it. Therefore, no residual cumulative impact and no compensation required. Regardless, additional efforts to improve the nearby wetland integrity at the WWTW discharge outlet are encouraged.	

Ecosystem Conservation Targets

Impact Assessment	Prior to development	Wetland size (ha)	0,465	
		Habitat intactness (%)	20	
	Post development	Habitat intactness (%)	0	
		Change in habitat intactness (%)	20	
	Development Impact (Habitat hectare equivalents)		0,093	
Determining offset ratios	Ecosystem Status	Wetland Vegetation Group (or type based on local clasification)	Artificial - dominated by wide-spread sedge species and alien invasive plants, such as Kikuyu Grass. Highly degraded and previously disturbed vegetation. Grazed and trampled.	
		Threat status of wetland	Threat status	LT
			Threat status Score	1
		Protection level of wetland	Protection level	Not Protected
			Protection level Score	2
			Ecosystem Status Muliplier	2
	Regional and National Conservation context	Priority of wetland as defined in Regional and National Conservation Plans	Not specifically identiifed as important	0,5
			Regional & National Context Multiplier	0,5
	Local site attributes	Uniqueness and importance of biota present in t	Low biodiversity value	0,5
		Buffer zone integrity (within 500m of wetland)	Buffer compatability score	0,2
		Local connectivity	Low connectivity	0,5
			Local Context Multiplier	0,4
			Ecosystem Conservation Ratio	0,44
Offset Calculation	Development Impact (Habitat hectare equivalents)		0,0930	
	Ecosystem Conservation Ratio		0,4	
	Ecosystem Conservation Target (Habitat hectare equivalents)		0,0	

Species Conservation Targets

Species review and selection	Desktop Evaluation: Species flagged as potentially occurring at the site	Species Name		
		Juncus effusus		
		Cyperus congestus		
		Cenchrus clandestinus		
		Eleocharis limosa		
		Persicaria decipiens		
	Specialist assessment: Species of conservation concern identified as requiring offset activities	Species Selected	Rationale for species selection	
		None	No species of concern	
Target Species 1:		No species of concern		
Impact Assessment	Impact measure	No species of concern	Habitat measure	
		No species of concern	Habitat measure	
		Description and rationale for species impact measure selected		
		No species of concern		
	Prior to development	Species impact measure	0	
	Post development	Species impact measure	0	
		Change in species impact measure	0	
	Development Impact (Species impact measure)		0	
Determining offset ratios	Offest Ratios	Offset Ratio	0,0	
		Description and rationale for offset ratio selected		
		No species of concern		
			Species Conservation Ratio	0,0
Offset Calculation	Development Impact (Species impact measure)		0,0	
	Species Conservation Ratio		0,0	
	Species Conservation Target (Species measure)		0,0	

Table 3: Assessment of gains of receiving wetland – HGM2 – from rehabilitation efforts

Offset Receiving Areas: Assessing potential gains				
Contribution Towards Wetland Functionality Targets				
Wetland attributes	Wetland Reference		HGM 2 - tributary wetland to Gwaing River at WWTW outlet	
Alignment with site selection guidelines	Criterion	Relevance	Site attributes	Acceptability Guidelines
	Wetland type	Targeted wetlands should typically be of the same type to ensure that similar services to those impacted are improved through offset activities.	Wetland is of a different type to the impacted wetland.	Acceptable
	Key services targeted	Targeted wetlands should be prioritised and selected based on their ability to compensate for key regulating and supporting services impacted by the proposed development.	Selected wetland is well placed to contribute meaningfully towards improving key regulating and supporting services identified.	Ideal
	Offset site location relative to impacted wetland	Targeted wetlands should ideally be located as close to the impacted site as possible.	Selected wetland is located within the same local catchment as the impacted wetland.	Ideal
	Overall comment on alignment with site selection guidelines	Rehabilitation of a reach of the downsnstream wetland (a tributary to the Gwaing River) at the WWTW discharge pipe outlet will improve the regulatory and supporting services provided by the nearby, ecologically important wetland system (such as water purification and sediment trapping). This will more than compensate for the loss of a small patch of artificial, temprary wetland formed within the old excavation on the BFF site.		
Preliminary Offset Calculation	Prior to offset activities	Wetland size (ha)	2,7	
		Functional value (%)	60	
	Following sucessful offset implimentation	Functional value (%)	68	
		Change in functional value (%)	8	
	Preliminary Offset Contribution (Functional hectare equivalents)		0,2	
Final Offset Calculation	Criterion	Relevance	Offset activity	Adjustment factor
	Types of offset activities proposed	The risk of offset failure is linked to the type of offset activity planned with wetland establishment considered less preferable and more risky than rehabilitation or averted loss activities.	Rehabilitation & Protection	0,66
	Final Offset Contribution (Functional hectare equivalents)		0,1	
Contribution Towards Ecosystem Conservation Targets				
Wetland attributes	Wetland Reference		HGM 2 - tributary wetland to Gwaing River at WWTW outlet	
	Wetland Vegetation Group (or type based on local clasification)		Garden Route Granite Fynbos	
	Threat status of wetland		Threat status	CR
Alignment with site selection guidelines	Criterion	Relevance	Site attributes	Acceptability Guidelines
	Like for Like	Targeted wetlands should be aligned with "like-for-like" criteria to ensure that gains associated with wetland protection are commensurate with losses.	Wetland is of an alternative wetland type of a higher threat status in another wetland vegetation group (trading up)	Potentially acceptable
	Landscape planning	To what degree is wetland selection aligned with Regional and National Conservation Plans	Wetlands have been identified as being of high importance in landscape planning	Ideal
	Wetland condition	The habitat condition of the wetland should ideally be as good / better that that of the impacted site prior to development (or at least B PES Category in the case of largely un-impacted wetlands)	Final habitat condition is likely to be better than that of the impacted wetland.	Ideal
	Local biodiversity value	Wetlands that are unique or that are recognised as having a high local biodiversity value should be prioritised for wetland protection.	The wetland is charachterised by habitat and / species of high biodiversity value.	Ideal
	Viability of maintaining conservation values	Connectivity and consolidation with other intact ecosystems together with the potential for linkage between existing protected areas is preferable.	The wetland is well connected to other intact natural areas	Acceptable
	Overall comment on alignment with site selection guidelines	The site is within the same local catchment and the wetland is of higher conservation value but needs rehabilitation		
Preliminary Offset Calculation	Wetland areas to be secured	Wetland size (ha)	2,7	
		Habitat intactness (%)	68	
		Wetland habitat contribution (hectare equivalents)	1,8	
	Buffer zones to be secured	Area of wetland buffer zone included in the wetland offset site	0	
		Integrity of buffer zone	1	
		Buffer zone hectare equivalents	0,0	
		Buffer zone contribution (hectare equivalents)	0,0	
Final Offset Calculation	Criterion	Relevance	Site attributes	Adjustment factor
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement are more likely to be maintained in the long-term and are therefore preferred.	Minimum acceptable security of tenure for shortest acceptable period	1
	Offset Contributions	Wetland habitat contribution (hectare equivalents)	1,8	
		Buffer zone contribution (hectare equivalents)	0,0	
		Functional Offset Contribution (hectare equivalents)	1,8	
Contribution Towards Species Conservation Targets				
Target Species 1:		Natural habitat and biota - potentially endemic species		
Proposed offset activities	Description of offset activities proposed	Rehabilitation of degraded wetland		
	Rationale for proposed offset activities	Improvement of nearby, ecologically important habitat in lieu of artificial wetland loss		
Preliminary Offset Calculation	Species impact measure	Selected species impact measure	Habitat measure	
		Selected unit of measurement	Habitat measure	
		Species impact measure (secured)	2,0	
	Preliminary species contribution		2,0	
Final Offset Calculation	Criterion	Relevance	Site attributes	Adjustment factor
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement are more likely to be maintained in the long-term and are therefore preferred.	Minimum acceptable security of tenure for shortest acceptable period	1
	Risk of proposed activities	The risk of activities potentially failing to deliver desired outcomes should be taken into accont when assessing the potential offset contributions.	Moderate Risk	0,66
	Species Adjustment Factor			0,66
	Final Offset Contribution (Species measure)		1,3	

8.3 SIGNIFICANCE OF IMPACTS

The impact significance of the proposed BFF project was determined to be Low, after mitigation. Refer to Table 4 for the impact assessment table.

Mitigation requires the implementation of rehabilitation efforts in nearby aquatic habitat.

Table 4: Impact of loss of artificial depression for the BFF

PHASE:	Construction (at BFF)	
Potential impact and risk:	Loss of artificial wetland habitat	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Site and Permanent	None
Magnitude of impact or risk:	Low	
Probability of occurrence:	Definite	
Degree to which the impact may cause irreplaceable loss of resources:	Irreplaceable loss	
Degree to which the impact can be reversed:	Irreversible	
Indirect impacts:	None	
Cumulative impact prior to mitigation:	Medium	
Significance rating of impact prior to mitigation	Low	
Degree to which the impact can be avoided:	None	
Degree to which the impact can be managed:	None	
Degree to which the impact can be mitigated:	Can be mitigated	
Proposed mitigation:	• Implement rehabilitation efforts in nearby aquatic habitat to compensate for loss of artificial depression. • Appropriate stormwater management and prevention of hillslope erosion surrounding the facility	Duty of Care- Alien clearing and pollution control
Residual impacts:	Negligible	
Cumulative impact post mitigation:	Low	
Significance rating of impact after mitigation	Low	None

9 MITIGATION

It was determined that no wetland offsets for the loss of the artificial wetland on the BFF site are necessary (refer to Section 8.2 above). Rehabilitation efforts in nearby aquatic habitat will sufficiently compensate for the negligible amount and significance of loss. Therefore, from an aquatic perspective, the proposed project is deemed as acceptable, and the BFF construction will have a Low impact, after mitigation.

Figure 13 shows the area recommended for rehabilitation of HGM2 at the WWTW discharge point, in lieu of infilling the artificial depression within the BFF site.

Key rehabilitation measures include:

- Including the recommended rehabilitation in the project scope
- Provision of financial resources for rehabilitation efforts
- Appointment of a qualified engineer to design and implement interventions to rehabilitate the eroded channel
- Stabilisation of the erosion at the discharge outlet in the reach of the HGM2 wetland indicated in the maps below
- Compile a method statement for the removal of alien invasive plant species in the indicated rehabilitation area.
- Provide for the financial resources required for the alien plant clearing as part of this project
- Appoint and monitor the alien plant clearing activities
- Consult with an ecologist throughout regarding rehabilitation

Figure 14 indicates the extent of the area recommended for rehabilitation to compensate for loss while avoiding the need for formal wetland offsets.

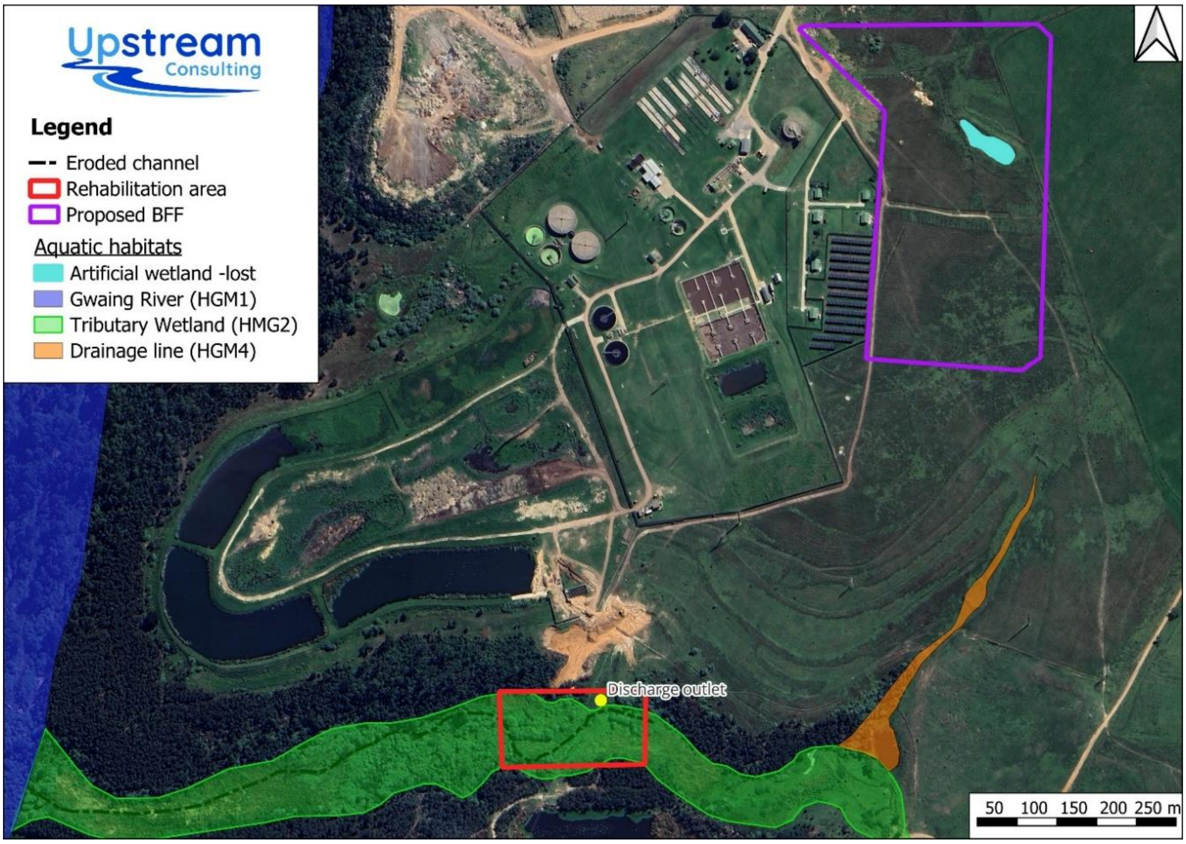

Figure 13: Map showing the area recommended for rehabilitation (red) of the HGM2 wetland – in relation to the WWTW and BFF - to achieve net gain

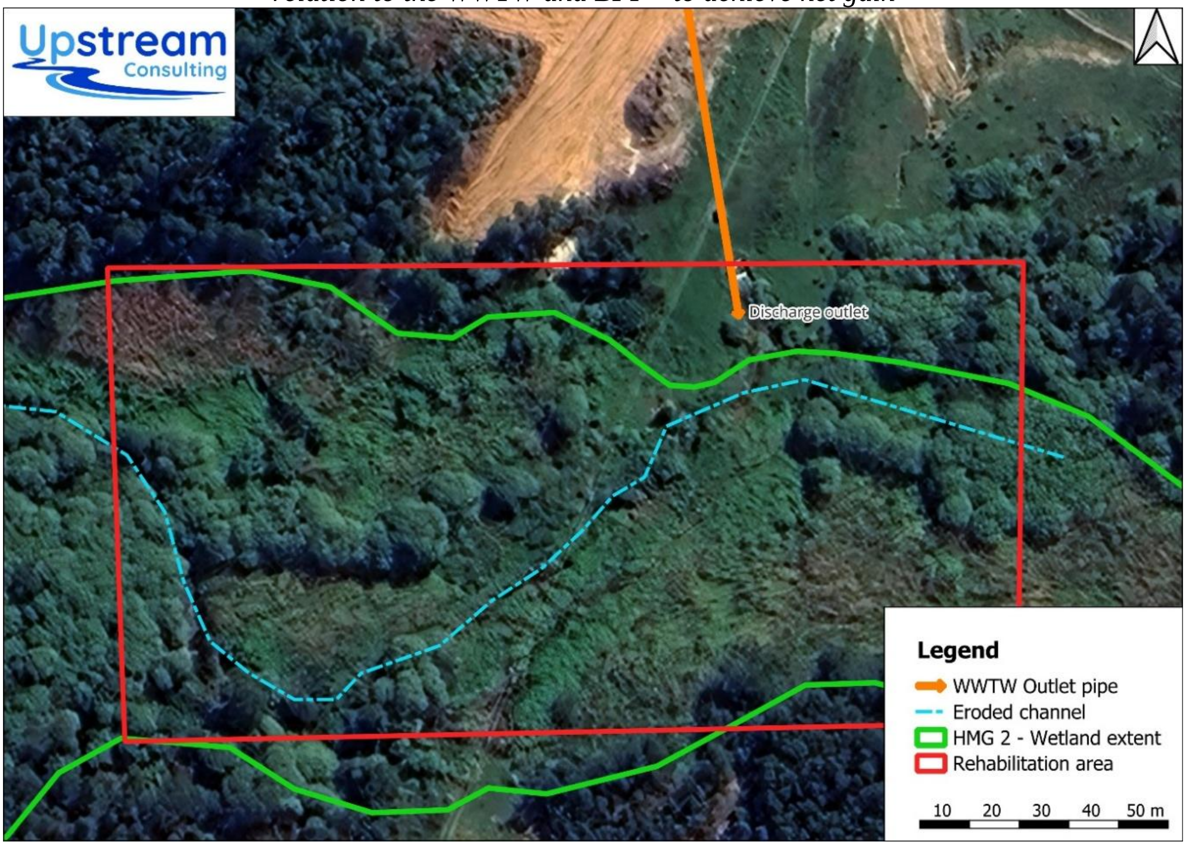

Figure 14: Location of the recommended rehabilitation area -for erosion control and alien plant clearing on HGM2- in relation to the WWTW discharge outlet

10 CONCLUSION

The proposed BBF development will result in the loss of a small, artificial wetland that has formed within an old excavation. This feature is not considered a natural wetland and does not support sensitive aquatic biodiversity. While its loss represents a direct impact, the significance is negligible at both local and broader ecological scales.

Crucially, the BBF will reduce ongoing pollution risks from unlined sludge stockpiles, thereby improving water quality protection for the Gwaing River. No formal wetland offsets are required; however, voluntary compensation through rehabilitation of the eroded wetland area downstream of the WWTW discharge outlet is strongly recommended and will result in a net ecological gain.

From an aquatic biodiversity perspective, the BBF project is considered environmentally acceptable, provided that the recommended mitigation and rehabilitation measures are implemented.

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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

11.1 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.

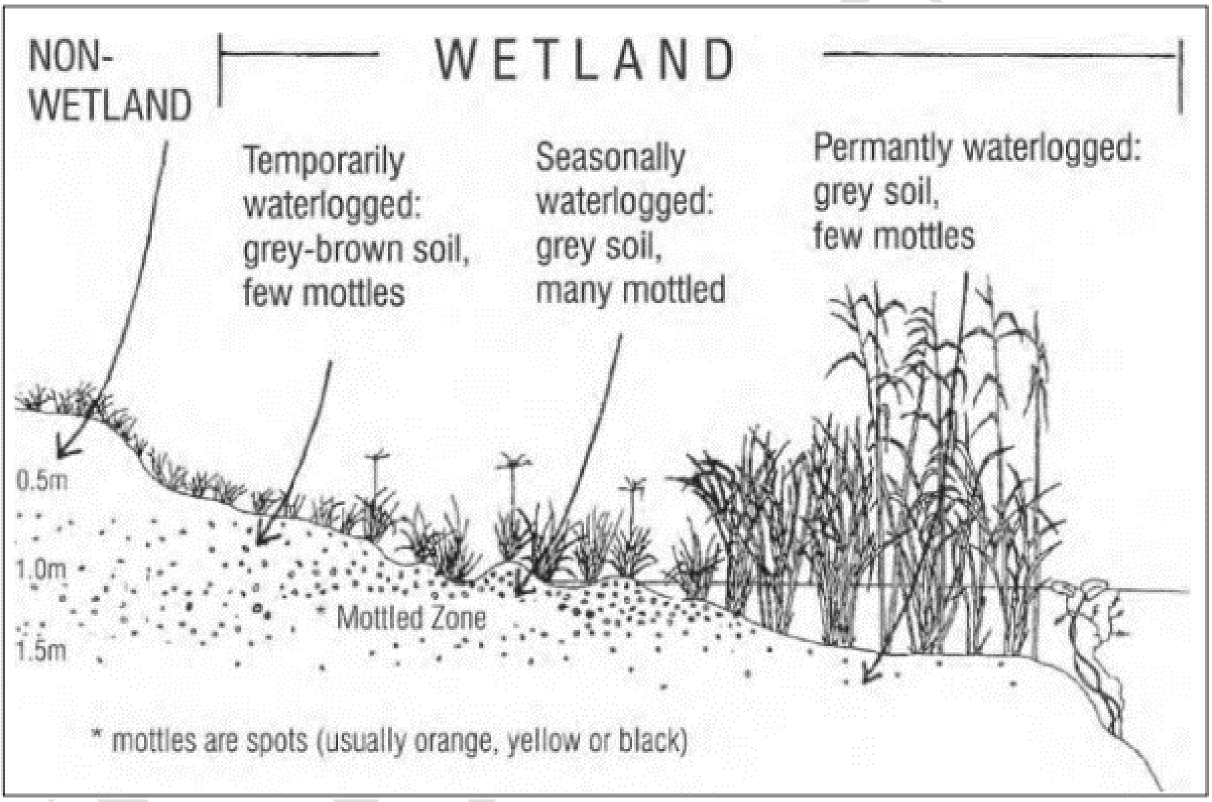

Figure A12.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

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).

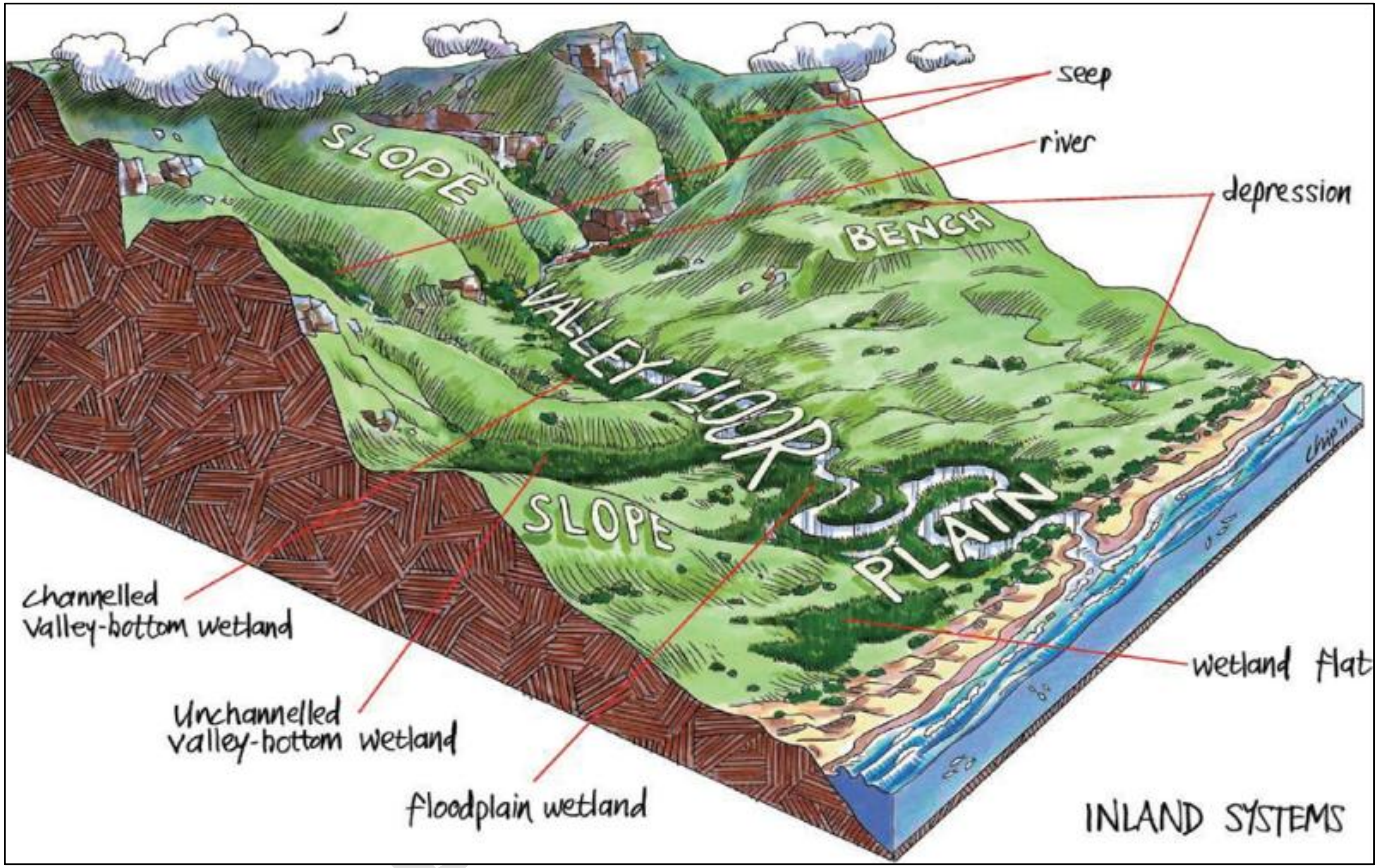

Figure A12.1b: Illustration of wetland types and their typical landscape setting (From Ollie et al. 2013)

11.2 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.

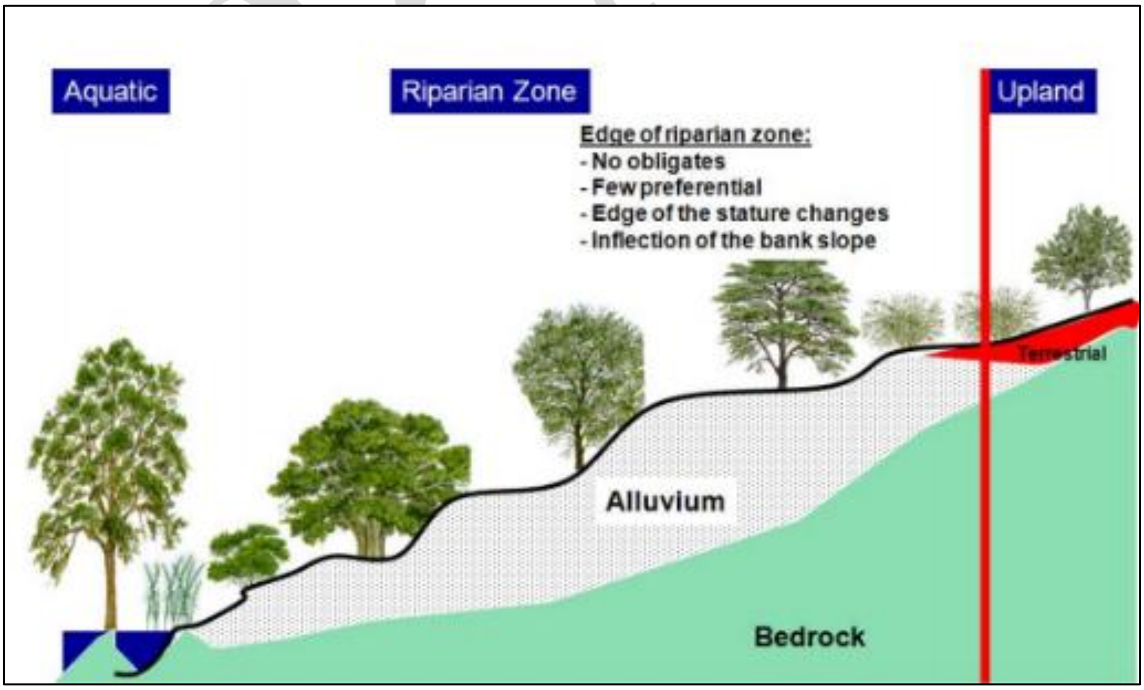

Figure A12.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and

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).

11.3 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

11.4 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

11.5 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.

11.6 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
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Date of birth: 26th August 1987
Country of origin: South Africa
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<u>Professional profile</u>

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).

<u>Tertiary Education</u>

- 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)