The proposed Oliphant Estate Township development on the Remainder of Portion 18 of the Farm Roode Pan 70, Northern Cape

Aquatic Biodiversity Assessment

February 2022

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Declaration of Independence

I, **Antoinette Bootsma**, in my capacity as a specialist consultant, hereby declare that I -

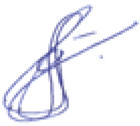
- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Antoinette Bootsma (PrSciNat)
Ecologist/Botanist
SACNASP Reg. No. 400222-09

2022.02.16
Date

I, **Bertus Fourie**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.



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2022.02.14
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Project name: The proposed Oliphant Estate Township development on the Remainder of Portion 18 of the Farm Roode Pan 70, Northern Cape			
Nature of Signoff	**Responsible Person**	**Role/Responsibility**	**Qualifications**
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Document number	**Checked by:**	**Electronic Signature:**	**Date**
Report Integration and Technical Review	Antoinette Bootsma		2022.02.16
Client review			
Final Report	Antoinette Bootsma		

EXECUTIVE SUMMARY

Limosella Consulting was appointed by Envirolution Consulting to undertake an aquatic biodiversity assessment to inform the Environmental Authorization for the proposed Oliphant Estate township development on the Remainder of Portion 18 of the Farm Roodepan 70, Northern Cape. A biodiversity assessment, including an assessment of wetlands, was undertaken by EcoAgent in 2018. The current assessment aimed to verify the extent and condition of wetlands presented in EcoAgent (2018) and further expands on the scope of the EcoAgent 2018 assessment to address all the aspects set out in the Protocols for the Assessment and Reporting of Environmental Themes, GN320, (March 2020). Fieldwork was undertaken in January 2022.

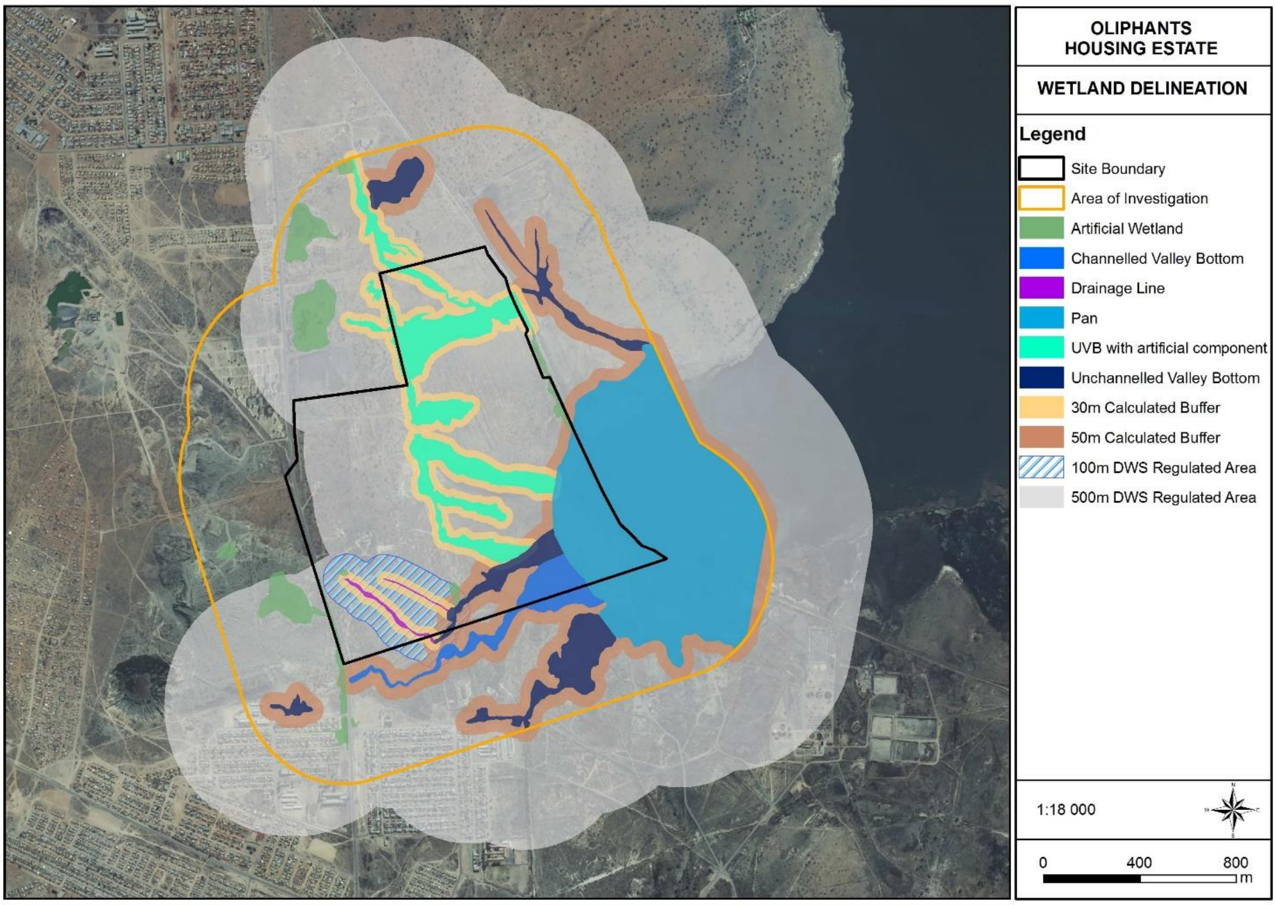
The terms of reference for the study were as follows:

- Verify the EcoAgent (2018) wetland delineation to inform the placement of infrastructure;
- Verify the EcoAgent (2018) classification of watercourses according to the system proposed in the national wetlands inventory if relevant,
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020, drawing from EcoAgent (2018) and confirmed by extensive fielwork undertaken in 2022,
- Verify and expand on the functional and integrity assessment of wetlands and riparian areas to address requirements set out in General Notice 267 of 24 March 2017;
- Undertake an impact assessment as specified in the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Review watercourse buffer zones presented in EcoAgent (2018) as specified in General Notice 267 of 24 March 2017, following Macfarlane *et al.,* 2015; and
- Review mitigation and management procedures presented in EcoAgent (2018) relevant to the conserving wetland areas on the site as specified in GN320, March 2020.

Two wetland drivers in addition to the natural surface water drainage are relevant to this study. These two drivers are soil with a high clay content and water spilt from leaking pipes.

The presence of soils with a high clay content occurs throughout the site. Depressions therefore quickly fill with rain water and also water leaking from pipes or sewage infrastructure, which allows the clay to swell and trap this water, resulting in wetland conditions. A distinction between natural and artificial wetlands are complicated by the long-term nature of leaks.

Wetland types recorded on the site include the pan (Kamfers Dam), Channelled and Unchannelled Valley Bottom wetlands, Unchannelled Valley Bottom wetlands with Artificial elements and Drainage Lines and Artificial wetlands which are obviously created by voids. The image below presents the delineated watercourses together with their associated buffer zones.



Expected significant impacts to these watercourses, and particularly to the downslope Kamfers Dam, are twofold. Firstly, the stormwater runoff generated by the development in the context of the already inundated pan and expected increased flood events resulting from climate change will add to cumulative impacts to the beleaguered pan. In addition, the risk of further addition of sewage into the pan is high. A single spill event will have significant negative impacts to the habitat of endangered bird species. The realistic likelihood of mitigating these impacts fall to the engineers to prove with empirical data and should be afforded a high level of scrutiny.

The important factors relevant to the project are summarised in **Error! Reference source not found.** Table b elow.

	Quaternary Catchment and WMA areas	Important Rivers possibly affected
	C91E – #5 WMA Vaal	The Vaal River lies 16km northwest of the site. Drainage lines drain into Kamfers Dam from its topographic catchment. Two drainage lines are shown to run through the study site
Kamfers Dam - Pan	**PES: C – Moderately Modified** with a combined PES score of 3.1, 69%. The Water Quality obtained the lowest score (F – Critically Modified). The condition of the wetland is expected to decrease gradually in the next 5 years, although Water Quality is expected to deteriorate rapidly unless catchment wide correction is effected. **ES** (2.2 – Moderate) + EI (4.0 Very High) = **EIS (4.0 Very High).** The most significant Ecosystem Services are Biodiversity Maintenance, Assimilation of Phosphate, Nitrate and Toxicants which scored Very High. Education and Research also scored Very High. **Water quality:** The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS_ this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm. **Instream habitat (IHAS):** The IHAS score was calculated to 40% and 38% sample site .This indicates the habitat is "Insufficient for supporting a diverse aquatic macro invertebrate community" (Table 34). **Aquatic macroinvertebrate assemblages:** Sample 1: Not completed due to classification of system Sample 2: SASS score 30, 8 taxa, ASPT 3.8. Using the "Dallas Bands" (Dallas, 2007) the SASS5 Ecological Category was determined to **E/F** classification. The classification suggests that the system is in **poor** condition. This assessment is in line with the site observations. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**	
Unchannelled Valley Bottom wetlands (UVB)	**PES: C – Moderately Modified** with a combined PES score of 2.2 – 78%. The Vegetation module of the assessment scored highest (B) although the modules Hydology, Geomorphology and Water Quality showed more impact (PES Class C). The condition of the wetland is expected to decrease gradually in the next 5 years. ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**	

<table>
<tr><td>Channelled Valley Bottom Wetlands (CVB)</td><td colspan="4">

PES: C – Moderately Modified with a combined PES score of 2.7 – 73%. All four modules fall in the C category. The condition of the wetland is expected to decrease gradually in the next 5 years.

ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate.

Water quality: The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS_ this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm.

Instream habitat (IHAS): The IHAS score was calculated to 40% and 38% sample site This indicates the habitat is “Insufficient for supporting a diverse aquatic macro invertebr.ate community” (Table 34).

Aquatic macroinvertebrate assemblages:
Sample 3: SASS score 10, 5 taxa, ASPT 2
Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C

</td></tr>
<tr><td>Channelled Valley Bottom wetlands with Artificial Elements (CVB with Artificial Elements)</td><td colspan="4">

PES: C – Moderately Modified with a combined PES score of 3.7 – 63%. The modules Hydrology and Geomorphology fall in the C category. Modules Water Quality and Vegetation are more impacted and fall in the D category. The condition of the wetland is expected to decrease gradually in the next 5

ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate.

Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C

</td></tr>
<tr><td>Drainage Lines</td><td colspan="4">

EC: The Ecological Category obtained for the two drainage lines fall in the

ES (1.0 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Service is Phosphate Assimilation which scored Very High.

Recommended Ecological Management Category: C

</td></tr>
<tr><td>Buffer zones</td><td colspan="4">Calculated (Macfarlane et al, 2015): 30m and 50m</td></tr>
<tr><td rowspan="4">NEMA 2014 Impact Assessment</td><td colspan="2">The impact scores for the following aspects are relevant:</td><td>Without Mitigation</td><td>With Mitigation</td></tr>
<tr><td rowspan="2">Changes to flow dynamics</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>M</td></tr>
<tr><td>Sedimentation</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
</table>

		Operation Phase	M	L
	Establishment of alien plants	Construction Phase	M	L
		Operation Phase	M	L
	Pollution of watercourses	Construction Phase	M	L
		Operation Phase	M	M
	Loss of fringe vegetation and habitat	Construction Phase	M	L
		Operation Phase	L	L
	Loss of aquatic habitat	Construction Phase	M	M
		Operation Phase	M	M
Does the specialist support the development?	No. More in depth understanding of the alternatives and realistic mitigation measures are needed before we can support the development. The Kamfers Dam is a resource that should be protected from further degradation. It appears likely that the development will contribute to significant cumulative impacts to the pan.			
Recommendations	In addition to the measures listed in the impact tables the following should be noted: • It is recommended that attenuation of stormwater is done at more than 50% of storm event to protect the Kamfers dam from inundation. • Currently it is well known that the wastewater treatment of the Kimberly is not operational. Additional sewage cannot be sent to a system that is already not operational. Sewage must be treated on site before reticulation to irrigate open space areas or sent to evaporation ponds. • Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.			

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Tables

1 INTRODUCTION

Limosella Consulting was appointed by Envirolution Consulting to undertake an aquatic biodiversity assessment to inform the Environmental Authorization for the proposed mixed use residential development on the Remainder of Portion 18 of the Farm Roode Pan 70 in Kimberley in the Sol Plaatjie Local Municipality, Northern Cape Province. The property lies approximately 10km to the north of Kimberley between the Kamfers Dam and the Midlands Road, the total study area proposed for development is approximately 150 hectares.

A biodiversity assessment, including an assessment of wetlands, was undertaken by EcoAgent in 2018. The current assessment aimed to verify the extent and condition of wetlands presented in EcoAgent (2018) and further expands on the scope of the EcoAgent 2018 assessment to address all the aspects set out in the Protocols for the Assessment and Reporting of Environmental Themes, GN320, (March 2020). Fieldwork was undertaken in January 2022.

1.1 Details of the Proposed Development

Oliphants Housing Estate (Pty) Ltd is proposing the construction of a mixed use residential development. The development entails an estimated 2886 housing units consisting of 175 freehold units and 2711 sectional title units including High Density Residential, Lower Density Residential Nodes and a Business Node. The overarching objective for the Oliphant Estate Township Development is to drive economic growth within the northern section of Kimberley while minimising social and environmental impacts. The current housing backlog in the Sol Plaatjie Local Municipality is estimated at 4 000 units.

The full number of units will be provided with surfaced access roads, a metered water supply and waterborne sewerage. The following associated infrastructure will also be constructed to provide basic services to the development:

- Construction of internal access roads to serve the entire development,
- As far as reasonably possible, the existing road that provide direct access to the site will be utilised and upgraded where required,
- Public open spaces; and
- Storm water management systems

The proposed layout is presented in Figure 1 below. No alternatives were available for assessment.

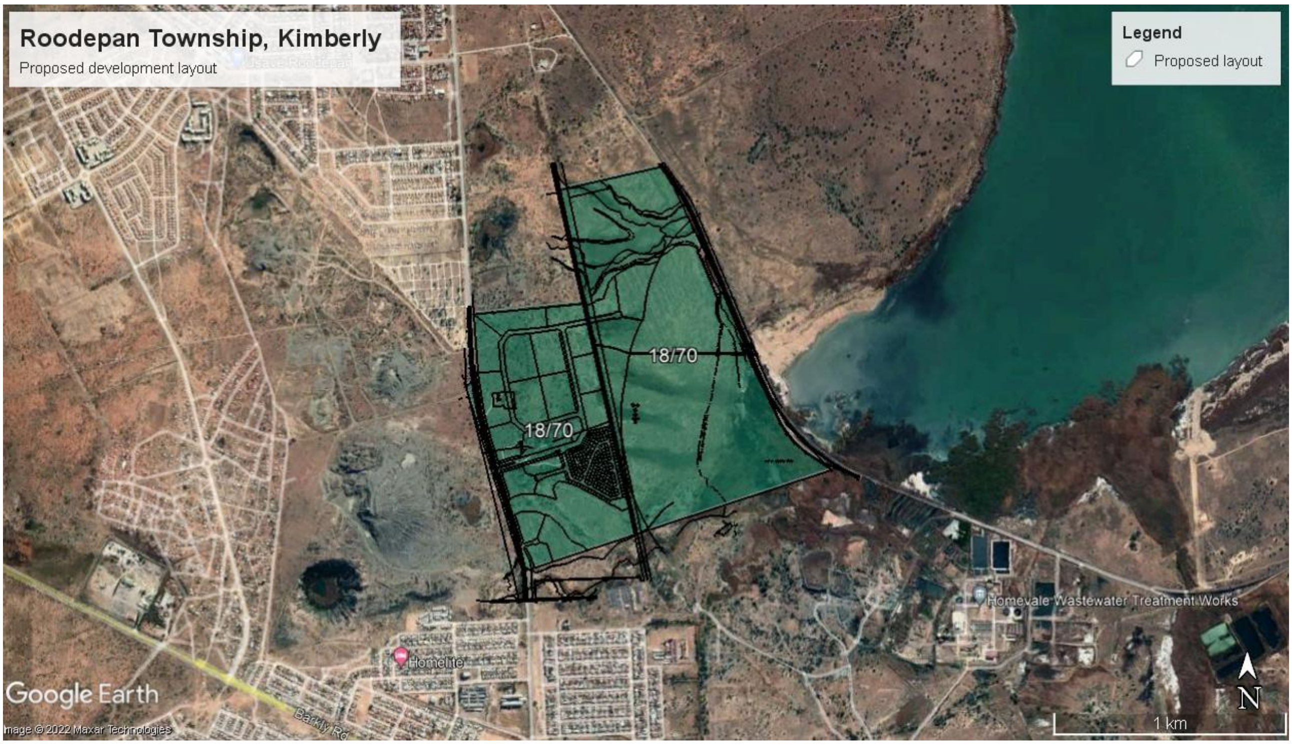

Figure 1: Proposed development layout for Roodepan Township

1.2 Terms of Reference

The terms of reference for the study were as follows:

- Verify the EcoAgent (2018) wetland delineation to inform the placement of infrastructure;
- Verify the EcoAgent (2018) classification of watercourses according to the system proposed in the national wetlands inventory if relevant,
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020, drawing from EcoAgent (2018) and confirmed by extensive fielwork undertaken in 2022,
- Verify and expand on the functional and integrity assessment of wetlands and riparian areas to address requirements set out in General Notice 267 of 24 March 2017;
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- Review mitigation and management procedures presented in EcoAgent (2018) relevant to the conserving wetland areas on the site as specified in GN320, March 2020.

1.3 Assumptions and Limitations

- The information provided by the client forms the basis of the planning and layouts discussed.
- No alternatives were available for assessment at the time of writing this report. This requirement of GNR982 (as amended by GN326) could therefore not be addressed.

- All wetlands within 500 m and riparian areas within 100m of any developmental activities should be identified as per the DWS Water Use Licence Application regulations. Wetlands and riparian areas presented in EcoAgent (2018) were verified based on detailed soil and vegetation sampling. Wetlands presented in EcoAgent (2018) that fall outside of the site, but that fall within 500 m of the proposed activities were delineated based on desktop analysis of vegetation gradients visible from aerial imagery.
- The detailed field study was conducted from a once off field trip and thus would not depict any seasonal variation in the macroinvertebrates or wetland plant species composition and richness.
- Description of the depth of the regional water table and geohydrological and hydropedological processes falls outside the scope of the current assessment
- Floodline calculations fall outside the scope of the current assessment
- A Red Data scan, fauna and flora assessments were not included in the current study
- The recreation grade GPS used for wetland and riparian delineations is accurate to within five meters.
- Wetland delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.

1.4 Definitions and Legal Framework

The National Water Act, 1998 (Act No. 36 of 1998) [NWA] provides for Constitutional water demands including pollution prevention, ecological and resource conservation and sustainable utilisation. In terms of this Act, all water resources are the property of the State and are regulated by the Department of Water and Sanitation (DWS). The NWA sets out a range of water use related principles that are to be applied by DWS when taking decisions that significantly affect a water resource. The NWA defines a water resource as including a watercourse, surface water, estuary or aquifer. A watercourse includes a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, pan or dam, into which or from which water flows; any collection of water that the Minister may declare to be a watercourse; and were relevant its beds and banks.

The NWA defines a wetland as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.” In addition to water at or near the surface, other distinguishing indicators of wetlands include hydromorphic soils and vegetation adapted to or tolerant of saturated soils (DWA, 2005).

Riparian habitat often times performs important ecological and hydrological functions, some similar to those performed by wetlands (DWA, 2005). Riparian habitat is also the accepted indicator used to delineate the extent of a river’s footprint (DWAF, 2005). It is defined by the NWA as follows: “Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas".

Water uses for which authorisation must be obtained from DWS are indicated in Section 21 of the NWA. Section 21 (c) and (i) is applicable to any activity related to a watercourse:
Section 21(c): Impeding or diverting the flow of water in a watercourse; and
Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

Authorisations related to wetlands are regulated by Government Notice 509 of 2016 regarding Section 21(c) and (i). This notice grants General Authorisation (GA) from the DWS for the above water uses should the Risk Assessment matrix (DWS, 2016) reflect a Low score. Activities that obtain a Medium or High risk score requires authorisation through a Water Use Licence (WUL) from the Department.
Conditions for impeding or diverting the flow of water or altering the bed, banks, course or characteristics of a watercourse (Section 21(c) and (i) activities) include:
9. (3) (b). The water user must ensure that the selection of a site for establishing any impeding or diverting the flow or altering the bed, banks, course or characteristics of a watercourse works:
(i) is not located on a bend in the watercourse;
(ii) avoid high gradient areas, unstable slopes, actively eroding banks, interflow zones, springs, and seeps.

In March 2020, the Department of Environmental Affairs issued General Notice 320 set out requirements of the EIA Screening Tool Protocols for the Assessment and Reporting of Environmental Themes including Aquatic Biodiversity. These specifications overlap somewhat with the 2014 EIA regulations as amended (GN 982 of 2017). Compliance to these requirements are presented in Appendix A.
In addition to the above, the proponent must also comply with the provisions of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP).
- National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA].
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- Regulations GN R.982, R.983, R. 984 and R.985 of 2014, promulgated under NEMA.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983).
- Regulations and Guidelines on Water Use under the NWA.
- South African Water Quality Guidelines under the NWA.
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 287 of 2002).
- GN 267 (Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals)
- GN 982 of 2017 NEMA EIA regulations

1.5 Locality of the study site

The site is located approximately 10km north of Kimberley between Kamfers Dam and Midlands Road. Kamfers Dam is known for its resident population of Lesser Flamingo (*Phoenicoparrus minor*). The township of Galeshewe lies directly south of the site and the suburb of Roodepan lies to the northwest of the site (Figure 2). A railway line forms the northeastern boundary of the site. A powerline runs through the site.

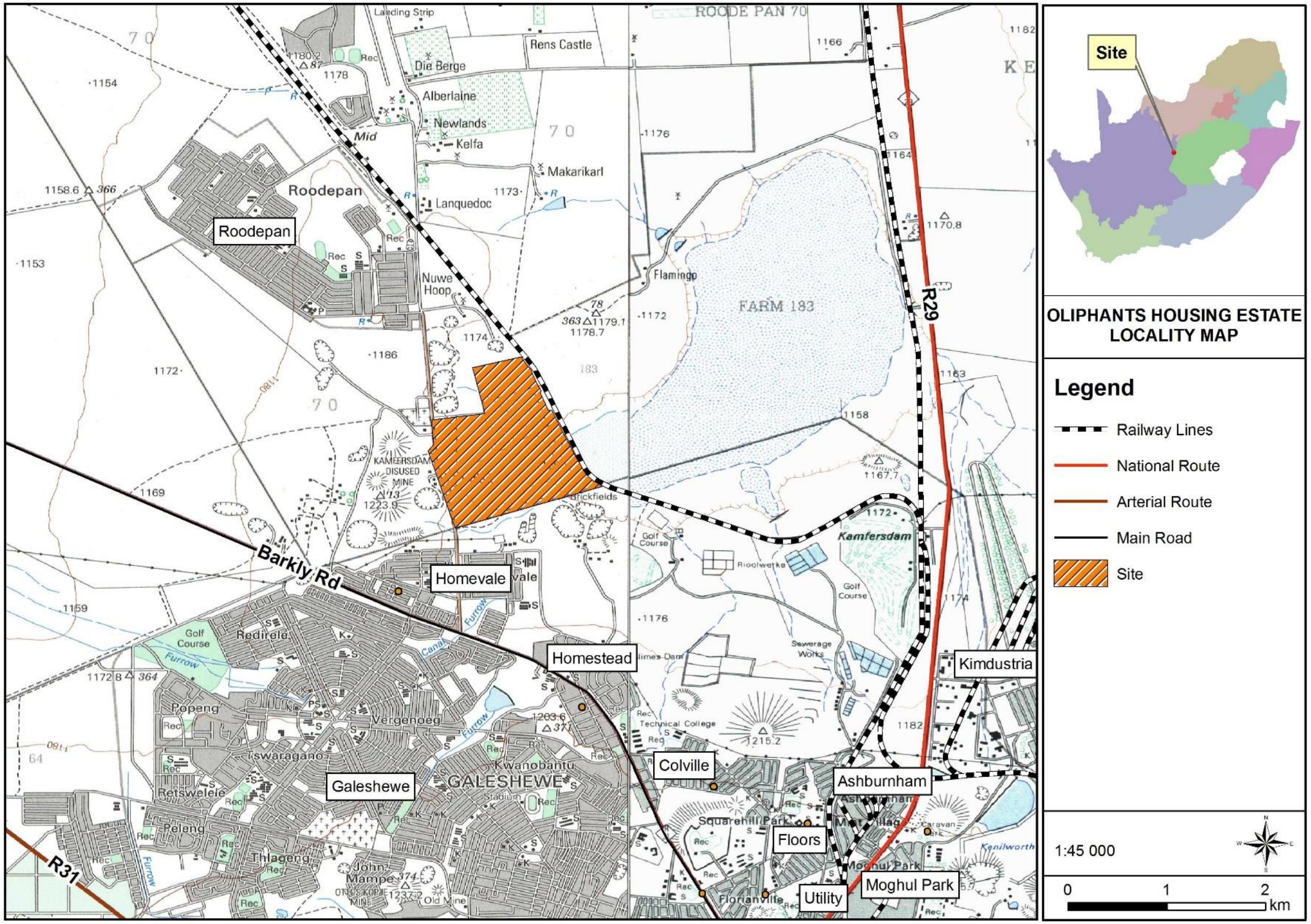

Figure 2: Locality Map

1.6 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state. Table 1 below provides a summary of the important aspects.

Table 1: A summary of relevant site information obtained from a review of available spatial data

National Screening Tool (Https://screening.environment .gov.za/screeningtool)	
	Kamfers Dam is classified as High aquatic sensitivity. The areas outside the dam are classified as Low aquatic sensitivity
General Description (Mucina & Rutherford, 2006)	
GPS Coordinates	28°41'5.05"S and 24°44'15.82"E
Topography	The landscape slopes town towards Kamfers Dam which forms the lowest point in the area. The slope on the site is generally south-eastwards from about 1175 to 1159 masl close to Kamfers Dam
Climate	Summer and autumn rainfall and very dry winters are typical of the area with a mean annual precipitation of about 450 mm. Extreme variation exists between winter minimum (mean monthly minimum in July -4.1oC) and summer maximum (mean monthly maximum in January 37.5oC) temperatures. The winters are dry and cold and frost is frequent in winter
Broad Vegetation Units	Kimberley Thornveld (SVk 4) and Vaalbos Rocky Shrubland (SVk 5). Kamfers Dam is considered to be a pan classified as Highveld Salt Pans (AZi 10)
Conservation Status	Least threatened
Hydrology and National Freshwater Ecosystem Priority Area (NFEPA) (2011) Database	
Important Rivers (CDSM, 1996) (Figure 3)	The Vaal River lies 16km northwest of the site. Drainage lines drain into Kamfers Dam from its topographic catchment. Two drainage lines are shown to run through the study site
Quaternary Catchment	C91E
WMA (Government Gazette, 16 September 2016)	#5 Vaal Major: rivers include the Wilge, Liebenbergsvlei, Mooi, Renoster, Vals, Sand, Vet, Harts, Molopo and Vaal
DWAF (2014) http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx	2969 (Vaal River) (PES=) (EI=High) (ES=High)
Wetland Ecosystem Type	Eastern Kalahari Bushveld Group 3
NFEPA Wetlands (Nel *et al.*, 2011)	Kamfers Dam is listed as n NFEPA wetland, Rank 2.This rank refers to wetlands with the following attributes: • Wetlands within 500 m of a IUCN threatened frog point locality; • Wetlands within 500 m of a threatened waterbird point locality;

	• Wetlands (excluding dams) with the majority of its area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes; • Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional biodiversity importance, with valid reasons documented; • Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose
Geology and soils	
Geology	Located on both Dolomite and Shale
Soils	Fb13 - Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in upland soils but generally present in low-lying soils Fa14 - Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape
Conservation Status	
Northern Cape Dept of Env and Nature Conservation 2016 (Figure 4)	Kamfer's Dam (pan) is classified as a Critical Biodiversity Area as is the northern part of the site. The remainder of the site is classified as 'Other Natural Areas'

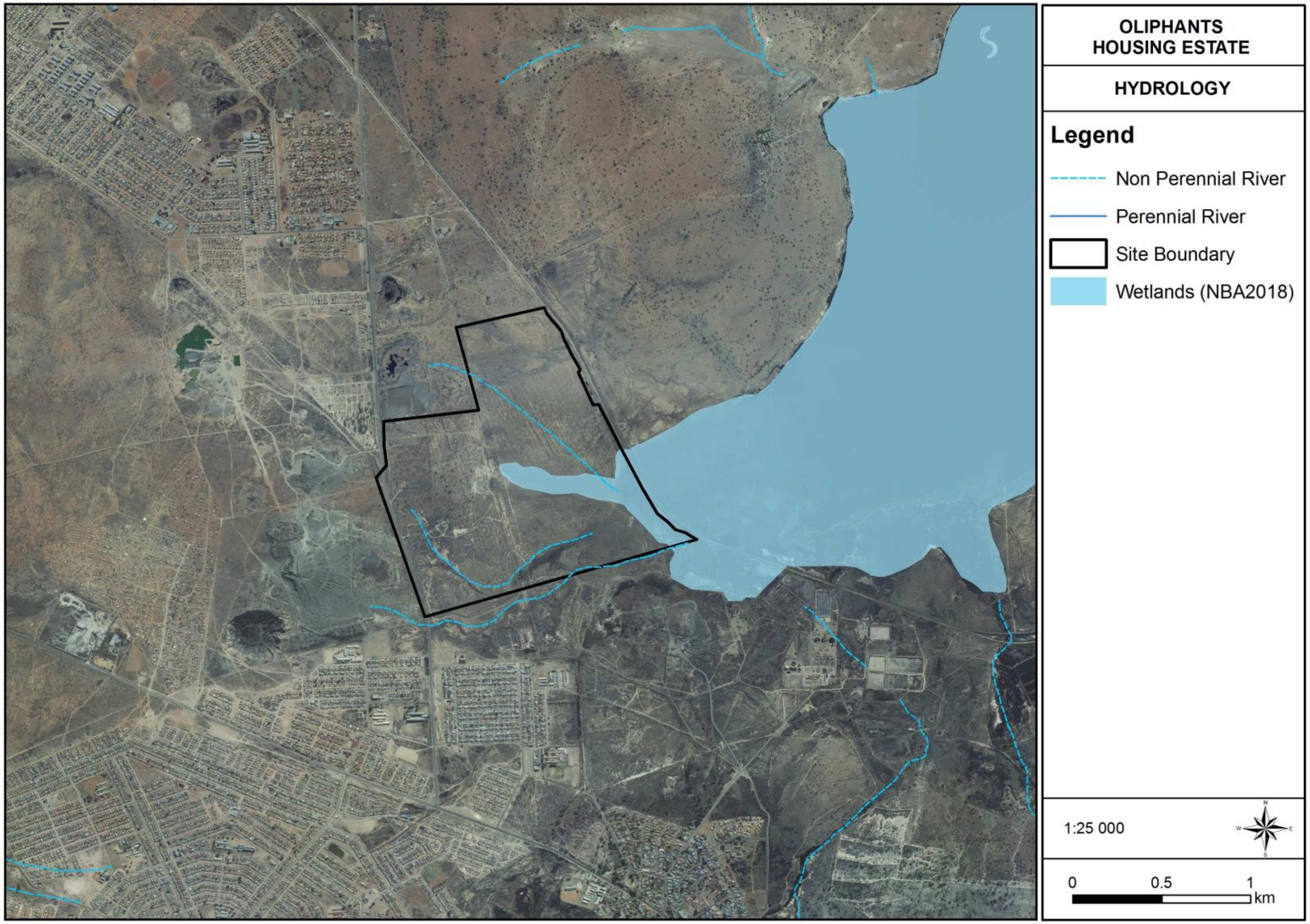

Figure 3: Regional hydrology

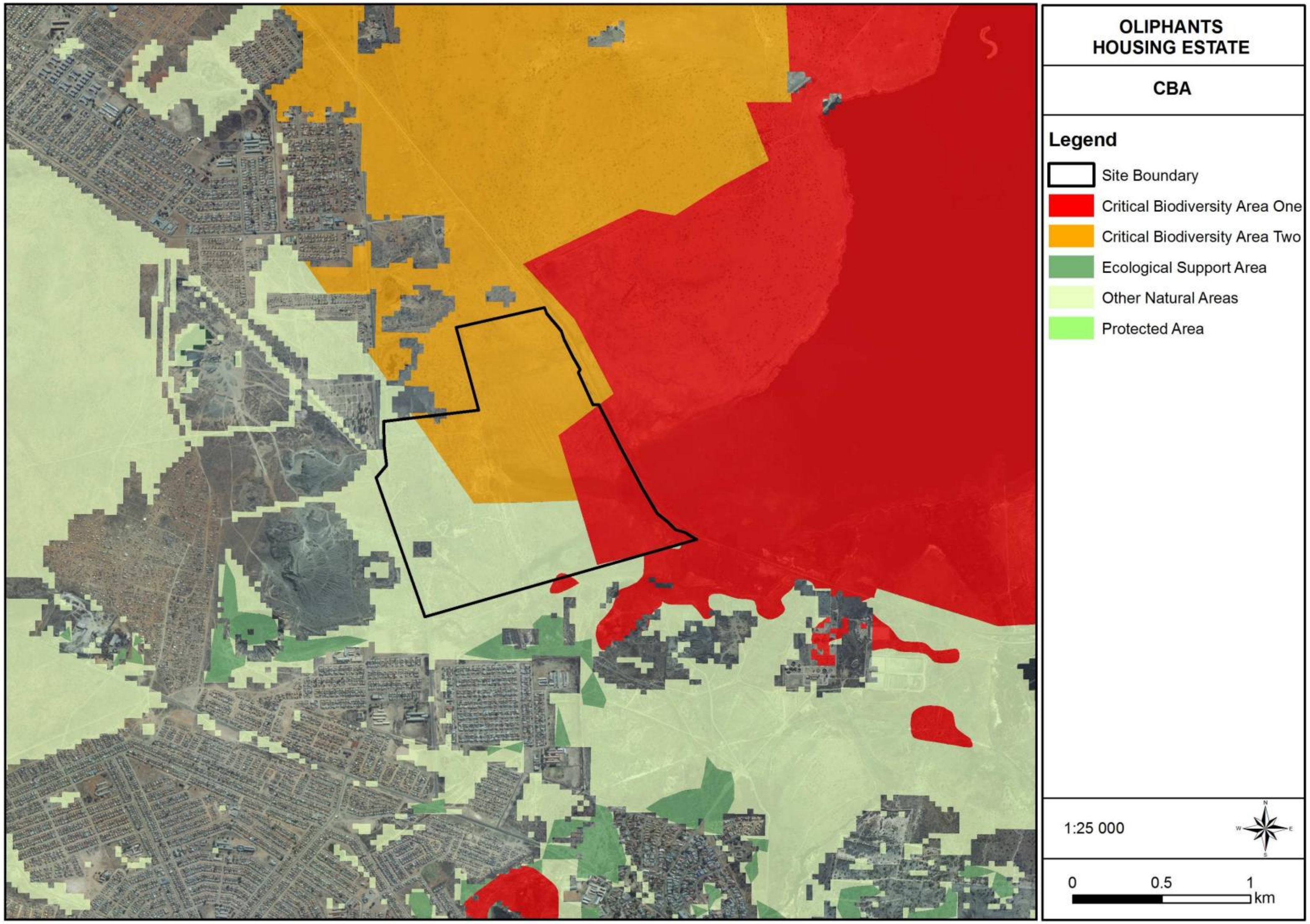

Figure 4: C-Plan classification of the study area and surroundings.

2 METHODOLOGY

The Aquatic Biodiversity Assessment report complies with GN320, March 2020. A summary table indicating the minimum requirements indicated in these documents, and their relevance to this report, is presented in Annexure A.

The delineation method documented by the DWS in their document "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), as well as the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al.*, 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held Garmin Montana 650 and/or a Samsung S10 smartphone was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey. Applications used on the smartphone includes GPX Viewer Pro and Google Earth.

Following a desktop assessment highlighting watercourses to be groundtruthed in the field, soil and vegetation sampling on site informed a fine scale delineation. Functional and integrity assessments were conducted to indicate the baseline status of the watercourses identified. No wetland conditions were recorded on the site. The riparian habitat was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Kleynhans *et al*, 2008.

In order to ease the legibility of the report, details regarding the methods used in each phase of the watercourse assessment are presented in Appendix B.

2.1 Conducting the 2022 Baseline Aquatic Assessment

In South Africa, the River Health Programme (under the Department of Water and Sanitation) has developed a suite of different programs to rapidly assess the quality of aquatic systems. One of the most popular and robust indicators of aquatic ecology health is the South African Scoring System or SASS currently in version 5 (SASS5).

The South African Scoring System is a biotic index initially developed by Chutter (1998). It has been tested and refined over several years and the current version is SASS5 (Dickens and Graham, 2002). This technique is based on a British biotic index called the Biological Monitoring Working Party (BMWP) scoring system and has been modified to suit South African aquatic micro-invertebrate fauna and conditions. SASS5 is a rapid biological assessment method developed to evaluate the impact of changes in water quality using aquatic macro-invertebrates as indicator organisms. SASS is widely used as a bio-assessment tool in South Africa because of the following reasons:

- It does not require sophisticated equipment
- Method is rapid and relatively easy to apply.

This method is very cheap in comparison to chemical analysis of water samples and analysis and interpretation of output data is simple. Sampling is generally non-destructive, except where representative collections are required, (the biodiversity index of SASS5 is described in Dickens and Graham (2002).
It provides some measure of the biological status of rivers in terms of water quality.

SASS is therefore a method for detection of current water quality impairment and for monitoring long-term trends in water from an aquatic invertebrate's perspective. Although SASS5 is user-friendly and cheap, it has some limitations. The method is dependent on the sampling effort of the operator and the total SASS score is greatly affected by the number of biotopes sampled.

SASS5 is not accurate for lentic conditions (standing water) and should be used with caution in ephemeral rivers (systems that do not always flow) (Dickens and Graham, 2002) The resolution of SASS5 is at family level; therefore, changes in species composition within the same family due to environmental changes cannot be detected.

Although the SASS5 score acts as a warning 'red flag' for water quality deterioration, it cannot pinpoint the exact cause and quantity of a change. SASS5 does not cover all invertebrate taxa. SASS also cannot provide information about the degradation of habitat, so habitat assessment also indices, to show the state of the habitat. The initial SASS protocol was described by Chutter (1998) and refined by Dickens and Graham (2002) require collections of macro-invertebrates from a full range of biotopes available at each site.

The biotopes sampled include vegetation both in and out of current (VG- aquatic and marginal), stones (S- both stones in current and out of current) and gravel, sand and mud (GSM) (Dickens & Graham, 2002). The standardised sampling methods allow comparisons between studies and sites. Macro-invertebrate sampling is done using a standard SASS net (mesh size 1000 mm, and a frame of 30 cm x 30 cm). There are nineteen (19) possible macro-invertebrates from each biotope that are tipped into a SASS tray half filled with water and families are identified for not more than 15 minutes/biotype at the streamside.

Invertebrates encountered from each biotope are recorded on a SASS5 score sheet, with their abundance being noted on the sheet. Each taxon (usually a family) of invertebrates from South African rivers has been allocated a score ranging from 1 for those taxa that are most tolerant of pollutants, to 15 for those that are most sensitive to pollutants (Chutter, 1998). To complete the SASS exercise the scores for all the taxa are added together (total score). The average score per taxon (ASPT) is calculated by dividing the total score by the number of taxa. All three scores (SASS5, ASPT and number of families) are used in the interpretation of the status of the site or river being assessed dependant on operator choice.

Table 2: Ecological Categories for interpreting SASS data

Ecological Category	Ecological Category Name	Description	Colour
A	Natural	Unmodified natural	Blue
B	Good	Largely natural with few modifications	Green
C	Fair	Moderately modified	Yellow
D	Poor	Largely modified	Red
E	Seriously modified	Seriously modified	Purple
F	Critically modified	Critically or extremely modified	Black

2.2 Invertebrate Habitat Assessment System (IHAS)

Invertebrate Habitat Assessment System (IHAS) was specifically developed to be used in conjunction with SASS, based on habitat availability (McMillan, 1998). The scoring system is based on sampling habitat (i.e. availability of a range of habitats, which could be utilized by in-stream invertebrates) and more general stream characteristics such as anthropogenic or natural impacts (McMillan, 1998). This habitat scoring system is based on 100 points (or percentage) and is divided into two sections reflecting the sampling habitat (50 points) and stream characteristics (50 points).

The sampling habitat section is further broken down into three subsections: stones in current (20 points), vegetation (15 points) and other habitats (15 points) (McMillan, 1998). Very specific questions and answers score between 0 and 5. Higher scores indicate better habitat for macro-invertebrates. The ideal condition is not based on the ultimate pristine stream, but rather on the representation of all habitats adequately and in reasonable conditions. The IHAS form must be completed for each site sampled during each sampling season. This index is mostly subjective with the data collected dependent on the assessor's visual observation and level of expertise. IHAS data was to aid the interpretation of SASS data. As the site has not yet been developed this assessment is seen as a reference condition assessment of the macroinvertebrate assemblages of the site.

3 RESULTS

3.1 Land Use, Cover and Ecological State

The region has been impacted by mining for about 150 years as is evidenced by the mine spoils visible to the east of Midlands Road. Evidence of old agricultural fields are visible on the site. Currently, communal grazing and powerline dominate land use (EcoAgent, 2018).

3.2 Watercourse Classification and Delineation

The EcoAgent (2018) assessment identified several wetland types as shown in Figure 5 below. Note the site boundary in the current assessment is reduced from the site assessed in 2018. While the current assessment agrees with much of the 2018 wetland delineation and classification, a few changes are proposed. The extent of several wetlands are slightly increased and changes to the classification of several wetlands are made. Two wetland drivers in addition to the natural surface water drainage are relevant to this study, and also to the proposed changes to the delineation and classification presented in 2018. These two drivers are soil with a high clay content and water spilt from leaking pipes.

The presence of soils with a high clay content occurs throughout the site. Depressions therefore quickly fill with rain water and also water leaking from pipes or sewage infrastructure, which allows the clay to swell and trap this water, resulting in wetland conditions. A distinction between natural and artificial wetlands are complicated by the long-term nature of leaks. It appears as though the volume of water leaked into the adjacent landscape is higher that in 2018. This observation is based on the fact that wetlands partly driven by leaking infrastructure are more extensive than in 2018. However, depressions in the landscape not linked to the leaking infrastructure had not filled with rainwater (they were dry and soil was cracked) in 2022. This leads us to the conclusion that the extended wetlands did not result only from the higher rainfall the region experienced in the last two seasons.

The change in classification of wetlands is related to the same drivers. It is unlikely that clay soils will form extensive seepage conditions as is indicated in EcoAgent (2018). Seepage wetlands are therefore reclassified as Unchannelled Valley Bottom Wetlands with Artificial Components. The Artificial Seep indicated in Figure 5 does have a slight correlation with wetlands reflected on historic imagery (EcoAgent, 2018) although it is acknowledged that the correlation is not strong. An elevation profile shows benches with shallow valleys in the slope of the site that correspond to the branches of this wetland (Figure 6). Following the precautionary principle they are included into the classification of Unchannelled Valley Bottom with Artificial Components. Abbreviations for wetlands include:

- CVB – Channelled Valley Bottom wetland
- UVB – Unchannelled Valley Bottom

The revised wetland map, including a 500m Area of Investigation around the amended site boundary, calculated buffer zones and the DWS regulated Area are shown in Figure 7 below.

It is evident that wetland boundaries will respond to changes in the drivers for example, should issues regarding stormwater and sewage be managed so as to reduce spills, the extent and nature of the wetlands affected by these spills will be altered.

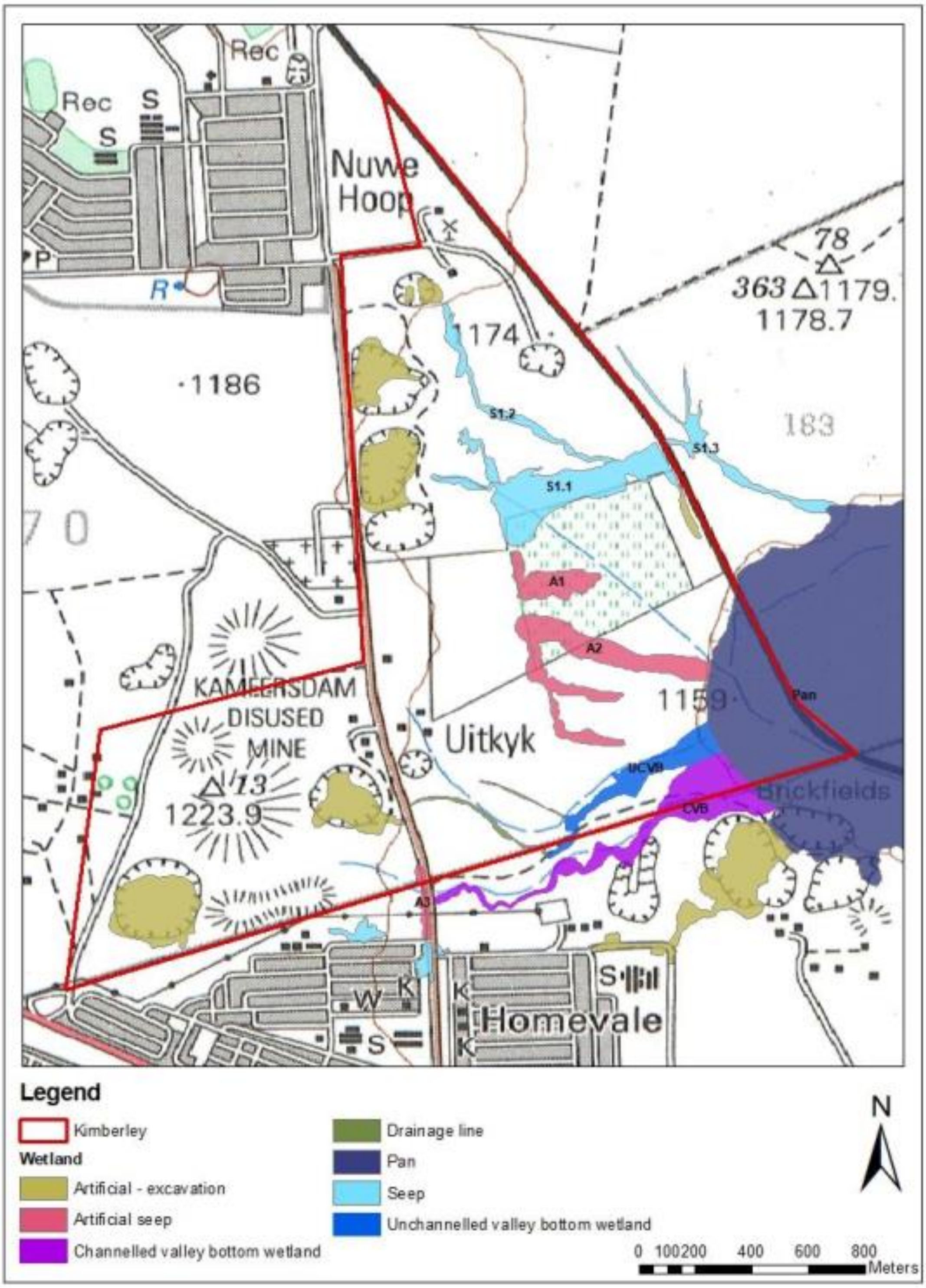

Figure 5: Watercourses delineated and classified in EcoAgent (2018).

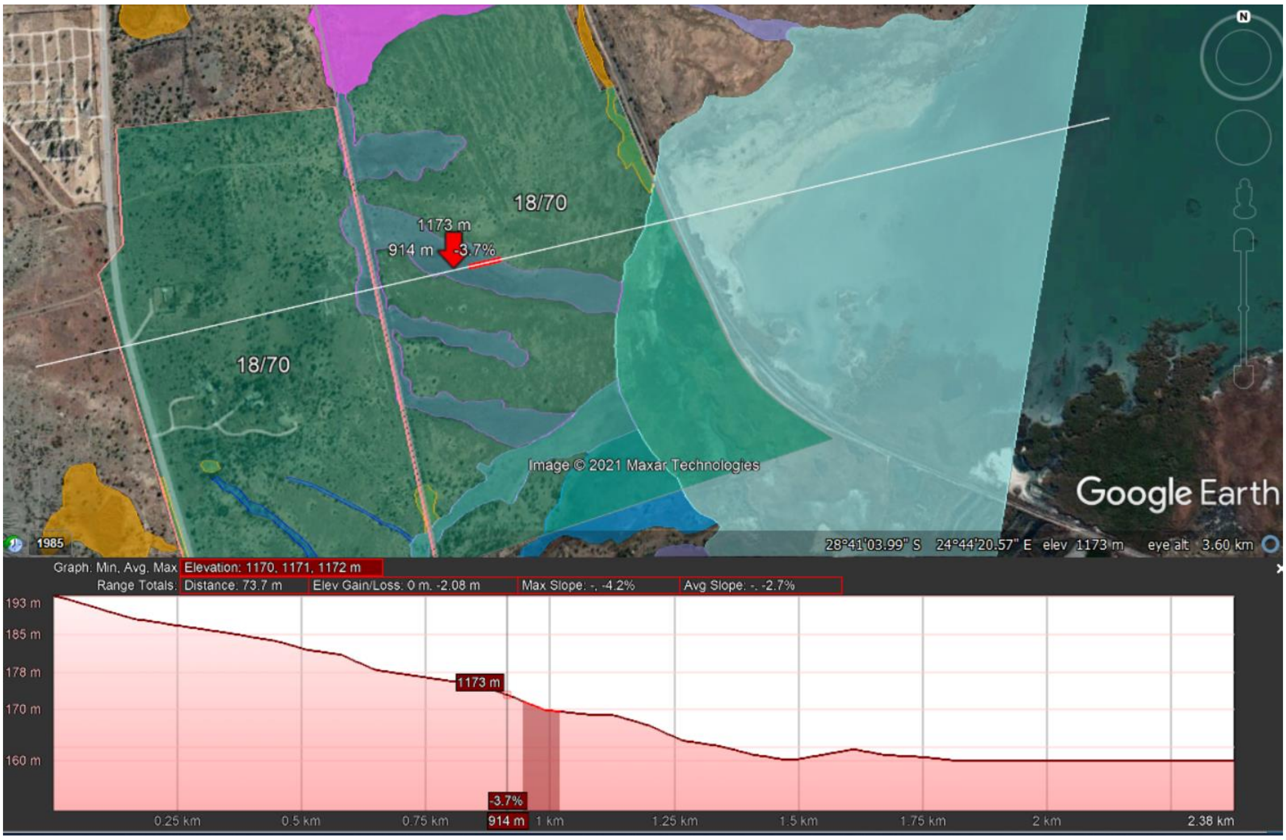

Figure 6: The Google Earth elevation profile showing benches and shallow valleys that correspond to the branches of the wetlands classified as Artificial Seeps in EcoAgent (2018).

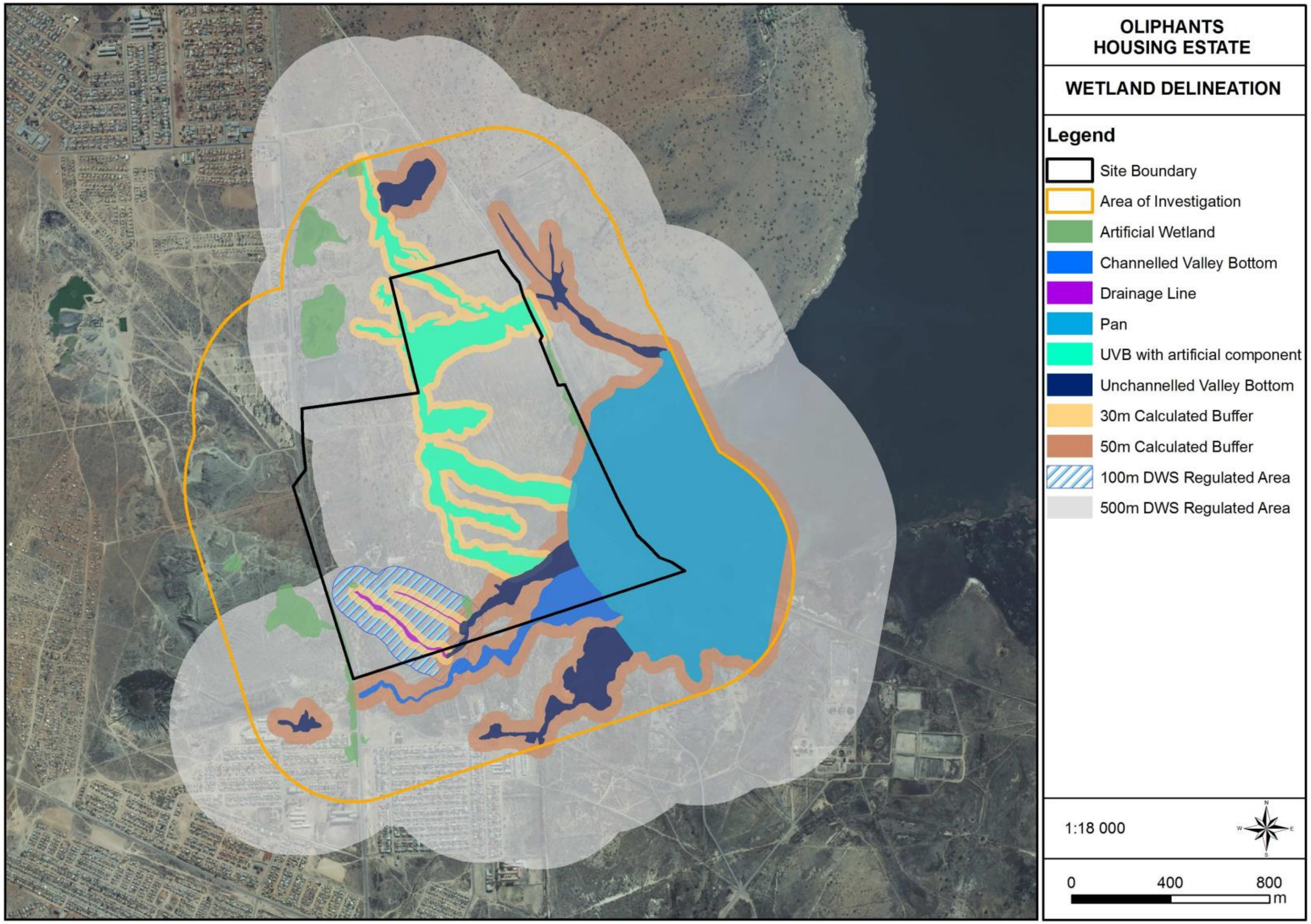

Figure 7: Verified watercourses and associated calculated buffer zone, stormwater outlets and the DWS regulated area

3.2.1 Soil & Vegetation Indicators

Soil and vegetation characteristics recorded in 2018 have not altered significantly. Bleached clay with clear redoximorphic features were observed throughout the delineated wetlands (Figure 8). An extensive list of plant species recorded in the wetlands is presented EcoAgent (2018).

Figure 8: Plant and soil characteristics observed on site support the description in EcoAgent (2018).

3.3 Watercourse Functional Assessment

EcoAgent (2018) describes various impact to the different watercourse units on site including the railway bisecting a section of the pan, the powerline, roads, leaking pipelines and excavation. The status of water quality forms the focus of Sections 3.3.4 below. This aspect of watercourse integrity is the subject of concern for many stakeholders as it significantly impacts on the viability of a breeding population of Lesser Flamingos.

In order to reflect a comprehensive suite of assessments appropriate to each watercourse type and characteristics, the following assessments are discussed in the sections below (Table 3).

Table 3: Assessments undertaken in the current assessment

Watercourse Type	**Assessment Method**
Kamfers Dam - Pan	• WetHealth V2 (EC/PES) (Macfarlane *et al.,* 2020) • WetEcosystem Services V2 (ES) (Kotze *et al*., 2020) • Environmental Importance and Sensitivity category (EIS) (Kotze *et al.,* 2020) • Instream habitat (IHAS) (Mcmillan ph (1998)) • Aquatic Macroinvertebrate Assemblages (Dickens and Graham (2002)). Only applied to sections suitable for the methodology • Recommended Ecological Category (REC) Rountree *et al.,* (2013)
Channelled Valley Bottom Wetlands (CVB)	• WetHealth V2 (EC/PES) (Macfarlane *et al.,* 2020) • WetEcosystem Services V2 (ES) (Kotze *et al*., 2020) • Environmental Importance and Sensitivity category (EIS) (Kotze *et al.,* 2020) • Instream habitat (IHAS) (Mcmillan ph (1998)) • Aquatic Macroinvertebrate Assemblages (Dickens and Graham (2002)). Only applied to sections suitable for the methodology • Recommended Ecological Category (REC) Rountree *et al.,* (2013)
Unchannelled Valley Bottom wetlands (UVB)	• WetHealth V2 (EC/PES) (Macfarlane *et al*., 2020) • WetEcosystem Services V2 (ES) (Kotze *et al*., 2020) • Environmental Importance and Sensitivity category (EIS) (Kotze *et al*., 2020) • Recommended Ecological Category (REC) Rountree *et al*., (2013)
Unchannelled Valley Bottom wetlands with Artificial Elements (UVB with Artificial Elements)	• WetHealth V2 (EC/PES) (Macfarlane et al., 2020) • WetEcosystem Services V2 (ES) (Kotze et al., 2020) • Environmental Importance and Sensitivity category (EIS) (Kotze *et al.,* 2020) • Recommended Ecological Category (REC) Rountree *et al.,* (2013)
Drainage Lines	• VEGRAI (EC) Kleynhans et al, 2008 • Environmental Importance and Sensitivity category (EIS) (Kotze *et al*., 2020) • Recommended Ecological Category (REC) Rountree *et al*., (2013)

3.3.1 Present Ecological Status (PES) - WetHealth Version 2 (Kotze *et al.*, 2020).

Present Ecological Status scores obtained in 2018 are presented in Table 4 below (EcoAgent, 2018). No scores are calculated for the artificial wetlands since the PES assessment calculates the change from a theoretical reference condition. The reference condition for artificial wetlands is a terrestrial environment and therefore a calculation of PES is not relevant.

Table 4: Summary of the results of the WetHealth assessment conducted by EcoAgent (2018).

Wetland Unit	Hydrology		Geomorphology		Vegetation		Combined PES	
	Score	Class	Score	Class	Score	Class	Score	Class
Pan	1.0	B	0.3	A	0.6	A	0.7	A
CVB	3.0	C	0.1	A	0.4	A	1.4	B
UCVB	7.5	E	1.2	B	2.6	C	4.2	D
UCVB with artificial elements	3.3	C	0.2	A	1.9	B	2.0	C

The WetHealth version 2 method includes a water quality component and also takes into account catchment wide impacts that affect the watercourse unit being assessed. A review of the 2018 scores was therefore considered necessary. Revised scores are presented in Table 5.

Table 5: Summary of the results of the WetHealth (Version 2) assessment conducted for each wetland unit

Kamfers Dam - Pan

Final (adjusted) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	1.5	1.3	9.0	1.5
PES Score (%)	86%	88%	10%	85%
Ecological Category	**B**	**B**	**F**	**B**
Trajectory of change	→	→	↓↓	↓
Confidence (revised results)	Medium	Medium	High	Medium
Combined Impact Score	3.1			
Combined PES Score (%)	69%			
Combined Ecological Category	**C**			
Hectare Equivalents	501.2 Ha			

Unchannelled Valley Bottom

Final (adjusted) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	2.3	2.1	1.5	3.0
PES Score (%)	77%	79%	85%	70%
Ecological Category	**C**	**C**	**B**	**C**
Trajectory of change	↓	↓	↓	↓
Confidence (revised results)	Medium	Medium	Medium	Medium
Combined Impact Score	2.2			
Combined PES Score (%)	78%			
Combined Ecological Category	**C**			
Hectare Equivalents	7.0 Ha			

Channelled Valley Bottom

Final (adjusted) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	2.6	2.1	3.0	3.0
PES Score (%)	74%	79%	70%	70%
Ecological Category	**C**	**C**	**C**	**C**
Trajectory of change	↓	↓	↓	↓
Confidence (revised results)	Medium	Medium	Medium	Medium
Combined Impact Score	2.7			
Combined PES Score (%)	73%			
Combined Ecological Category	**C**			
Hectare Equivalents	10.5 Ha			

CVB with Artificial Components	Final (adjusted) Scores				
	PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
	Impact Score	2.8	2.8	5.5	4.0
	PES Score (%)	72%	73%	45%	60%
	Ecological Category	C	C	D	D
	Trajectory of change	↓	↓	↓	↓
	Confidence (revised results)	Medium	Medium	Medium	Medium
	Combined Impact Score	3.7			
	Combined PES Score (%)	63%			
	Combined Ecological Category	C			
	Hectare Equivalents	14.3 Ha			

3.3.2 WetEcoServices Kotze *et al.*, (2020)

A summary of the assessment of ecosystem services of the wetlands on the site is presented in Tables 6 to 8. The valley bottom wetlands were assessed as a group whereas Kamfers Dam was assessed as a separate unit. The known breeding habitat for the flamingos is clearly reflected in the high scores for Biodiversity Maintenance.

Table 6: Summary of the Ecosystem Services provided by Kamfers Dam (Pan)

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.0	2.0	0.0	Very Low
	Stream flow regulation	2.0	0.0	0.5	Very Low
	Sediment trapping	0.6	0.0	0.0	Very Low
	Erosion control	0.8	1.0	0.0	Very Low
	Phosphate assimilation	3.0	4.0	3.5	Very High
	Nitrate assimilation	3.0	4.0	3.5	Very High
	Toxicant assimilation	3.0	4.0	3.5	Very High
	Carbon storage	1.2	2.7	1.1	Low
	Biodiversity maintenance	4.0	4.0	4.0	Very High
PROVISIONING SERVICES	Water for human use	0.0	0.0	0.0	Very Low
	Harvestable resources	0.5	0.0	0.0	Very Low
	Food for livestock	0.5	0.0	0.0	Very Low
	Cultivated foods	1.5	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	3.0	0.3	1.7	Moderately Low
	Education and Research	3.0	5.3	4.0	Very High
	Cultural and Spiritual	4.0	0.0	2.5	Moderately High

Table 7: Summary of the Ecosystem Services provided by the Valley Bottom wetlands on site

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.5	0.5	0.0	Very Low
	Stream flow regulation	0.5	0.5	0.0	Very Low
	Sediment trapping	2.0	3.0	2.0	Moderate
	Erosion control	0.8	1.1	0.0	Very Low
	Phosphate assimilation	3.0	4.0	3.5	Very High
	Nitrate assimilation	2.0	4.0	2.5	Moderately High
	Toxicant assimilation	2.0	3.0	2.0	Moderate
	Carbon storage	0.9	2.7	0.8	Very Low
	Biodiversity maintenance	3.0	0.0	1.5	Moderately Low
PROVISIONING SERVICES	Water for human use	0.0	0.0	0.0	Very Low
	Harvestable resources	2.0	0.0	0.5	Very Low
	Food for livestock	3.0	0.0	1.5	Moderately Low
	Cultivated foods	2.5	0.0	1.0	Low
CULTURAL SERVICES	Tourism and Recreation	0.5	0.3	0.0	Very Low
	Education and Research	0.5	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.0	Very Low

Table 8: Summary of the Ecosystem Services provided by the drainage lines on site

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.5	0.5	0.0	Very Low
	Stream flow regulation	0.5	0.5	0.0	Very Low
	Sediment trapping	2.0	3.0	2.0	Moderate
	Erosion control	0.5	1.1	0.0	Very Low
	Phosphate assimilation	3.0	4.0	3.5	Very High
	Nitrate assimilation	2.0	4.0	2.5	Moderately High
	Toxicant assimilation	2.0	3.0	2.0	Moderate
	Carbon storage	0.0	0.0	0.0	Very Low
	Biodiversity maintenance	3.0	0.0	1.5	Moderately Low
PROVISIONING SERVICES	Water for human use	0.0	0.0	0.0	Very Low
	Harvestable resources	1.5	0.0	0.0	Very Low
	Food for livestock	1.0	0.0	0.0	Very Low
	Cultivated foods	3.0	0.0	1.5	Moderately Low
CULTURAL SERVICES	Tourism and Recreation	0.5	0.3	0.0	Very Low
	Education and Research	0.5	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.0	Very Low

3.3.3 Ecological Importance and Sensitivity (EIS)

The EIS score comprises a combination two components, Ecological Sensitivity (ES) and Ecological Integrity (EI) listed in the DWS Resource Quality Objectives datasets (for example, DWS, 2014). Both these components draw from the Ecosystem Service scores presented above as set out in Table 9. Integrating ES and EI scores to obtain a final EIS score uses the matrix in Table 10. Final EIS scores for each watercourse unit are presented in Table 11.

Table 9:Ecological Sensitivity (ES) values for watercourses

Watercourse Unit	Ecosystem Service obtained from Section 3.3.2			ES score	Maximum ES score = EI score
	Biodiversity maintenance	Regulating and Supporting services	Provisioning and Cultural Services		
Kamfers Dam Pan	4.0 – Very High	1.7 - Low	0.9 – Very Low	2.2 - Moderate	4.0 – Very High
Valley Bottom wetlands	1.5 - Moderate	1.3 - Low	0.4 - Very Low	1.1 - Low	1.5 - Moderate
Drainage Lines	1.5 - Moderate	1.2 - Low	0.4 - Very Low	1.0 - Low	1.5 - Moderate

Table 10: Table for integrating EI and ES into a composite EIS score (Kotze *et al.,* 2020)

		Ecological Importance (EI)				
		Very Low	Low	Moderate	High	Very High
Ecological Sensitivity (ES)		0	1	2	3	4
Very Low	0	0.00	0.00	1.00	2.00	3.00
Low	1	0.00	0.50	1.50	2.50	3.50
Moderate	2	0.00	1.00	2.00	3.00	4.00
High	3	0.50	1.50	2.50	3.50	4.00
Very High	4	1.00	2.00	3.00	4.00	4.00

Table 11: Final EIS scores for each wetland unit

Watercourse Unit	Final EIS score
Kamfers Dam Pan	4.0 – Very High
Valley Bottom wetlands	1.5 - Moderate
Drainage Lines	1.5 - Moderate

3.3.4 Baseline Freshwater Aquatic Invertebrate Assessment

This section includes a discussion of the results obtained, both with regard to the evaluation of habitat conditions and disturbances, as well as the species response of the assessed aquatic biota by determining their occurrence and composition at the sampling points described below.

3.3.4.1 Overview of Sampling Points

To assess the aquatic invertebrate populations two sample sites were used, sample site 2 and 3 (Figure 9)

.

Figure 9: Sample site locations

3.3.4.2 In situ drivers

Water quality analysis for select parameters were completed for the study site at all three sample points. Table 12 provides a summary of the water quality assessment results.

Table 12: Water quality assessment results

Aspect	Unit	Target Water Quality Range for aquatic ecosystems	Sample 1	Sample 2	Sample 3	
pH	pH	6,0-9,0	8,3	7,74	7,69	Circumneutral
Total Dissolved Salts/ solids (TDS)	mg/l	450	3470	486	220	Elevated at sample site 1 and high at sample 2.
NO_3	mg/l	<2.5	0,265	0,203	1,02	All samples below TWQR
PO_4	mg/l	<0.075	1,09	0,068	0,079	Sample 1 and 3 elevated
E.coli	CFU/100ml	0	-1	21	32000	Sample 2 and 3 exceeds TWQR
Total coliforms	CFU/100ml	0	-1	2400	100000	
Total oxidised nitrogen as N	mg/l	<2.5	0,265	0,203	1,02	All samples below TWQR

The total coliforms and *E.coli* results from sample 2 and 3 exceeds the TWQR. Sample 3 is of grave concern as this can be construed to be raw sewage. This sample site is also interesting as it feeds from the existing residential area of Homevale. This holds relevance as any expansion of residential developments in the area will be assessed in terms of the current ability of the municipality to facilitate sewage reticulation.

Total dissolved solids of sample 1 exceeds the TWQR for aquatic ecosystems by more than 3000 mg/l. Acute levels of dissolved solids is given by the TWQR as 2400 mg/l. Sample 2 also has elevated TDS but exceeds the TWQR by 36 mg/l. It is not clear if the pan has a typical higher salt concentration as associated with pans in the Northern Cape.

During the site visit sample 1 had a large amount floating/ suspended algae on the surface (Figure 10). This indicates a possibility of increased nutrients in the water possibly attributed to anthropogenic activities. The PO4 assessment of sample 1 is of concern. Sample 3 also exceeds the TWQR and can possibly be a cause of increased phosphates. Occasional increases in the inorganic phosphorus concentration above the Target Water Quality Range (TWQR) are less important than continuously high concentrations. Single measurements of phosphorus are a poor basis for assessment.

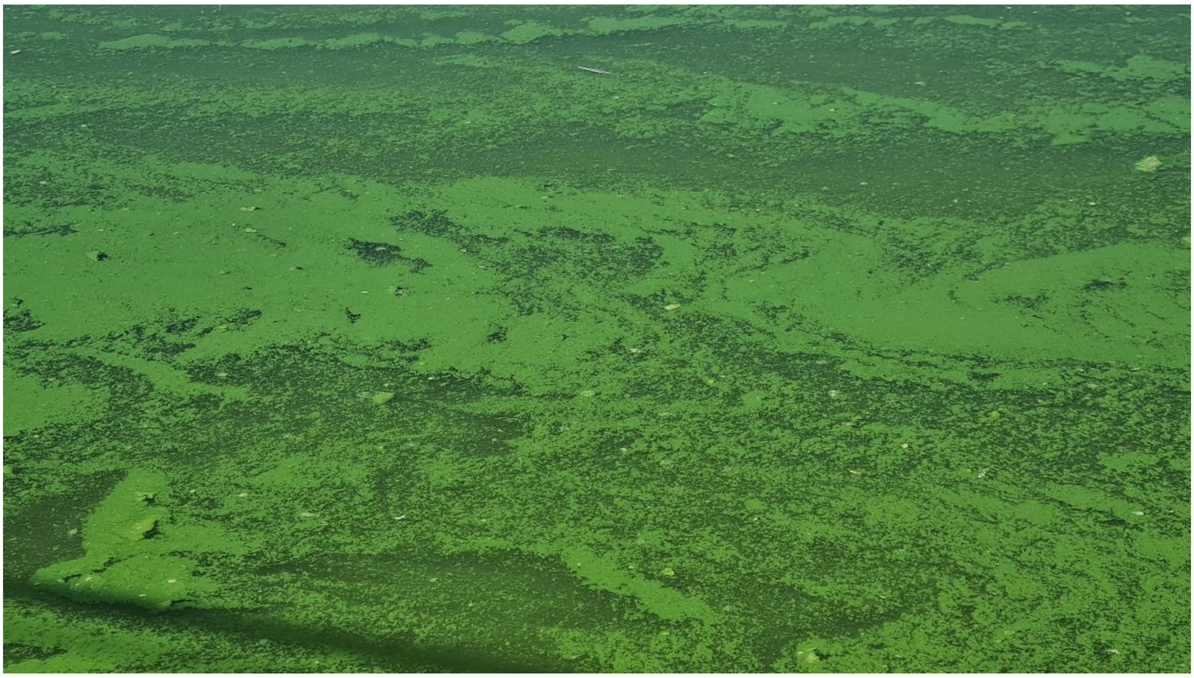

Figure 10: Water at Sample 1

3.3.4.3 Habitat assessment using the IHAS system

Due to the classification of sample 1 as a depression system the application of the SASS 5 methodologies could not be completed for the sample. Only sample 2 and 3 was completed.

- Sample site 2 had low flow conditions with diffused flows between standing wetland phytomass (Figure 11). The IHAS score of sample site 2 was calculated to 40% (Table 13),
- Sample site 3 had moderate flows with good water coulomb into dense stands of Phragmites (Figure 11 The IHAS score of the sample site 3 was calculated to 38% (Table 14),

- From the IHAS scores it can be assessed that both sample sites are "Insufficient for supporting a diverse aquatic macro invertebrate community".


Figure 11: Sample site 2 (left) and Sample site 3 (right)

Table 13: Sample 2 IHAS assessment

SAMPLING HABITAT RATING (K)						
SCORE	**0**	**1**	**2**	**3**	**4**	**5**
Stones in current (SIC)						
Total lengths of white water rapids (riffles)(in metres)	None	0-1	1-2	2-3	3-5	5+
Total length of submerged stones in current (run) (in metres)	None	0-2	2-5	5-10	10+	
Number of separate SIC area's kicked (not individual stones	0	1	2-3	4-5	6+	
Average stone sizes kicked (in cm's)(< 2>10<2or>10)(<2=gravel)	None	<2>10	2-5	5-10	2-10	
Amount of stone surface clear (of algae,sediment,etc)(in percent)		0-25	25-50	50-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes	0	<1	1	2	3	>3
Subtotal	0	2	0	3	0	0
(A=SIC boxes total; B=adjustment to equal 20 PERCENT C=final total)	**5**	**A**	**1**	**B**	**6**	**C**
Vegetation						
Length of fringing vegetation sampled (banks) (in metres)	None	0-0.5	0.5-1	1-2	2	>2
Amount of aquatic vegetation/algaesampled (underwater)(in m²)	None	0-0.5	0.5-1	>1		
Fringing vegetation sampled in: (none, pool or still only, mixture or both)	None		run	pool		mix
Type of veg (% leafy vegetation as opposed to stems/shoots)(aq.veg.only=50)		0	1-25	25-50	50-75	>75
Subtotal	0	1	2	3	0	0
(D=veg. boxes total; E=adjustment to equal 15 PERCENT ; F=final total)	**6**	**D**	**1**	**E**	**7**	**F**
Other Habitat						
Stones out of Current (SOOC) sampled: PROTOCOL in m²	None	0-0.5	0.5-1	1	>1	
Sand Sampled (PROTOCOL in Minutes)	None	0-0.5	0.5-1	1	>1	
Mud sampled (PROTOCOL in minutes)	None	0-0.5	1	>0.5		
Gravel sampled (PROTOCOL in minutes)	all	None	0-0.5	1	>0.5	
Bedrock sampled (all=no SIC,sand, gravel)	None	Some			all	
Tray identification (PROTOCOL using time corr = correct times		Under		corr		over
Subtotal	0	2	4	3	0	0
(G= O>H boxes total; H=adjustment to equal 15 PERCENT ; I=final total)	**9**	**G**	**1**	**H**	**10**	**I**
(J=Total adjustment (B+E+H) K=Total habitat (C+F+I)			**3**	**J**	**23**	**K**
STREAM CHARACTERISTICS (L)						
Physical						
River make up (pool=pool/stil/dam only; run only; rapid only: 2 mix=2 types etc)	pool		run	rapid	2mix	3mix
Average width of stream: (meters)		>10	5-10	<1	1-2	2-5
Average depth of stream: (meters)	>2	1-2	1	0.5-1	1	<0.5
Approximately velocity of stream (slow = 0.5m/s fast = 1m/s)	still	slow	fast	med		mix
Water colour (disc=discoloured with visible colour but still clearish	silly	opaq		discol	clear	crystal
Visible disturbance due to: (constr. = ongoing construction)	flood	constr	livest	other		none
Bank/riparian vegetation is: (grass=includes reeds, shrubs=includes trees)	none		grass	shrub		mix
Surrounding impacts:(erosn=erosion, informal settlements, farmland, nature.	erosn	settle	farm	trees	clear	nature
Left bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>95
Right bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>96
Subtotal	0	4	2	6	0	5
(L=Physical boxes final total) **Stream Characteristics Total;**					**17**	**L**
Total IHAS Score: (K+L)					40	

Table 14: Sample site 3 IHAS assessment

SAMPLING HABITAT RATING (K)						
SCORE	0	1	2	3	4	5
Stones in current (SIC)						
Total lengths of white water rapids (riffles)(in metres)	None	0-1	1-2	2-3	3-5	5+
Total length of submerged stones in current (run) (in metres)	None	0-2	2-5	5-10	10+	
Number of separate SIC area's kicked (not individual stones	0	1	2-3	4-5	6+	
Average stone sizes kicked (in cm's)(< 2>10<2or>10)(<2=gravel)	None	<2>10	2-5	5-10	2-10	
Amount of stone surface clear (of algae,sediment,etc)(in percent)		0-25	25-50	50-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes	0	<1	1	2	3	>3
Subtotal	0	2	0	3	0	0
(A=SIC boxes total; B=adjustment to equal 20 PERCENT C=final total)	5	A	1	B	6	C
Vegetation						
Length of fringing vegetation sampled (banks) (in metres)	None	0-0.5	0.5-1	1-2	2	>2
Amount of aquatic vegetation/algaesampled (underwater)(in m²)	None	0-0.5	0.5-1	>1		
Fringing vegetation sampled in: (none, pool or still only, mixture or both)	None		run	pool		mix
Type of veg (% leafy vegetation as opposed to stems/shoots)(aq.veg.only=50)		0	1-25	25-50	50-75	>75
Subtotal	0	1	2	3	0	0
(D=veg. boxes total; E=adjustment to equal 15 PERCENT ; F=final total)	6	D	1	E	7	F
Other Habitat						
Stones out of Current (SOOC) sampled: PROTOCOL in m²	None	0-0.5	0.5-1	1	>1	
Sand Sampled (PROTOCOL in Minutes)	None	0-0.5	0.5-1	1	>1	
Mud sampled (PROTOCOL in minutes)	None	0-0.5	1	>0.5		
Gravel sampled (PROTOCOL in minutes)	all	None	0-0.5	1	>0.5	
Bedrock sampled (all=no SIC,sand, gravel)	None	Some			all	
Tray identification (PROTOCOL using time corr = correct times		Under		corr		over
Subtotal	0	2	4	3	0	0
(G= O>H boxes total; H=adjustment to equal 15 PERCENT ; I=final total)	9	G	1	H	10	I
(J=Total adjustment (B+E+H) K=Total habitat (C+F+I)			**3**	**J**	**23**	**K**
STREAM CHARACTERISTICS (L)						
Physical						
River make up (pool=pool/stil/dam only; run only; rapid only: 2 mix=2 types etc)	pool		run	rapid	2mix	3mix
Average width of stream: (meters)		>10	5-10	<1	1-2	2-5
Average depth of stream: (meters)	>2	1-2	1	0.5-1	1	<0.5
Approximately velocity of stream (slow = 0.5m/s fast = 1m/s)	still	slow	fast	med		mix
Water colour (disc=discoloured with visible colour but still clearish	silly	opaq		discol	clear	crystal
Visible disturbance due to: (constr. = ongoing construction)	flood	constr	livest	other		none
Bank/riparian vegetation is: (grass=includes reeds, shrubs=includes trees)	none		grass	shrub		mix
Surrounding impacts:(erosn=erosion, informal settlements, farmland, nature.	erosn	settle	farm	trees	clear	nature
Left bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>95
Right bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>96
Subtotal	0	4	2	9	0	0
(L=Physical boxes final total) **Stream Characteristics Total;**					15	L
Total IHAS Score: (K+L)					38	

3.3.4.4 Aquatic macroinvertebrates using the SASS 5 methodology

The benthic aquatic macroinvertebrate population assessment was completed using the SASS5 methodology at sample site 2 and 3. The results indicate the sample sites are in **poor** condition. Low ASPT results with most of the taxa sampled being *Diptera*. These taxa are associated with high organic load systems brought about by sewage pollution. The lack of stones habitat can also contribute to the reduced ASPT observed (higher scoring species are associated with stones) (Tables 15 to 17).

Table 15: Summary of SASS5 analysis

	Sample site 1	Sample site 2	Sample site 3
SASS Score	Not completed due to classification of system as depression wetland	30	10
No of Taxa		8	5
Average score per Taxa (ASPT)		3.8	2

Table 16: SASS 5 results for Sample site 2

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1				
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4		A		A
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4				
Lestidae (Emerald Damselflies/Spreadwing	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8		A		A
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6			A	A
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5			A	A
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2			A	A
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1		A		A
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1			A	A
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3			A	A
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					30
No. of Taxa					8
ASPT					3,8
Other biota:					
Comments/Observations:					
+B14:S57					

Table 17: SASS 5 results for Sample site 3

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3		A		A	Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5					Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1					Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2		A		A
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1				
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1		A		A
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5				
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1			A	A
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4					Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3			A	A
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					10
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					5
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					2,0
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13										
Lestidae (Emerald Damselflies/Spreadwin	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10										
						Psephenidae (Water Pennies)	10										

3.3.4.5 SASS5 EC

Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardized graphs that are used as a guideline for interpreting any data obtained during the study. For the study site the Southern Kalahari Bands was used (Figure 12).

Using the field data results in Section 3.3.4.4 (Table 15) and the bands (Dallas, 2007) the sites Classification was assessed to be E/F: "The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable" & "Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota".

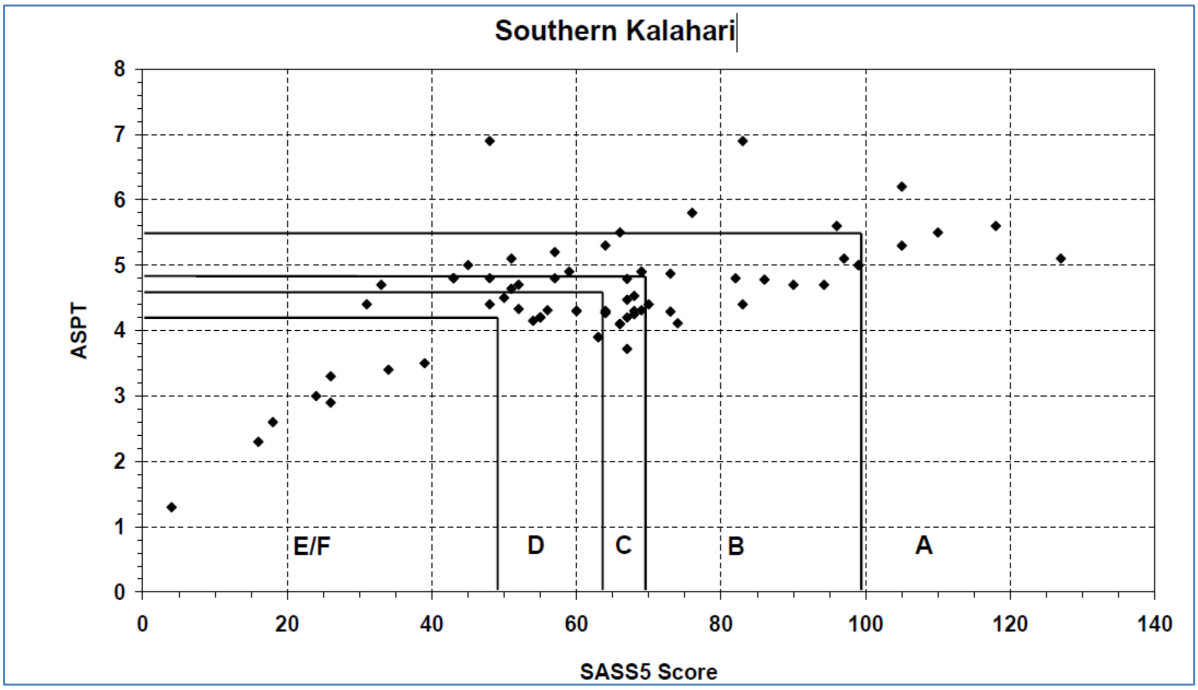

Figure 12: Dallas Bands for the Southern Kalahari Ecoregion

3.4 Summary of Findings

Table 1918 provides a summary of the results recorded for the watercourse units potentially affected by the proposed Oliphant Township.

Table 18: Summary of results for each watercourse unit discussed

Watercourse Type	Assessment Method
Kamfers Dam - Pan	**PES: C – Moderately Modified** with a combined PES score of 3.1, 69%. The Water Quality obtained the lowest score (F – Critically Modified). The condition of the wetland is expected to decrease gradually in the next 5 years, although Water Quality is expected to deteriorate rapidly unless catchment wide correction is effected. **ES** (2.2 – Moderate) + EI (4.0 Very High) = **EIS (4.0 Very High).** The most significant Ecosystem Services are Biodiversity Maintenance, Assimilation of Phosphate, Nitrate and Toxicants which scored Very High. Education and Research also scored Very High. **Water quality:** The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS_ this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm. **Instream habitat (IHAS):** The IHAS score was calculated to 40% and 38% sample site (**Error! Reference source not found.**). This indicates the habitat is "Insufficient f or supporting a diverse aquatic macro invertebrate community" (Table 34). **Aquatic macroinvertebrate assemblages:** Sample 1: Not completed due to classification of system Sample 2: SASS score 30, 8 taxa, ASPT 3.8. Using the "Dallas Bands" (Dallas, 2007) the SASS5 Ecological Category was determined to **E/F** classification. The classification suggests that the system is in **poor** condition. This assessment is in line with the site observations. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Unchannelled Valley Bottom wetlands (UVB)	**PES: C – Moderately Modified** with a combined PES score of 2.2 – 78%. The Vegetation module of the assessment scored highest (B) although the modules Hydology, Geomorphology and Water Quality showed more impact (PES Class C). The condition of the wetland is expected to decrease gradually in the next 5 years.

	ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Channelled Valley Bottom Wetlands (CVB)	**PES: C – Moderately Modified** with a combined PES score of 2.7 – 73%. All four modules fall in the C category. The condition of the wetland is expected to decrease gradually in the next 5 years. ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Water quality:** The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS_ this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm. **Instream habitat (IHAS):** The IHAS score was calculated to 40% and 38% sample site (**Error! Reference source not found.**). This indicates the habitat is "Insufficient f or supporting a diverse aquatic macro invertebrate community" (Table 34). **Aquatic macroinvertebrate assemblages:** Sample 3: SASS score 10, 5 taxa, ASPT 2 **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Channelled Valley Bottom wetlands with Artificial Elements (CVB with Artificial Elements)	**PES: C – Moderately Modified** with a combined PES score of 3.7 – 63%. The modules Hydrology and Geomorphology fall in the C category. Modules Water Quality and Vegetation are more impacted and fall in the D category. The condition of the wetland is expected to decrease gradually in the next 5 ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Drainage Lines	**EC: The Ecological Category obtained for the two drainage lines fall in the**

	ES (1.0 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Service is Phosphate Assimilation which scored Very High. **Recommended Ecological Management Category: C**

3.5 Impacts and Mitigations

The Kamfers Dam was an ephemeral pan seasonally inundated from the natural receiving environment. Anthropogenic activities in Kimberly have led to the release of additional storm water and sewage (both treated and untreated) into the system. This has transformed the pan into a permanently inundated system. Increased water levels have led to the inundation and destruction of breeding habitat for Lesser Flamingo. Ekapa Mining attempted to mitigate the issue with the installation of a S-shaped breeding habitat. This was inundated as the water levels in the pan rose again.

Lesser flamingos inhabit many large alkaline or saline lakes, salt pans and estuaries throughout Africa. The nesting habitats of lesser flamingos includes areas in very shallow water so they can construct their nests out of the wet mud found in the area. The water typically measures less than one meter deep. During the site visit in January 2021 a very full Kamfers Dam was observed. This is attributed to above seasonal rainfall and pre-rainfall season levels of the pan.

The proposed development layout relative to the delineated wetlands with their associated buffer zones is presented in Figure 13. No alternatives were considered in this assessment.

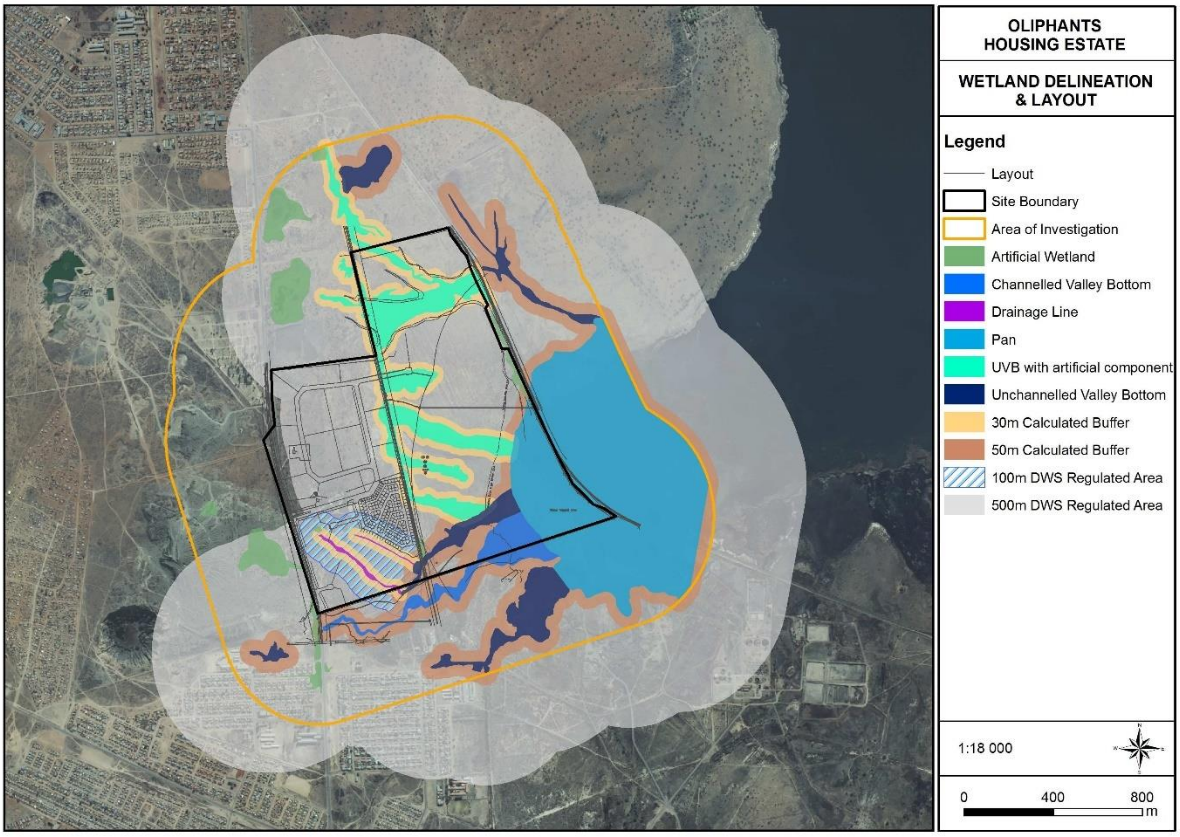

Figure 13: The proposed development layout relative to the delineated watercourses and their buffer zones

The establishment of a residential development adjacent to Kamfers Dam will increase the burden of regional stormwater infrastructure and services that are currently dysfunctional. Although the proposed layout is largely excluded from watercourses and their buffer zones, development on the study site will lead to surface hardening of this section of Kamfers Dam's catchment. This will lead to increased runoff into the already unnatural permanently inundated depression system. With no observed attenuation in the town of Kimberly the risks of flooding events during high rainfall episodes are of grave concern. Currently water from the Homeville section of the catchment is contaminated with sewage (>32000 CFU/100mg *E.coli*). This indicates the sewage reticulation of an existing section of town of Kimberley not to be operational and cumulative impacts are a concern.

A discussion on impacts to the aquatic environment (as required in GN320 of March 2020) is sumarised in Table 19. Impact scores as set out in the NEMA 2016 Impact Assessment are presented in Section 3.5.1 below.

Table 19: Impacts as per GN320 of March 2020

Number	Impact question	Expected impact
2,5,3	How will the development impact on fixed and dynamic ecological processes that operate within or across the site	
	a) How will the development impact on fixed and dynamic ecological processes that operate within or across the site 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); and	Negatively. Fixed dynamic processes in terms of water levels will be altered by surface hardening. Additional releases of sewage into the pan are expected.
	b) Change in the sediment regime (e.g. sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns) of the aquatic ecosystem and its sub -catchment;	During the construction phase there can be a significant increase in sedimentation if mitigation measures are not adhered to. This is also expected in the early operation phase until areas are vegetated. Sediment regimes are expected to stabilize over time.
	c) The extent of the modification in relation to the overall aquatic ecosystem (i.e. 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.).	The Kamfers Dam has already been altered from an ephemeral to permanently inundated system. Additional releases of water as expected from the development will further exacerbate the issue
	d) to what extent will the risk associated with water uses and related activities change?	See risk assessment (GN509 of NWA) in the accompanying risk assessment report.
2,5,4	How will the proposed development impact on the functioning of the aquatic feature? This must include:	
	a) Base flows (e.g. too little/too much water in terms of characteristics and requirements of system)	Negative impact. Base flows will be increased.
	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)	Negative impact. It is expected that water contaminated with sewage and other hazardous substances will be released into the Kamfers Dam.
	c) Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchanneled valley -bottom wetland to a channelled valley -bottom wetland).	The Kamfers Dam has already been altered from an ephemeral to permanently inundated system. Additional releases of water as expected from the development will further exacerbate the issue. Typing will not be altered due to topography of the site.
	d) Quality of water (e.g. due to increased sediment load, contamination by chemical	Expected to be altered and degraded by the development

Number	Impact question	Expected impact
	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).	Some fragmentation is expected but will stabilise over time given that the trench is effectively rehabilitated. (Refer to Table 12).
	f) The loss or degradation of all or part of any unique or important features (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.) associated with or within the aquatic ecosystem.	Not observed and thus not expected to be impacted.
2,5,5,	How will the development impact on key ecosystem regulating and supporting services especially:	
	a) Flood attenuation	Flood attenuation functions of the site will be lost if not replaced with artificial attenuative structures
	b) Stream flow regulation	As with flood attenuation increased flows from the site is expected.
	c) Sediment trapping	Increased flows from the site will decrease sediment trapping functions. Increases in sediments are expected from the site.
	d) Phosphate assimilation	Assimilation of phosphates will be decreased due to deceased vegetated areas. Increases in phosphate sources into the aquatic ecosystem is also expected. The functionality will be decreased.
	e) Nitrate assimilation	Same as with phosphates.
	f) Toxicant assimilation	Additional toxicants are expected from the site. This will decrease the assimilation functionality of the system.
	g) Erosion Control	Increased surface hardening will increase erosive volumes of water. This will lead to decreased erosion controls.
	h) Carbon Storage?	Decreased vegetation areas will decrease sequestration of carbon throughout the site. Additions of phytoremediation will assist with carbon storage.

3.5.1 NEMA (2014) Impact Assessment

Table 20 to Table 2525 below indicate the impact scores for the potential impacts relevant to the proposed activities. These impacts include aspects of the aquatic environment as specified in GN350 of March 2020.

Table 20: Impacts to hydrological function at a landscape level

Nature: Changes to hydrological function at a landscape level 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). The extent of the modification in relation to the overall aquatic ecosystem (i.e. 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.). Changes to base flows (e.g. too little/too much water in terms of characteristics and requirements of system). Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).

ACTIVITY: The sources of this impact include the compaction of soil, the removal of vegetation, surface water redirection, changes to watercourse morphology or input of high energy surface water which could occur during construction and operation of the residential development.

	Without mitigation	**With mitigation**
	CONSTRUCTION PHASE	
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
	OPERATIONAL PHASE	
Probability	Highly probable (4)	Highly probable (4)
Duration	Medium term (3)	Medium term (3)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**36 (moderate)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes, with exceptional effort	

Mitigation:

- During the construction phase, best practice mitigation measures should be implemented.
- Stormwater attenuation on site should accommodate more than 50% of storm event to protect the Kamfers dam from further inundation.
- Predictions of stormwater flows should take into consideration expected climate change related catchment changes.
- Effective control of stormwater from access roads should be undertaken

Cumulative impacts: High. Further disturbance of water flow in this wetland will exacerbate an already impacted system

Residual Risks: Expected to be high. Stormwater management in the town of Kimberly is already functioning sub-optimally. Adding to the burden will affect hydrological function on a landscape level, flood regimes, base flows and dynamic processes

Table 21: Changes in sediment regime

Nature: Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns

Activity: Construction and maintenance activities will result in earthworks and soil disturbance as well as the disturbance of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourses and pan and increase the turbidity of the water. Possible sources of the impacts include:

- Earthwork activities during construction
- Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil.
- Disturbance of soil surface
- Disturbance of slopes through creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse)

	Without mitigation	**With mitigation**
	CONSTRUCTION PHASE	
Probability	Highly probable (4)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Regional (3)	Local (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**16 (low)**
Status (positive or negative)	Negative	Negative
	OPERATIONAL PHASE	
Probability	Probable (3)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Limited to Local Area (2)	Regional (3)
Magnitude	Moderate (6)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Consider the various methods and equipment available and select whichever method(s) that will have the least impact on watercourses.
- Sediment traps should be installed
- Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area.
- Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.
- During the construction phase measures must be put in place to control the flow of excess water so that it does not impact on the adjacent surface vegetation.
- Sediment control should be effective and not allow any release of sediment pollution downstream. This should be audited on a weekly basis to demonstrate compliance with upstream conditions.

- Any excavated soil/ stockpiles may not exceed 1 m in height. Mixture of the lower and upper layers of the excavated soil should be kept to a minimum, so as for later usage as backfill material.
- Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas.
- Monitoring should be done to ensure that sediment pollution is timeously addressed

Cumulative impacts: Expected to be low. Should mitigation measure not be implemented effectively, sediment deposition may affect the capacity of the pan and lead to a loss of bird habitat. Reversing this process is unlikely and should be prevented in the first place.

Residual Risks: Expected to be limited provided that the mitigation measures are implemented effectively and sedimentation is appropriately managed.

Table 22: Introduction and spread of alien vegetation impact ratings.

Nature: Introduction and spread of alien vegetation.

Activity: The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users.

	Without mitigation	With mitigation
	CONSTRUCTION PHASE	
Probability	Probable (3)	Probable (3)
Duration	Long term (4)	Short term (2)
Extent	Regional (3)	Local (2)
Magnitude	Moderate (6)	Low (4)
Significance	**39 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
	OPERATIONAL PHASE	
Probability	Probable (3)	Possible (2)
Duration	Medium-term (3)	Medium term (3)
Extent	Regional (4)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Undertake an Alien Plant Control Plan which specifies actions and measurable targets
- Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area and returning it where possible afterwards.
- Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Pan
- Rehabilitate or revegetate disturbed areas

Cumulative impacts: Since alien vegetation is already present in the catchment, cumulative impacts can be Moderate to High. Regular monitoring should be implemented during construction, rehabilitation including for a period after rehabilitation is completed.
Residual Risks: Expected to be limited provided that an Alien Plant Control Plan is effectively implemented

Table 23: Loss and disturbance of watercourse/pan habitat and fringe vegetation impact ratings.

Nature: Loss and disturbance of watercourse habitat and fringe vegetation.		
Activity: Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Definite (5)	Probable (3)
Duration	Medium-term (3)	Medium-term (3)
Extent	Local (2)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**45 (moderate)**	**27 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Possible (2)	Possible (2)
Duration	Short-term (2)	Short-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Low (4)
Significance	**20 (low)**	**16 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation: • The development footprint should remain outside the delineated wetland, riparian areas and buffer zones. • Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas • Implement an Alien Plant Control Plan • Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. • Monitor the establishment of alien invasive species within the areas affected by the construction and take immediate corrective action where invasive species are observed to establish		
Cumulative impacts: Expected to be Low. Should degradation occur, it may result in a high degree of irreplaceable loss of resources.		
Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.		

Table 24: Changes in water quality.

Nature: Changes in water quality due to input of foreign materials e.g. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication		
Activity: Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (4)	Probable (4)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**40 (moderate)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Locate the infrastructure outside the calculated buffer zone
- Implementation of appropriate stormwater management around the excavation to prevent the ingress of run-off into the excavation and to prevent contaminated runoff into the watercourse.
- Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone
- The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc.
- Currently it is evident that the wastewater treatment of the Kimberly is not operational. Additional sewage cannot be sent to a system that is already not operational. Sewage must be treated on site before reticulation to irrigate open space areas or sent to evaporation ponds.
- Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.
- It should be ensured that regular maintenance takes place to prevent failure of any infrastructure associated with the proposed development;
- The managing authority should test the integrity of the sewer pipelines at least once every five years or more often should there be any sign or reports of a leak.
- A detailed rehabilitation plan should be drawn up with the input from a water quality, soil contamination assessment and ecologist should any spills occur.
- Independent water quality analyses should be undertaken annually, or as specified by an aquatic specialist, to demonstrate and audit compliance of effective pollution control measures

Cumulative impacts: Decreased water quality from spills of contaminants will contribute to regional water quality decrease, therefore should be considered a significant cumulative impact
Residual Risks: Although it may be controlled and largely prevented, the impact of a single spill will have a significant residual effect on the local watercourse integrity. Residual risks should therefore be considered significant

Table 25: Loss of aquatic biota

Nature: Loss of instream habitat, deposition of wind-blown sand, loss of fringing vegetation and erosion, alteration in base flow, natural fire regimes and subsequent loss of non-marginal and marginal vegetation. Increase in invasive species due to disturbance. Change in water quality. Changes in flow		
Activity: Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Medium term (3)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (4)	Highly probable (4)
Duration	Medium term (3)	Medium term (3)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Moderate (6)	Low (4)
Significance	**48 (moderate)**	**36 (moderate)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Ensure that no unnecessary vegetation is removed during the construction phase,
- Avoid unnecessary aquatic ecosystem crossing - limit work within the stream, river or wetland. The use of single access points for crossings.
- Other than approved and authorized structure, no other development or maintenance infrastructure is allowed within the delineated watercourse or its associated buffer zones.
- Mark all areas which don't form part of the proposed development within the watercourse as no-go areas.
- Weed control in aquatic ecosystem and buffer zone.
- Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance of the proposed infrastructure and take immediate corrective action where invasive species are observed to establish.

• Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.
Cumulative impacts: Moderate – Significant further loss of aquatic biota in Kamfers Dam
Residual Risks: Since pollution and changed hydrology of Kamfers Dam is significant, the aquatic fauna assemblages are reduced to more hardy species. Residual risks to further loss of aquatic fauna is therefore moderate. It remains an important source of food for endangered bird species

4 CONCLUSION

Two wetland drivers in addition to the natural surface water drainage are relevant to this study. These two drivers are soil with a high clay content and water spilt from leaking pipes.

The presence of soils with a high clay content occurs throughout the site. Depressions therefore quickly fill with rain water and also water leaking from pipes or sewage infrastructure, which allows the clay to swell and trap this water, resulting in wetland conditions. A distinction between natural and artificial wetlands are complicated by the long-term nature of leaks.

Wetland types recorded on the site include the pan (Kamfers Dam), Channelled and Unchannelled Valley Bottom wetlands, Unchannelled Valley Bottom wetlands with Artificial elements and Drainage Lines and Artificial wetlands which are obviously created by voids.

Expected impacts to these watercourses, and particularly to the downslope Kamfers Dam, are twofold. Firstly, the stormwater runoff generated by the development in the context of the already inundated pan and expected increased flood events resulting from climate change will add to cumulative impacts to the beleaguered pan. In addition, the risk of further addition of sewage into the pan is high. A single spill event will have significant negative impacts to the habitat of endangered bird species. The realistic likelihood of mitigating these impacts fall to the engineers to prove with empirical data and should be afforded a high level of scrutiny. Table 26 presents a summary of pertinent findings.

Table 26: Summary of important findings

	Quaternary Catchment and WMA areas	**Important Rivers possibly affected**
	C91E – #5 WMA Vaal	The Vaal River lies 16km northwest of the site. Drainage lines drain into Kamfers Dam from its topographic catchment. Two drainage lines are shown to run through the study site
Kamfers Dam - Pan	**PES: C – Moderately Modified** with a combined PES score of 3.1, 69%. The Water Quality obtained the lowest score (F – Critically Modified). The condition of the wetland is expected to decrease gradually in the next 5 years, although Water Quality is expected to deteriorate rapidly unless catchment wide correction is effected. **ES** (2.2 – Moderate) + EI (4.0 Very High) = **EIS (4.0 Very High).** The most significant Ecosystem Services are Biodiversity Maintenance, Assimilation of Phosphate, Nitrate and Toxicants which scored Very High. Education and Research also scored Very High. **Water quality:** The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS, this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system	

	possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm. **Instream habitat (IHAS):** The IHAS score was calculated to 40% and 38% sample site . This indicates the habitat is "Insufficient for supporting a diverse aquatic macro invertebrate community" (Table 34). **Aquatic macroinvertebrate assemblages:** Sample 1: Not completed due to classification of system Sample 2: SASS score 30, 8 taxa, ASPT 3.8. Using the "Dallas Bands" (Dallas, 2007) the SASS5 Ecological Category was determined to **E/F** classification. The classification suggests that the system is in **poor** condition. This assessment is in line with the site observations. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Unchannelled Valley Bottom wetlands (UVB)	**PES: C – Moderately Modified** with a combined PES score of 2.2 – 78%. The Vegetation module of the assessment scored highest (B) although the modules Hydology, Geomorphology and Water Quality showed more impact (PES Class C). The condition of the wetland is expected to decrease gradually in the next 5 years. ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C**
Channelled Valley Bottom Wetlands (CVB)	**PES: C – Moderately Modified** with a combined PES score of 2.7 – 73%. All four modules fall in the C category. The condition of the wetland is expected to decrease gradually in the next 5 years. ES (1.1 – Low) + EI (1.5 Moderate) = **EIS (1.5 Moderate).** The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate. **Water quality:** The SASS EC if read with the water quality results indicate that the aquatic habitat is highly altered and modified by anthropogenic activities. The water quality assessment indicated that the system at sample site 3 is polluted with *E.Coli*- this should not be present in a natural system. The TDS of sample 1 (Kamfers Dam) is of concern and it is not clear if this is part of the natural cycle as associated with many Northern Cape depression systems. Sample 2 also indicates elevated TDS, this can also influence the results at sample 1. Elevated phosphates (PO_4) in conjunction with elevated NO3 and Total oxidised nitrogen as N indicates a system possibly in Mesotrophic conditions. Further testing inclusive of Chemical oxygen demand (COD) is recommended to confirm. **Instream habitat (IHAS):** The IHAS score was calculated to 40% and 38% sample site. This indicates the habitat is "Insufficient for supporting a diverse aquatic macro invertebrate community" (Table 34).

<table>
<tr><td></td><td colspan="4">Aquatic macroinvertebrate assemblages:
Sample 3: SASS score 10, 5 taxa, ASPT 2

Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C</td></tr>
<tr><td>Channelled Valley Bottom wetlands with Artificial Elements (CVB with Artificial Elements)</td><td colspan="4">PES: C – Moderately Modified with a combined PES score of 3.7 – 63%. The modules Hydrology and Geomorphology fall in the C category. Modules Water Quality and Vegetation are more impacted and fall in the D category. The condition of the wetland is expected to decrease gradually in the next 5

ES (1.1 – Low) + EI (1.5 Moderate) = EIS (1.5 Moderate). The most significant Ecosystem Services are Phosphate Assimilation which cored Very High. Sediment Trapping, Nitrate and Toxicant Assimilation scored Moderate.

Recommended Ecological Management Category: C. The development may not result in further deterioration of the Ecological Category below C</td></tr>
<tr><td>Drainage Lines</td><td colspan="4">EC: The Ecological Category obtained for the two drainage lines fall in the

ES (1.0 – Low) + EI (1.5 Moderate) = EIS (1.5 Moderate). The most significant Ecosystem Service is Phosphate Assimilation which scored Very High.

Recommended Ecological Management Category: C</td></tr>
<tr><td>Buffer zones</td><td colspan="4">Calculated (Macfarlane et al, 2015): 30m and 50m</td></tr>
<tr><td rowspan="13">NEMA 2014 Impact Assessment</td><td colspan="2">The impact scores for the following aspects are relevant:</td><td>Without Mitigation</td><td>With Mitigation</td></tr>
<tr><td rowspan="2">Changes to flow dynamics</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>M</td></tr>
<tr><td rowspan="2">Sedimentation</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Establishment of alien plants</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Pollution of watercourses</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>M</td></tr>
<tr><td rowspan="2">Loss of fringe vegetation and habitat</td><td>Construction Phase</td><td>M</td><td>L</td></tr>
<tr><td>Operation Phase</td><td>L</td><td>L</td></tr>
<tr><td rowspan="2">Loss of aquatic habitat</td><td>Construction Phase</td><td>M</td><td>M</td></tr>
<tr><td>Operation Phase</td><td>M</td><td>M</td></tr>
<tr><td>Does the specialist support the development?</td><td colspan="4">No. More in depth understanding of the alternatives and realistic mitigation measures are needed before we can support the development. The Kamfers Dam is a resource that should be protected from further degradation. It appears likely that the development will contribute to significant cumulative impacts to the pan.</td></tr>
<tr><td>Recommendations</td><td colspan="4">In addition to the measures listed in the impact tables the following should be noted:
• It is recommended that attenuation of stormwater is done at more than 50% of storm event to protect the Kamfers dam from inundation.</td></tr>
</table>

	• Currently it is well known that the wastewater treatment of the Kimberly is not operational. Additional sewage cannot be sent to a system that is already not operational. Sewage must be treated on site before reticulation to irrigate open space areas or sent to evaporation ponds. • Incorporation of phytoremediation into the storm water attenuation systems to facilitate nutrient reduction, sediment regime control and manage toxicants releases.

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APPENDIX A: Requirements for Aquatic Biodiversity Assessments

The NEMA regulations of 2014 (as amended) specify required information to be included in specialist reports. Table 27 presents a summary of these requirements following GNR982 as amended by GN326. In March 2020, the Department of Environmental Affairs issued General Notice 320 set out requirements of the EIA Screening Tool Protocols for the Assessment and Reporting of Environmental Themes including Aquatic Biodiversity. These specifications overlap somewhat with the 2014 EIA regulations as amended (GN 982 as amended by GN326). Table 28 presents a summary of the requirements of this protocol with notes on sections of the report applicable to each aspect.

Table 27: Legislative report requirements GNR982

GNR982 as amended by GN326	Report Section
(1) A specialist report prepared in terms of these Regulations must contain—	
(a) details of—	
(i) the specialist who prepared the report; and	Page 5
(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Appendix C
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Pages 2 and 3
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.2
(cA) an indication of the quality and age of base data used for the specialist report;	Section 1.6, Table 1
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 3
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	P13
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 2 and Appendix B
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 3. No alternatives were provided for assessment
(g) an identification of any areas to be avoided, including buffers;	Section 3
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 3.5
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3
j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 3, summarised in Section 4
(k) any mitigation measures for inclusion in the EMPr;	Section 3.5
(l) any conditions for inclusion in the environmental authorisation;	Section 4
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 3.5, also refer to the accompanying Rehabilitation and Monitoring Plan
(n) a reasoned opinion—	
(i) whether the proposed activity, activities or portions thereof should be authorised;	Section 4

(iA) regarding the acceptability of the proposed activity or activities; and	Section 4
(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 4
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not Applicable
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not Applicable
(q) any other information requested by the competent authority.	Not Applicable
(2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Not Applicable

Table 28: Content of Specialist report GN320

Requirement	Section
2.3.1. a description of the aquatic biodiversity and ecosystems on the site, including; (a) aquatic ecosystem types; and (b) presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns;	Section 3
2.3.2. the threat status of the ecosystem and species as identified by the screening tool;	Section 1.6, Table 1
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 1.6, Table 1
2.3.4. a description of the ecological importance and sensitivity of the aquatic ecosystem including:	Section 3
(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	Section 3
(b) the historic ecological condition (reference) as well as present ecological state of rivers (in- stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Section 3
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.	No alternatives were available for consideration at the time of the assessment
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:	Section 3.5
2.5.1. Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Section 3
2.5.2. is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	Section 3

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 3.5
(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);	Section 3.5, Table 20
(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);	Section 3.5, Table 21
(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 I seasonal I permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and	Section 3.5, Table 20
(d) to what extent will the risks associated with water uses and related activities change;	See the accompanying Risk Assessment report
2.5.4. how will the proposed development impact on the functioning of the aquatic feature? This must include:	
(a) base flows (e.g., too little or too much water in terms of characteristics and requirements of the system);	Section 3.5, Table 20
(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);	Section 3.5, Table 20
(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);	Section 3.5, Table 20
(d) quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication);	Section 3.5, Table 24
(e) fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and	Section 3.5, Table 23
(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.);	Section 3.5, Table 23
2.5.5. how will the proposed development impact on key ecosystems regulating and supporting services especially: (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 3.5, Tables 20 to 25
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 3.5, Table 23 and 25
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;	Not applicable

(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).	

APPENDIX B: Detailed Methodology

Wetland and Riparian Delineation

Wetlands are delineated based on scientifically sound methods and utilizes a tool from the DWS 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAF, 2005) as well as the "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008). The delineation of the watercourses presented in this report is based on both desktop delineation and groundtruthing.

Desktop Delineation

A desktop assessment was conducted with wetland and riparian units potentially affected by the proposed activities identified using a range of tools, including:

- 1: 50 000 topographical maps;
- Recent, relevant aerial and satellite imagery, including Google Earth;
- NFEPA wetlands and Rivers (http://bgisviewer.sanbi.org/)
- Municipal and DWS spatial datasets.

All areas suspected of being wetland and riparian habitat based on the visual signatures on the digital base maps were mapped using google earth.

Ground Truthing

Field investigations confirmed fine-scale wetland and riparian boundaries.

Wetland Indicators

Wetlands were identified based on one or more of the following characteristic attributes (DWAF, 2005) (Figures 14 & Figure 15):

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

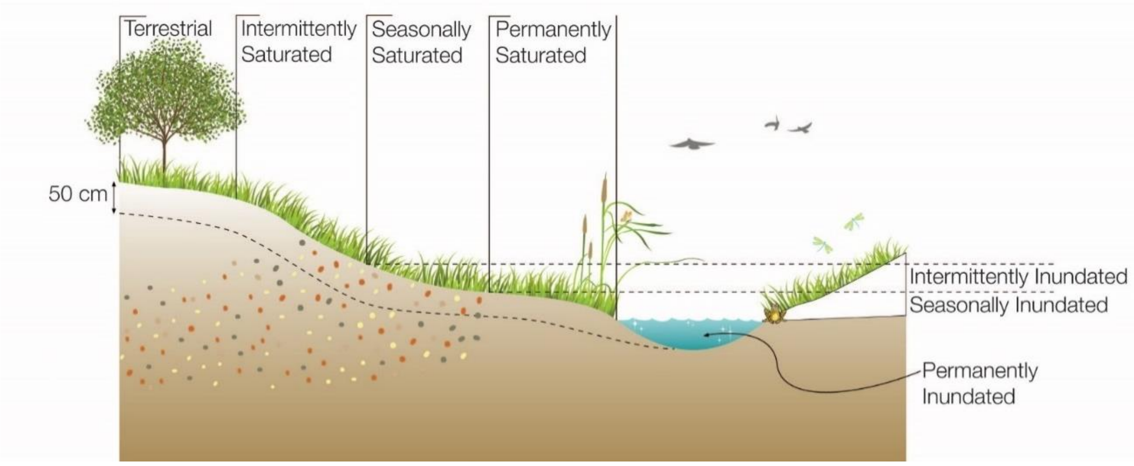


Figure 14: Typical cross section of a wetland (Ollis, 2013)

The terrain unit indicator is an important guide for identifying the parts of the landscape where wetlands might possibly occur and is relevant to the hydropedological setting of a wetland. For example, some wetlands occur on slopes higher up in the catchment where groundwater discharge is taking place through seeps. The type of wetland which occurs on a specific topographical area in the landscape is described using the Hydrogeomorphic classification which separates wetlands into 'HGM' units. The classification of Ollis, *et al*., (2013) is used, where wetlands are classified on Level 4 as either Rivers, Floodplain wetlands, Valley-bottom wetlands, Depressions, Seeps, or Flats.

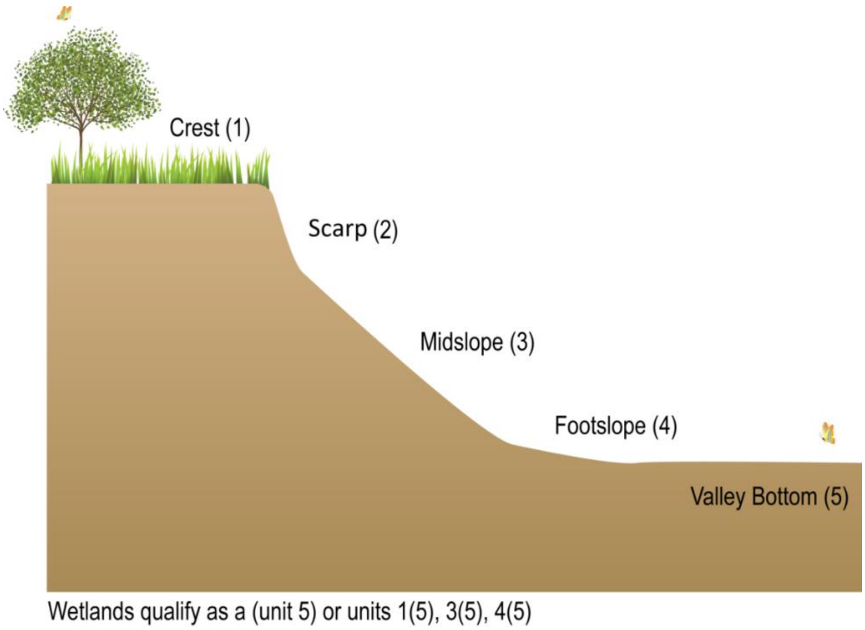


Figure 15. Terrain units (DWAF, 2005).

Riparian Indicators

A riparian area can be defined as a linear fluvial, eroded landform which carries channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone (Kotze, 1999).

Riparian habitat is classified primarily by identifying riparian vegetation along the edge of the macro stream channel. The macro stream channel is defined as the outer bank of a compound channel and should not be confused with the active river bank. The macro channel bank often represents a dramatic change in the energy with which water passes through the system. Rich alluvial soils deposit nutrients making the riparian area a highly productive zone. This causes a very distinct change in vegetation structure and composition along the edges of the riparian area (DWAF, 2008). The marginal zone includes the area from the water level at low flow, to those features that are hydrologically activated for the greater part of the Year (WRC Report No TT 333/08 April, 2008). The non-marginal zone is the combination of the upper and lower zones (Figure 16).

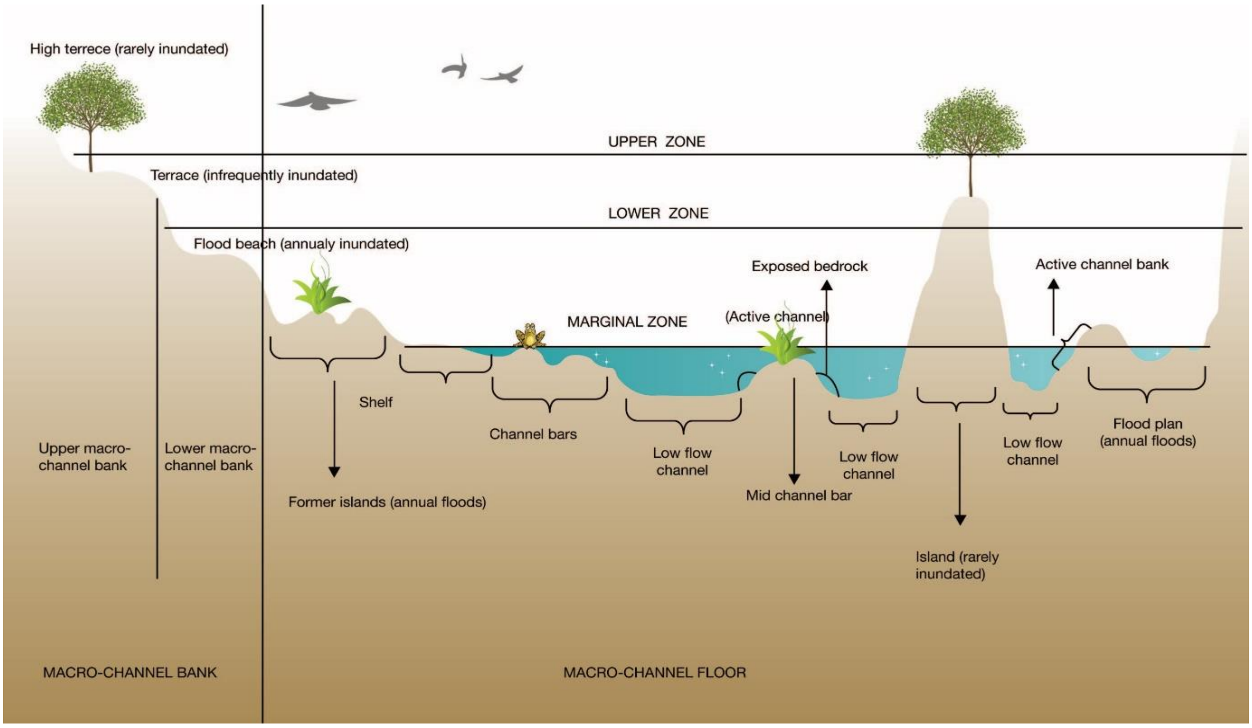


Figure 16: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans *et al*, 2007)

Riparian areas can be grouped into different categories based on their inundation period per year. Perennial rivers are rivers with continuous surface water flow, intermittent rivers are rivers where surface flow disappears but some surface flow remains, temporary rivers are rivers where surface flow disappears for most of the channel (Figure 17). Two types of temporary rivers are recognized, namely "ephemeral" rivers that flow for less time than they are dry and support a series of pools in parts of the channel, and "episodic" rivers that only flow in response to extreme rainfall events, usually high in their catchments (Seaman *et al*, 2010).

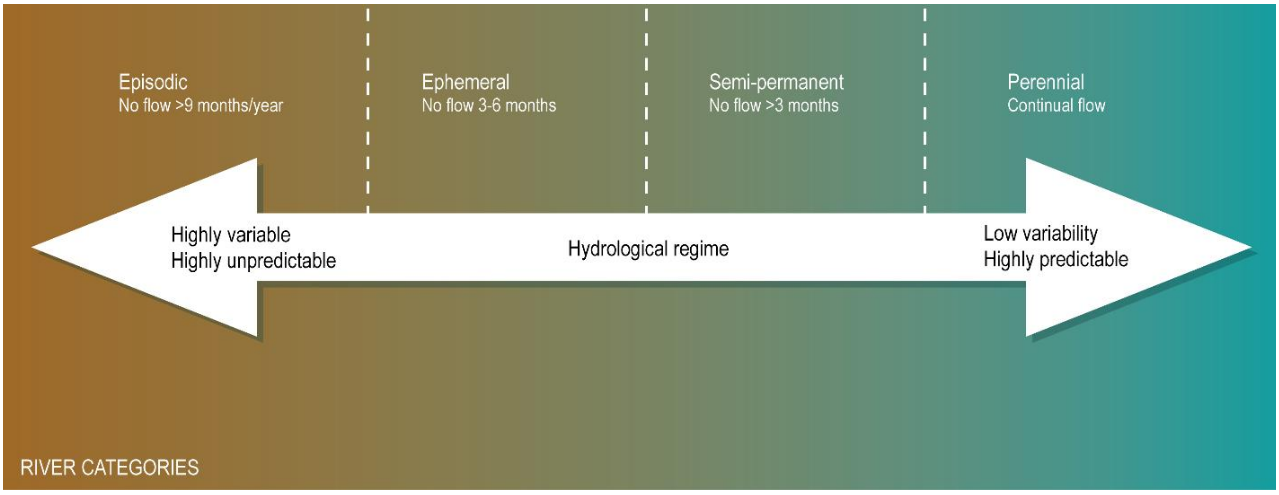


Figure 17: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

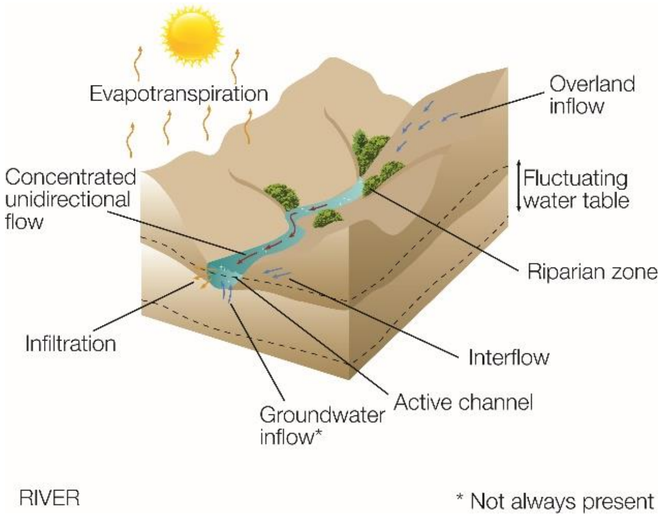
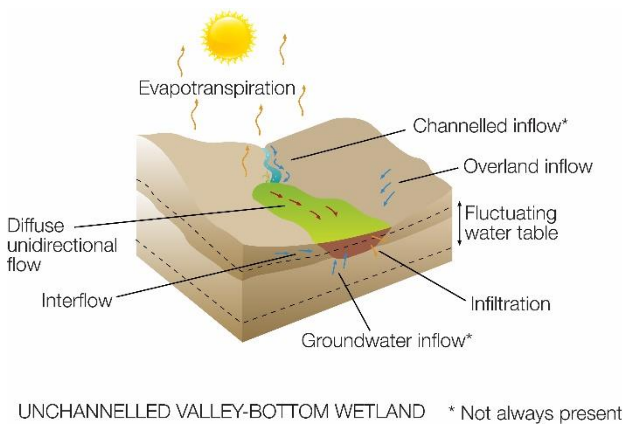
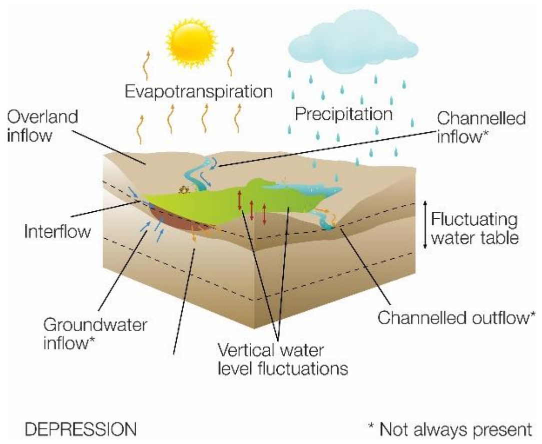
Wetland/Riparian Classification

The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2013). The current watercourse assessment follows the same approach by classifying watercourses in terms of a functional unit recognised in the classification system proposed in SANBI (2013). HGM units take into consideration factors that determine the nature of water movement into, through and out of the watercuorse system. In general, HGM units encompass three key elements (Kotze et al, 2005):

- Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
- Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
- Hydrodynamics - This refers to how water moves through the wetland.

The classification of watercourse areas found within the study site and/or within 500 m of the study site (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005) are as follows (Table 29):

Table 29: Watercourse Types and descriptions

Watercourse Type:	**Description:**
Valley bottom without a channel 	inear fluvial, eroded landforms which carry channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The “river” includes both the active channel (the portion which carries the water) as well as the riparian zone.
Valley bottom without a channel 	Linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas, or at tributary junctions where the sediment from the tributary smothers the main drainage line.
Depressional pans 	Small (deflationary) depressions which are circular or oval in shape; usually found on the crest positions in the landscape. The topographic catchment area can usually be well-defined (i.e. a small catchment area following the surrounding watershed). Although often apparently endorheic (inward draining), many pans are “leaky” in the sense that they are hydrologically connected to adjacent valley bottoms through subsurface diffuse flow paths.

Buffer Zones and Regulated Areas

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a watercourse. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is, therefore, often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. Although buffer zones can be effective in addressing diffuse source pollution in storm water run-off, they should typically be seen as part of a treatment train designed to address storm water impacts (MacFarlane & Brendin, 2017).

Authorisation from the DWS requires calculation of a site-specific buffer zone (General Notice 267 of 24 March 2017), following Macfarlane et al 2015. This Excel-based tool calculates the best suited buffer for each wetland or section of a wetland based on numerous on-site observations. The resulting buffer zone can thus have large differences depending on the current state of the wetland as well as the nature of the proposed development. Developments with a high-risk factor such as mining are likely to have a larger buffer area compared to a residential development with a lower risk factor.

Figure 18 images represent the buffer zone setback for the watercourse types discussed in this report.

It should be noted that the buffer calculation tool does not take into account the effects of climate change or cumulative impacts to floodflows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

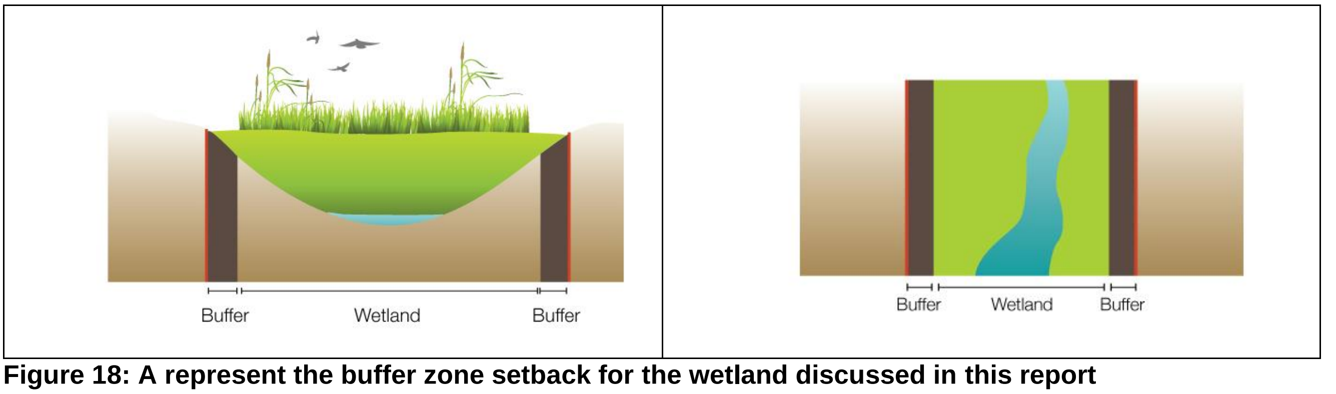


Figure 18: A represent the buffer zone setback for the wetland discussed in this report

Regulated areas are zones within which authorisation is required. The DWS specify a 500m regulated area around all wetlands and 100m around all riparian zones within which development must be authorised from their department. Development within 32m of the edge of the watercourse triggers the requirement for authorisation under the National Environmental Management Act (NEMA): Environmental Impact Assessment (EIA) Regulations of 2014 (GNR 326) as amended.

Watercourse Functionality, Status and Sensitivity

Watercourse functionality is defined as a measure of the deviation of structure and function from its natural reference condition. The natural reference condition is based on a theoretical undisturbed state extrapolated from an understanding of undisturbed regional vegetation and hydrological conditions.
The allocations of scores in the functional and integrity assessment are somewhat subjective and are thus vulnerable to the interpretation of the specialist. With the exception of the assessment of water quality and invertebrates, collection of empirical data is precluded at this level of investigation due to project constraints including time and budget. Water quality values, species richness and abundance indices, surface and groundwater volumes, amongst others, should ideally be used rather than a subjective scoring system such as is presented here.
The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) unit. Following the calculation of PES and EC scores, a Recommended Ecological Category can be obtained. This score reflects an auditable management or rehabilitation target to be achieved by the proposed project. The sections below provide a brief description of each method.

Present Ecological Status (PES) – WET-Health

A summary of the three components of the WET-Health Namely Hydrological; Geomorphological and Vegetation Health assessment for the wetlands found on site is described in Table 30. A Level 1 assessment was used in this report. Level 1 assessment is used in situations where limited time and/or resources are available.

Table 30: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2020)

Description	Impact Score Range	PES Score	Summary
Unmodified, natural.	0.0.9	A	Very High
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	High
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	Moderate
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D	Moderate

Description	Impact Score Range	PES Score	Summary
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E	Low
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	Very Low

A summary of the change class, description and symbols used to evaluate wetland health are summarised in Table 31.

Table 31: Trajectory class, change scores and symbols used to evaluate Trajectory of Change to wetland health (Macfarlane *et al*, 2020)

Change Class	Description	Symbol
Improve	Condition is likely to improve over the over the next 5 years	(↑)
Remain stable	Condition is likely to remain stable over the next 5 years	(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years	(↓)
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years	(↓↓)

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both PES and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance.
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors.
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the wetlands is represented are described in the results section. Explanations of the scores are given in Table 32.

Table 32: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1

Ecosystem Services (ES)

The DWS authorisations related to wetlands are regulated by Government Notice 267 published in the Government Gazette 40713 of 24 March 2017. Page 196 of this notice provides a detailed "terms of reference" for wetland assessment reports and includes the requirement that the ecological integrity and function of wetlands be addressed. This requirement is addressed through the WetEcoServices toolkit (Kotze et al. 2020). This wetland assessment method is an excel based tool which is based on the integral function of wetlands in terms of their hydrogeomorphic setting. Each of seven benefits are assessed based on a list of characteristics (e.g. slope of the wetland) that are relevant to the particular benefit. Scores are subjectively awarded to characteristics of the wetland and its catchment relative to the proposed activity. Scores are ranked as High, Moderate or Low.

Present Ecological Category (EC): Riparian

The VEGRAI assessment (Kleynhans et al, 2007) is an Excel-based tool which combines input on the degree of change of marginal and non-marginal vegetation to provide an Ecological Category score for the riparian zone (Table 33).

Table 33: Generic ecological categories for EcoStatus components (modified from Kleynhans, 1996 & Kleynhans, 1999).

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

Physical Habitat Assessment the IHAS method

The quality of the instream and riparian habitat has a direct influence on the aquatic community. Evaluating the structure and functioning of an aquatic ecosystem must therefore take into account the physical habitat to assess the ecological integrity. The IHAS sampling protocol, of which version 2 is currently used, was developed by McMillan in 1998 for use in conjunction with the SASS5 protocol to determine which habitats are present for aquatic macroinvertebrates.

IHAS consists of a scoring sheet that assists to determine the extent of each of the instream habitats, together with the physical parameter of the stream. For example, the proportion of stones in current and stones out of current will be compared with the presence of instream vegetation. This sampling protocol assists with the interpretation of the SASS5 data.

Data recorded during the site visit concerning sampling habitat and stream condition is uploaded into an excel spreadsheet. The results are then interpreted according to the categories supplied by McMillan (Table 34).

Table 34: IHAS score interpretation table

IHAS SCORE	INTERPRETATION
<65%	Insufficient for supporting a diverse aquatic macro invertebrate community
65%-75%	Acceptable for supporting a diverse aquatic macroinvertebrate community
75%	Highly suitable for supporting a diverse aquatic macroinvertebrate community

In Situ Water Quality

Water quality has a direct influence on in stream biota, and can fluctuate, depending on site-specific conditions. The biological monitoring of especially macroinvertebrates and fish thus need to be augmented with the in situ measurement of basic water quality indicator parameters (DWAF 1996), namely:

Temperature, which plays an important role in water by affecting the rates of chemical reactions and therefore the metabolic rates of organisms. Temperature is one of the major factors controlling the distribution of aquatic organisms. The temperatures of inland waters in South Africa generally range from 5 – 30°C. Natural variations in water temperature occur in response to seasonal and diel cycles and organisms use these changes as cues for activities such as migration, emergence and spawning. Artificially-induced changes in water temperature can thus impact on individual organisms and on entire aquatic communities.

pH, which gives an indication of the level of hydrogen ions in water, as calculated by the expression: $pH = -\log_{10}[H^+]$, where $[H^+]$ is the hydrogen ion concentration. The pH of pure distilled water (that is, water containing no other soluble chemicals) at a temperature of 24°C is 7.0, implying that the number of H^+ and OH^- ions are equal and the water is therefore electrochemically neutral. As the concentration of hydrogen ions increases, pH decreases and the solution becomes more acidic. As $[H^+]$ decreases, pH increases and the solution becomes more alkaline. For natural surface water systems, pH values typically range between 4 and 11, and depends on the availability of carbonate and bicarbonate, which influences the buffer capacity of the water, and which are determined by geological and atmospheric circumstances.

Electrical Conductivity ("EC") is the measurement of the ease with which water conducts electricity (in milli-Siemens/meter – mS/m) and can also be used to estimate the total dissolved salts ("TDS"): EC in mS/mx 7 ≈ TDS in mg/ℓ. Changes in the EC values provide useful and rapid estimates of changes in the TDS concentration, which indicates the quantity of all compounds dissolved in the water that carry an electrical charge. Natural waters contain varying concentrations of TDS as a consequence of the dissolution of minerals in rocks, soils and decomposing plant material. TDS thus depends on the characteristics of the geological formations which the water has been in contact with, and on physical processes such as rainfall and evaporation. Plants and animals possess a wide range of physiological mechanisms and adaptations to maintain the necessary balance of water and dissolved ions in cells and tissues. Changes in EC can affect microbial and ecological processes such as rates of metabolism and nutrient cycling. The effect on aquatic organisms depend more on the rate of change than absolute changes in concentrations of salts.

Dissolved Oxygen ("DO") is the measurement of the percentage saturation of water with gaseous oxygen, which is generated by aquatic plants during photosynthesis, or which dissolved into the water from the atmosphere. Gaseous oxygen is moderately soluble in water, and the saturation solubility varies non-linearly with temperature, salinity, atmospheric pressure (and thus altitude), and other site-specific chemical and physical factors. In unpolluted surface waters, dissolved oxygen concentrations are usually close to 100% saturation. Concentrations of less than 100% saturation indicate that DO has been depleted from the theoretical equilibrium concentration. Results in excess of 100% saturation (super-saturation of oxygen) usually indicate eutrophication in a water body. Typical oxygen saturation concentrations at sea level, and at TDS values below 3,000 mg/ℓ, are at around 13 mg/ℓ (@5 °C); 10 mg/ℓ (@15 °C); and 9 mg/ℓ (@20 °C). High water temperatures combined with low dissolved oxygen levels can compound stress effects on aquatic organisms. There is a natural diel (24-hour cycle) variation in DO, associated with the 24-hour cycle of photosynthesis and respiration by aquatic biota. Concentrations decline through the night to a minimum near dawn, then rise to a maximum by mid-afternoon. Seasonal variations arise from changes in temperature and biological productivity. The maintenance of adequate DO saturation levels in water is critical for the survival and functioning of aquatic biota, because it is required for the respiration of all aerobic organisms. Therefore, the DO saturation levels provide a useful measure of the health of an aquatic ecosystem (DWAF 1996). Measuring DO is measuring a dissolved gas, and is thus best measured in situ, to prevent de-oxygenation or oxygenation during transportation.

It should be noted that the *in situ* measurement of these water quality parameters does not represent the general water quality at the sampling points or the streams. It is not a laboratory analysis of water quality, and does not measure macro anions and cations, metals or organic contaminants, nutrients or pesticides. The *in situ* measurements of these parameters provide a snapshot of the water quality at the survey site at the time the biological samples were taken, and thus can provide valuable insight into the characteristics at a survey site that could have an influence on the aquatic biota at that site, and at the time of conducting the sampling for biomonitoring.

In situ measurements of pH, temperature (in °C), and EC (in µS/cm) were taken by means of a calibrated hand-held instrument (Hanna - HI 991300) in the main flow of the river or stream sampled, both prior to conducting the sampling for biomonitoring as well as after the completion of conducting the sampling for biomonitoring.

The EC measurements in µS/cm were converted to mS/m (10 µS/cm = 1 mS/m) by dividing with a factor of 10.

Receiving water quality objectives ("RWQOs") based on the water quality requirements for different users, are contained in a set of documents first published by DWAF in 1993, and revised in 1996 (DWAF, 1996). These documents are collectively known as the "South African Water Quality Guidelines" ("SAWQGs") and contain guidelines for specific types of water users, namely:

- SAWQG Volume 1: Domestic Water Use
- SAWQG Volume 2: Recreational Water Use
- SAWQG Volume 3: Industrial Water Use
- SAWQG Volume 4: Agricultural Water Use: Irrigation
- SAWQG Volume 5: Agricultural Water Use: Livestock Watering
- SAWQG Volume 6: Agricultural Water Use: Aquaculture
- SAWQG Volume 7: Aquatic Ecosystems

These guidelines provide useful information on the effects of various chemical substances on water resource quality and establish objectives for the management of the water resource based on the requirements of the different users of the water resource. The water quality requirements for protecting and maintaining the health of aquatic ecosystems differ from those of other water uses. It is difficult to determine the effects of changes in water quality on aquatic ecosystems, as the cause-effect relationships are not well understood. Therefore, water quality guidelines have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms. Certain quality ranges are required to protect and maintain aquatic ecosystem health. For each constituent, guideline ranges are specified, including the No Effect Range (Target Water Quality Range or “TWQR”), Minimum Allowable Values, Acceptable Range, and, for some parameters, Intolerable levels.

The SAWQGs for aquatic ecosystems that are applicable to the *in situ* measurements of water quality, are summarised below (DWAF 1996):

PARAMETER	UNIT	TARGET WATER QUALITY RANGE	MINIMUM ALLOWABLE VALUES
Temperature	°C	should not vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2 °C, **or** by > 10 %, whichever estimate is the more conservative	
EC	mS/m	Should not be changed by > 15 % from the normal cycles of the water body	
pH	pH units	Variation from background pH limited to <0.5 of a pH unit, or < 5%, whichever is the more conservative estimate	
DO	% saturation	80 – 120	> 60 (sub lethal) > 40 (lethal)

Data collected during the *in situ* measurements were compared against these SAWQGs for aquatic ecosystems.

SASS5

SASS5 is a rapid bioassessment method used to identify changes in species composition of aquatic invertebrates to indicate relative water quality (Dickens and Graham 2002). SASS5 requires the identification of invertebrates to a family level in the field.

SASS5 is based on the principle that some invertebrate taxa are more sensitive than others to alterations in ecological drivers such as pollutants or flooding events. Macroinvertebrate assemblages are good indicators of localized conditions in rivers. Many macroinvertebrates have limited migration patterns or are not free moving, which makes them well-suited for assessing site specific impacts with upstream/downstream studies. Benthic macroinvertebrates are abundant in most streams. Even small streams (1st and 2nd order) which may have a limited fish population will support a diverse macroinvertebrate fauna. These groups of species constitute a broad range of trophic levels and pollution tolerances. Thus, SASS5 is a useful method for interpreting the cumulative effects of impacts on aquatic environments.

Using a 'kick net', the SASS5 sampling method entails prescribed time-periods and spatial areas for the kicking of in-current and out-current stones and bedrock; sweeping of in-current and out-current marginal and aquatic vegetation, as well as of gravel, stones and mud ("GSM"); followed by visual observations and hand-picking. The results of each biotope are kept separate, until all observations are noted. The entire sample is then returned to the river, retained alive, or preserved for further identification.

In SASS5 analysis, species abundance is recorded on an SASS5 data sheet which weighs the different taxons common to South African rivers from 1 (pollutant tolerant) to 15 (pollution sensitive). The SASS5 score will be high at a particular site if the taxa are pollution sensitive and low if they are mostly pollution tolerant.

The SASS5 Score, the number of taxa observed, and the average score per taxon ("ASPT") are calculated for all of the biotopes combined. Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardised graphs that are used as a guideline for interpreting any data obtained during the study. The meaning of each SASS5 Ecological Category is as follows (Dallas 2007).

EC	ECOLOGICAL CATEGORY	DESCRIPTION
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

Physical properties of water

The physical properties of water are based on the temperature, Electrical conductivity (EC), pH, and oxygen content of the water- using physical methods. The physical properties of water influence the aesthetical – as well as the chemical qualities of water. Relevance of the indicators of the physical properties of water include pH- affects the corrosiveness of water and EC- an indication of the "freshness" of water (indicates the presence of dissolved salts and other dissolved particles). Included in the physical properties of water is the suspendoid's effects on water quality. This includes turbidity, and total suspended solids. Turbidity is measured in Nephelometric Turbidity Units (NTU's) and is the indication of the ability of light to pass through water. See Table 35 for a list of physical properties of water and comparative results.

Table 35: Table for comparative results of physical properties of water

pH Values	
pH > 8.5	Alkaline
pH 6.0-8.5	Circumneutral
pH < 6.0	Acidic
Total Hardness (in **mg CaCO3/l)**	

Hardness < 50 mg/l	Soft
Hardness 50-100 mg/l	Moderately soft
Hardness 100- 150 mg/l	Slightly hard
Hardness 150-200 mg/l	Moderately hard
Hardness 200-300 mg/l	Hard
Hardness 300-600 mg/l	Very hard
Total Dissolved Solids as indicator of salinity of water	
TDS <450 mg/l	Non saline
TDS 450-1000 mg/l	Saline
TDS 1000-2400 mg/l	Very saline
TDS 2400-3400 mg/l	Extremely saline
Total suspended solids (TSS)	
Background TSS concentrations are < 100 mg/l	Any increase in TSS concentrations must be limited to < 10 % of the background TSS concentrations at a specific site and time.

Chemical properties of water

The chemical quality of the water refers to the nature and concentrations of dissolved substances such as organic or inorganic compounds (including metals) in the water body. Many chemicals in water are essential for the biotic community and may form an integral part of the nutritional requirements. Various chemical properties can be tested for and is costly to conduct full spectrum analysis. For that reason, only select aspects are possibly tested for. See Table 36 for a list of some of the chemical aspects tested for.

Table 36: Some of the chemical aspects tested for

Chloride ion:	Normally all types of water contain chloride ion but its concentration is very low in natural water system. Chloride ion concentration increases in case of urine and sewage contaminated water. High concentration of chloride ion give salty taste and also corrodes pipelines of water. Normally 150 mg/l of chloride ion is harmless. Maximum permissible limit of chloride ion in drinking water is 200mg/ l.	Aquatic ecosystems= 0 mg/l Human consumption= 0-100 mg/l	
Ammonia	In water ammonia come from decomposition of organic matter like protein, amino acids etc. Its concentration also increases during water disinfection process using chloramine. In water Ammonia (NH3) is first oxidized into nitrite and then into nitrate. Therefore by measuring the concentration of NH3, nitrite and nitrate, we can predict the time of contamination of organic matter in water. In recently contamination, concentration of NH3 is very high than nitrite and nitrate. Concentration of NH3 in ground water system is usually 3mg/l If its concentration is greater than 50mg/l it gives characteristic taste and odor.	**Aquatic ecosystems = 0.007 mg NH_3/l** **Human consumption= 0-1.0 mg NH_3/l**	
Nitrite	It is very unstable intermediate formed during conversion of NH_2 into nitrate.	<0.5 mg/l	Oligotrophic conditions; usually moderate levels of species diversity; usually low productivity systems with rapid nutrient cycling; no nuisance

	In aerobic condition nitrite is oxidized into nitrate whereas in anaerobic condition, nitrite is reduced to ammonia. If concentration of nitrite is greater in drinking water, it brings serious health hazard to the consumers. Disease caused by high concentration of nitrite in infants is called Blue baby syndrome, which is characterized by blue coloration of skin. Level of nitrite in drinking water should not exceed 3mg/l.		growth of aquatic plants or the presence of blue-green algal blooms.
		0.5-2.5 mg/l	Mesotrophic conditions; usually high levels of species diversity; usually productive systems; nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms seldom toxic.
		2.5-10 mg/l	Eutrophic conditions; usually low levels of species diversity; usually highly productive systems, nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms may include species which are toxic to man, livestock and wildlife.
		>10 mg/l	Hypertrophic conditions; usually very low levels of species diversity; usually very highly productive systems; nuisance growth of aquatic plants and blooms of blue-green algae, often including species which are toxic to man, livestock and wildlife.
Nitrate	It is most stable oxidized form of nitrogen. In water nitrate comes from organic matter decomposition and from atmospheric nitrogen fixation.	<0.5 mg/l	Oligotrophic conditions; usually moderate levels of species diversity; usually low productivity systems with rapid nutrient cycling; no nuisance

	Like nitrite Nitrate should not exceed 3mg/l in drinking water. It is because nitrate can be reduced into nitrite in gut of infants and causes nitrite poisoning. Nitrate is very important in natural water system like lake and pond because high concentration of nitrate facilitates heavy growth of aquatic plants causing eutrophication.		growth of aquatic plants or the presence of blue-green algal blooms.
		0.5-2.5 mg/l	Mesotrophic conditions; usually high levels of species diversity; usually productive systems; nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms seldom toxic.
		2.5-10 mg/l	Eutrophic conditions; usually low levels of species diversity; usually highly productive systems, nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms may include species which are toxic to man, livestock and wildlife.
		>10 mg/l	Hypertrophic conditions; usually very low levels of species diversity; usually very highly productive systems; nuisance growth of aquatic plants and blooms of blue-green algae, often including species which are toxic to man, livestock and wildlife.

Phosphate	In water phosphate is present in the form of $H_2PO_4^-$, polyphosphate and as organic phosphate. Phosphate in water sources comes from agricultural wastes, sewage and from industrial effluent. Phosphate is not toxic to human being, but it is important chemical in natural water system like pond because its high concentration facilitates eutrophication.	<5 g/l	Oligotrophic conditions; usually moderate levels of species diversity; usually low productivity systems with rapid nutrient cycling; no nuisance growth of aquatic plants or blue-green algae.
		5-25 g/l	Mesotrophic conditions; usually high levels of species diversity; usually productive systems; nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms seldom toxic.
		25-250 g/l	Eutrophic conditions; usually low levels of species diversity; usually highly productive systems, with nuisance growth of aquatic plants and blooms of blue green algae; algal blooms may include species which are toxic to man, livestock and wildlife.
		>250 g/l	Hypertrophic conditions; usually very low levels of species diversity; usually very highly productive systems; nuisance growth of aquatic plants and blooms of blue-green algae, often including species which are toxic to man, livestock and wildlife.

Calcium (Ca)	High levels may be beneficial (see below) and waters which are rich in calcium (and hence are very hard) are very palatable	0	Aquatic ecosystems
		0-32 mg/l	Human consumption
Magnesium	Like calcium (q.v.), magnesium is abundant and a major dietary requirement for humans (0.3-0.5 g/day). It is the second major constituent of hardness (see above) and it generally comprises 15-20 per cent of the total hardness expressed as CaCO3. Its concentration is very significant when considered in conjunction with that of sulphate,	0	Aquatic ecosystems
		0-30 mg/l	Human consumption

Bacteriological properties of water

Generally, the microbiological quality of water refers to the presence of organisms that cannot be individually seen with the naked eye, such as protozoa, bacteria and viruses. Many of these microbes are associated with the transmission of infectious water-borne diseases such as gastro-enteritis and cholera. In order to determine the bacteriological status and safety of water, specifically focuses on total coliforms and *E. coli* (indicator of faecal coliforms) bacteria. Faecal Coliforms indicates recent faecal pollution and the potential risk of contracting infectious diseases and Total coliforms Indicates the general hygienic quality of the water. See Table 37 for interpretation guide for the results.

Table 37: Faecal coliform result interpretation guide

Faecal Effects coliform range (counts/ 100 mR)	**EFFECTS**
Target Water Quality range *0 - 130*	Which occasionally fall in this range. Risk increases if the geometric mean or median levels are consistently in this range *quality range coliforms indicate a possible risk to health, but the absence of indicators does not guarantee no risk*
130 - 600	Risk of gastrointestinal illness indicated at faecal coliforms levels *effects expected. The presence of faecal*
600 - 2 000	Noticeable gastrointestinal health effects expected in the swimmer and bather population. Some health risk, if single samples fall in this range, particularly if such events occur frequently. Four out of five samples should contain < 600 faecal coliforms/100 mr, or 95 % of Faecal coliform analyses should be < 2 000/100 mr
> 2 000	As the faecal coliform count increases above this limit, the risk of contracting gastrointestinal illness increases. The volume of water ingested in order to cause adverse effects decreases as the faecal coliform density increases

Recommended Ecological Category (REC)

The REC is determined by the Present Ecological State of the water resource and the importance and/or sensitivity of the water resource. Water resources which have Present Ecological State categories in an E or F ecological category are deemed unsustainable by the DWS. In such cases the REC must automatically be increased to a D.

Where the PES is in the A, B, C, D or E the EIS components must be checked to determine if any of the aspects of importance and sensitivity (Ecological Importance; Hydrological Functions and Direct Human Benefits) are high or very high. If this is the case, the feasibility of increasing the PES (particularly if the PES is in a low C or D category) should be evaluated. This is recommended to enable important and/or sensitive wetland water resources to maintain their functionality and continue to provide the goods and services for the environment and society.

If (Table 38):

- PES is in an E or F category:
  The REC should be set at least a D, since E and F EC's are considered unsustainable.
  - The PES category is in an A, B, C or D category, AND the EIS criteria are low or moderate OR the EIS criteria are high or even very high, but it is not feasible or practicable for the PES to be improved:
- The REC is set at the current PES.
  - The PES category is in a B, C or D category, AND the EIS criteria are high or very high AND it is feasible or practicable for the PES to be improved:
- The REC is set at least one Ecological Category higher than the current PES." (Rountree *et al.,* 2013).

Table 38: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Impact Assessments

NEMA (2014) Impact Ratings with reference to aquatic aspects specified in GN320 of March 2020

As required by the 2014 NEMA regulations (as amended), impact assessment should provide quantified scores indicating the expected impact, including the cumulative impact of a proposed activity. Specific aspects of the aquatic environment that should be assessed are set out in GN 320. These are listed in Appendix A. The impact assessment should follow the format presented below. Impact scores are calculated using the following parameters:

- Direct, indirect and cumulative impacts of the issues identified through the specialist study, as well as all other issues must be assessed in terms of the following criteria:
  - The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
  - The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
  - The **duration**, wherein it will be indicated whether:
    - The lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
    - The lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
    - Medium-term (5–15 years) – assigned a score of 3;
    - Long term (> 15 years) - assigned a score of 4; or
    - Permanent - assigned a score of 5;
  - The consequences (magnitude), quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
  - The probability of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
  - The significance, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
  - The status, which will be described as either positive, negative or neutral.
  - The degree to which the impact can be reversed.
  - The degree to which the impact may cause irreplaceable loss of resources.
  - The degree to which the impact can be mitigated.

The **significance** is calculated by combining the criteria in the following formula:

- S=(E+D+M)P
- S = Significance weighting

- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The **significance weightings** for each potential impact will be determined as follows (Table 39):

Table 39: Significance Weightings

Points	Significant Weighting	Discussion
< 30 points	Low	This impact would not have a direct influence on the decision to develop in the area.
31-60 points	Medium	The impact could influence the decision to develop in the area unless it is effectively mitigated.
> 60 points	High	The impact must have an influence on the decision process to develop in the area.

APPENDIX C: Abbreviated CVs of participating specialists

CURRICULUM VITAE (CV) OF ANTOINETTE BOOTSMA 2021

DIRECTOR and SENIOR WETLAND SPECIALIST at Limosella Consulting since 2009.
16 Years experience as an ecologist

Professional Affiliations:
Professional Natural Scientist (SACNASP) # 400222-09 Botany and Ecology
South African Wetland Society # NA6RY2FP
Grassland Society of South Africa

Highest Qualification - M.SC (Environmental Science), University of South Africa, 2017. *Awarded with distinction*. Project Title: Natural mechanisms of erosion prevention and stabilization in a Marakele peatland; implications for conservation management

Latest Publication - A.A. Boostma, S. Elshehawi, A.P. Grootjans, P.L Grundling, S. Khosa, M. Butler, L. Brown, P. Schot. 2019. Anthropogenic disturbances of natural ecohydrological processes in the Matlabas mountain mire, South Africa. South African Journal of Science Volume 115| Number 5/6, May/June 2019, P1 to 8

Relevant Employment History:
Director at Limosella Consulting (Pty) Ltd - 2009 – ongoing
Senior Wetland Specialist at Strategic Environmental Focus – 2007 to 2009
Technical Assistant at the Conservation Ecology Research Unit, University of Pretoria, Richards Bay field station, 2005 to 2007

Summary of relevant skills:

- Management of projects in terms of specialist input, including quotations, planning, technical review, submission of reports and invoicing;
- Fine scale wetland delineations and functional assessments;
- Strategic wetland assessments and open space management and planning;
- General Rehabilitation, Monitoring and Mitigation assessments.
- Wetland offset strategies
- Hydropedological investigations
- Implementation of wetland assessment tools including the DWS (2016) Risk Assessment, Present Ecological Status (PES) Macfarlane et al, (2020), Ecological Importance and Sensitivity (EIS) (DWAF, 1999), Recommended Ecological Category (REC) Rountree et al (2013), Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al, 2007) and QHI (Quick Habitat Integrity)

Short list of projects to demonstrate experience:

- More than 90 external peer reviews as part of mentorship programs for companies including Galago Environmental Consultants, Lidwala Consulting Engineers, Bokamoso Environmental Consultants, Gibb, 2009 ongoing
- Input into the Environmental Management Plan for repair to 90 bridges in the City of Johannesburg, 2020
- Wetland specialist input into the City of Tshwane Open Space Framework, 2019
- Wetland specialist input into the North West Environmental Outlook, 2018
- Wetland specialist input into the Gauteng Environmental Outlook, 2017

- Wetland specialist input into the Open Space Management Framework for Kyalami and Ruimsig, City of Johannesburg, 2016
- Kangra Maquasa East and Maquasa West and Nooitgesien Mine, Mpumalanga Province: Rehabilitation and Monitoring Assessment. June 2018
- Mbuyelo Coal Welstand Reserve Amendment: Wetland assessment. June 2017
- Proposed mining right to mine on portion of the remaining extent of the farm Dingwell No. 276 JT, Barberton Magisterial District, in Mpumalanga Province: Wetland Delineation and Assessment. January 2017
- Fine scale wetland specialist input including General Rehabilitation Plan into the ESKOM Bravo Integration Project 3, 4, 5 and Kyalami – Midrand Strengthening, December 2017
- Fine scale wetland specialist input including General Rehabilitation Plan into 3 Eskom Projects to lay underground power cables in Gauteng; Craighall to Sandton, Croyden to Germiston and Randburg, November 2017
- Dama Colliery, Near Utrecht, KwaZulu-Natal Province: Preliminary Wetland Delineation& Functional Assessment Report. February 2015
- Harmony Gold Mining co Ltd's Evander Operations Property Area, Mpumalanga Province: Wetland Delineation and Functional Assessment. February 2011

Curriculum Vitae

Bertus Fourie

Tertiary Education

M. Sc. M.Sc. Aquatic Health at University of Johannesburg, 2014. Research project title: *Biological aspects of the Mutale, Tshinane and Mutshundudi Rivers, Limpopo*

B Tech. Nature Conservation, 2009 specialization in Environmental Education& Freshwater management. Project title: *Ndumo Game count: A critical review of game count data 1999-2009.*

National diploma Nature Conservation, 2005

Accreditation: SASS 5 (Dickens & Graham, 2002)

SACNASP registered as Professional Natural scientist in the field of Ecology (SACNASP Pr.Sci.Nat. Reg. No: 400126/17)

Training:

Mine closure and land rehabilitation Enterprises at the University of Pretoria, 2020

Freshwater fish identification course South African Institute of Aquatic Biodiversity, 2016

Wetland Rehabilitation Centre for Environmental Management, University of Free State

Introduction to wetland soils and delineation South African soil surveyor's organization (SASSO)

Wetland Management: Introduction and Delineation Centre for Environmental Management, University of Free State

SASS 5 training Nepid consultants (2011), Ground Truth (2013)

Environmental Law for Environmental Managers: Centre for environmental studies (CEM) @ Northwest University

FGASA level 1 FGASA 2006

Work Experience

My work includes all aspects of ecology including terrestrial and aquatic. Main project involvements include:

- Veld and Game management plans (including Veld condition and plant diversity assessments)
- Environmental impact assessments
- Environmental Education
- Ecological Management Plans
- Monitoring Planning
- Aquatic Environmental Control Officer (AECO)
- Environmental Control officer
- Rehabilitation implementation
- Ridges Studies
- Wetland rehabilitation planning
- Aquatic ecosystem delineation (including wetlands and riparian)

Scientific societies Membership

Grassland Society of Southern Africa

South African Society of Aquatic Scientists

South African Wetland Society

Society of Wetland Scientist

Presenting of Wetland related training

Advanced Wetland course at the Centre for continued education at the University of Pretoria

APPENDIX D: Glossary of Terms

Baseflow	
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
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 land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).
Wetland delineation	the determination and marking of the boundary of a wetland on a map using the DWAF (2005) methodology. This assessment includes identification of suggested buffer zones and is usually done in conjunction with a wetland functional assessment. The impact of the proposed development, together with appropriate mitigation measures are included in impact assessment tables

APPENDIX E: Abbreviations

ASPT	Average score per taxon
CBAs	Critical Biodiversity Areas
DEA	Department of Environmental Affairs
DO	Dissolved Oxygen
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
ESAs	Ecological Support Areas
FSA	Fish Support Area
GSM	Gravel, Sand and Mud
GPS	Global Positioning System
IHAS	Integrated Habitat Assessment System
PES	Present Ecological Category
EC	Ecological Category
EIA	Environmental Impact Assessment
EIS	Ecological Integrity and Sensitivity
ES	Ecosystem Services
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NEMA	National Environmental Management Act 107 of 1998
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act 36 of 1998
PES/C	Present Ecological State/Category
RHP	River Health Programme
REC	Recommended Ecological Category
SASS5	South African Scoring System version 5
SAWQG	South African Water Quality Guideline
TDS	Total Dissolved Salts
TWQR	Target Water Quality Range
UJ	University of Johannesburg
UP	University of Pretoria
VEGRAI	Riparian Vegetation Response Assessment Index
WMA	Water Management Area