Aquatic ecosystem delineation
Die Vlakte 731
May 2026

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FIGURES:

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1. Introduction

Limnology PTY LTD was appointed for the aquatic ecosystems condition and impact ratings for the Farm Die Valkte 731 near Boshof, Free State.

1.1. Aquatic ecosystem rationale

Aquatic ecosystems are the result of various abiotic drivers, giving rise to habitat conditions and resulting species responses as further defined in Figure 1.

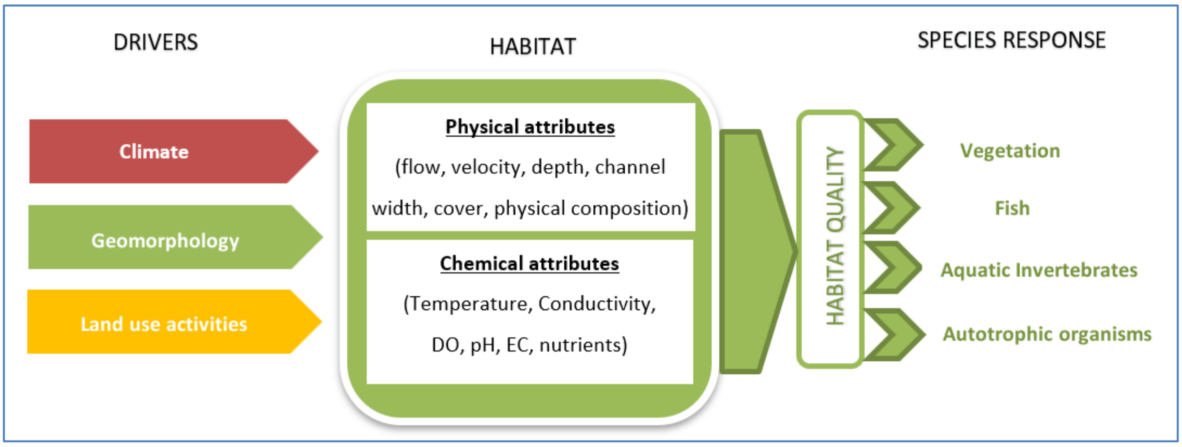


FIGURE 1: RELATIONSHIPS BETWEEN ECOSYSTEM RESPONSES TO DRIVERS OF CHANGE

Field-based fish bioassessment studies should incorporate multiple levels of biological organisation. At the organism level, indicators may include body condition indices, growth rates, deformities, parasite load, reproductive status, and biomarker responses to contaminants. At the population and community levels, metrics such as species richness, diversity indices, relative abundance, size-frequency distributions, and Index of Biotic Integrity (IBI)-type metrics provide ecologically meaningful assessments of system health (Figure 2). Organism-level responses provide a pivotal point through which mechanistic understanding and the ecological consequences of stressors can be linked (Figure 3).

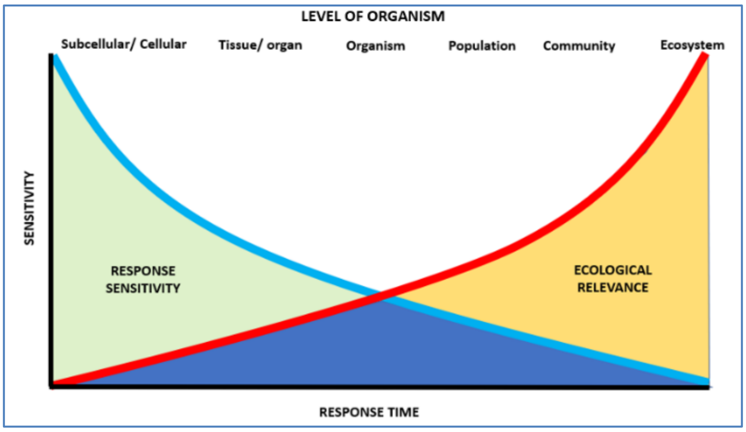


FIGURE 2: RESPONSE TIME IN RELATION TO SENSITIVITY AND LEVEL OF ORGANISM

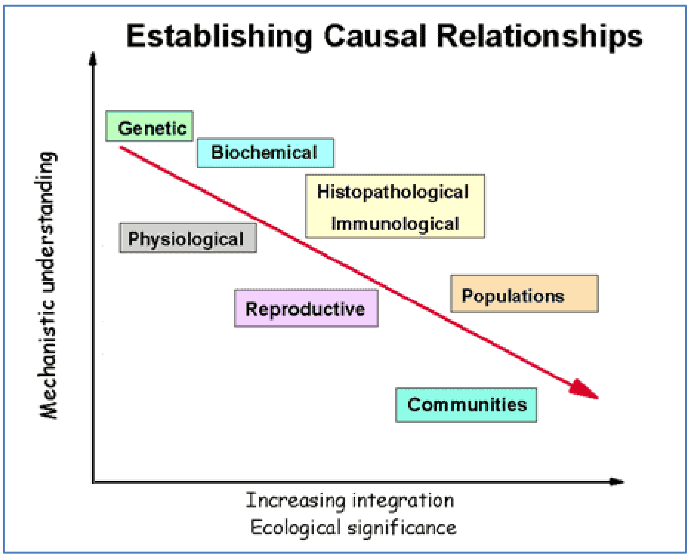


FIGURE 3: RELATIONSHIP BETWEEN MECHANISTIC UNDERSTANDING AND INCREASING INTEGRATION OF ECOLOGICAL SIGNIFICANCE

An aquatic ecosystem is defined as "an ecosystem that is permanently or periodically inundated by flowing or standing water or which has soils that are permanently or periodically saturated within 0.5 m of the soil surface" (Ollis *et al.* 2013). This term is further defined by the definition of a watercourse. In the National Water Act, 1998 (Act No. 36 of 1998) a watercourse is defined as:

(a) A river or spring;

(b) A natural channel in which water flows regularly or intermittently;

(c) A wetland, lake, or dam into which, or from which, water flows; and

(d) Any collection of water which the Minister may, by notice in the *Gazette*, declare to be a watercourse and a reference to a watercourse includes, where relevant, its bed and banks;

Different inland (freshwater) watercourses occur in South Africa and are defined by their topographical location, water source, hydroperiod, soils, vegetation, and functional units (Ollis, *et al*., 2013). The following illustration presents the types and typical locations of different inland aquatic systems found in South Africa (Figure 4).

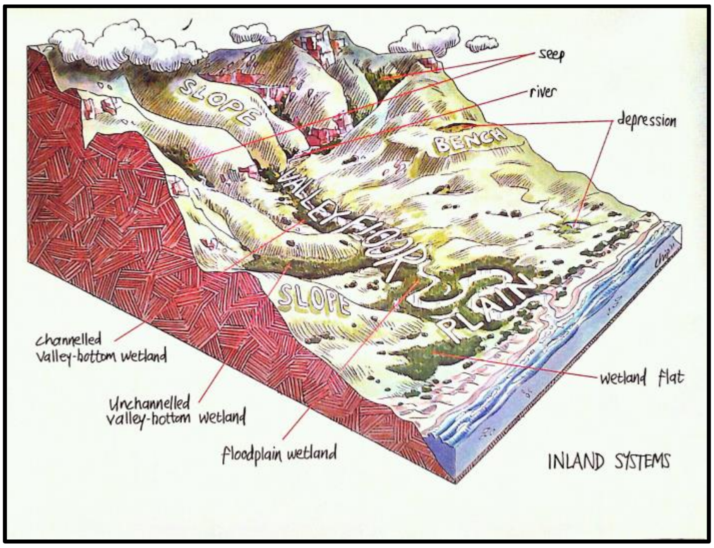


FIGURE 4: THE TYPES AND LOCATION OF INLAND AQUATIC ECOSYSTEMS (OLLIS, *ET AL*., 2013)

This definition of a watercourse is important especially if an area of increased hydrological movement is found but cannot be classified as either a wetland or riparian area. Important to note is that according to the National Water Act, 1998 (Act No. 36 of 1998), wetlands are defined as: *"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

It is very important that this definition is applied to both natural and manmade wetlands. Wetlands are very important in South Africa. Almost 50% of wetlands have been lost in South Africa and the conservation of the remaining wetlands is very important (WRC 2011) Wetlands provide many services to the ecosystem they are in (Kotze, *et al*. 2007). One of the most important services provided by wetlands is that of the impeding and holding back of floodwater to be released more constantly as well as slow water release through dry periods (Collins, 2005). Other very important functions that wetlands provide are as a source of habitat to many different species of fauna and flora. Wetlands also lead to an increase in the overall biodiversity of the area and ecological functioning (Collins, 2005).

Wetland conditions are formed when the prolonged saturation of water in the soils create different niche conditions for various fauna and flora. The source of water feeding into a wetland is very important, as it is an indication of the type and in many cases can provide an indication of the condition of the wetland.

As South Africa is a signatory of the Ramsar Convention for the conservation of important wetlands, we are committed to the conservation of all our wetlands. The Convention on Wetlands came into force for South Africa on 21 December 1975. South Africa presently has 21 sites designated as Wetlands of International Importance, with a surface area of 554,136 hectares (www.ramsar.org).

Although the term wetland describes the main *functions* provided by the wetland, there are many different hydrogeomorphic *types* of wetlands in South Africa.

The word "riparian" is drawn from the Latin word "riparious" meaning "bank" (of the stream) and simply refers to land adjacent to a body of water or life on the bank of a body of water (Wagner & Hagan, 2000).

The National Water Act, 1998 (Act No. 36 of 1998) also defines riparian areas as: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas".

The delineation of the riparian edge does not follow the same methodology, as is the case with wetlands. The riparian edge is demarcated using the physical structure of the vegetation found in the riparian area, as well as the micro topographical location of the riparian characteristics. In riparian areas, the increased water available to the plants (living in this area) has created a habitat with greater vegetation growth potential. This boundary of greater growth is used to delineate the riparian edge (Figure 5).

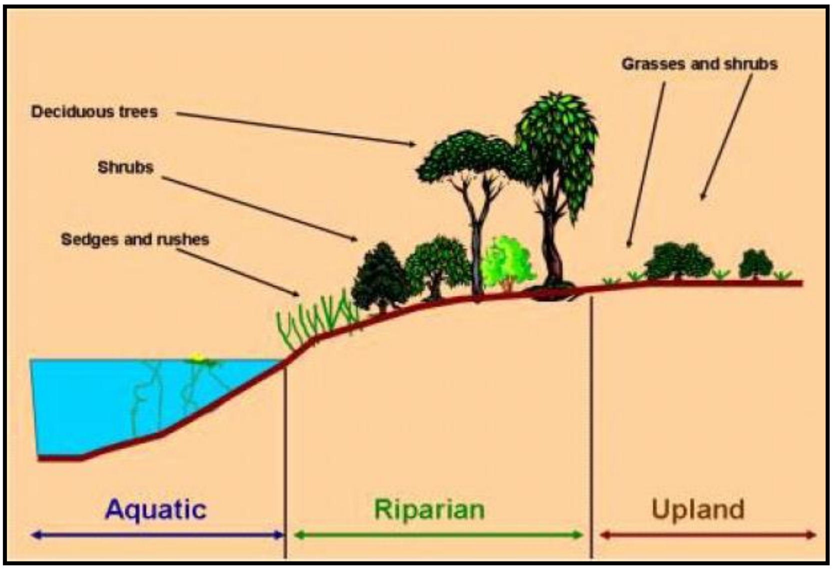
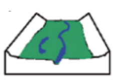


FIGURE 5: SKETCH INDICATING A CROSS SECTION OF RIPARIAN ZONATION COMMONLY FOUND IN SOUTH AFRICA – WWW.EPA.GOV/

The delineation guideline, Department of Water Affair's: Practical field procedure for identification and delineation of wetlands and riparian areas, Edition 1 September 2005, and revision 2 of 1998 was used. This identification and delineation of possible wetlands and riparian habitat is also done to mitigate any possible future contraventions of the National Water Act, Act no 36 of 1998.

Although the term wetland describes the main *functions* provided by the wetland, there are many different hydrogeomorphic *types* of wetlands in South Africa. The following table (Table 1) from Kotze, et al. 2007 illustrates the type of wetland as well as the hydrological source of the wetland. Important is Table 2 concerning the regulatory benefits provided by the wetland types.

TABLE 1: THE WETLAND HYDROGEOMORPHIC (HGM) TYPES TYPICALLY SUPPORTING INLAND WETLANDS IN SOUTH AFRICA (FROM KOTZE, *ET AL.* 2007)

Hydrogeomorphic (HGM) types		Description	Source of water maintaining wetland	
			Surface	Subsurface
Floodplain		Valley bottom areas with a well-defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/***

Hydrogeomorphic (HGM) types		Description	Source of water maintaining wetland	
			Surface	Subsurface
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and from adjacent slopes	***	*/***
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defines stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel	*	***
Depression (including Pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e., it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/***	*/***

Precipitation is an important water source and evapotranspiration an important output in all the above settings.

indicates wetland. Water source:

* Contribution usually small

*** Contribution usually large

*/ *** Contribution may be small or important depending on the local circumstances

*/ *** Contribution may be small or important depending on the local circumstances.

TABLE 2: THE REGULATORY BENEFITS POTENTIALLY PROVIDED BY WETLANDS (FROM KOTZE ET AL. 2007)

Wetland Hydrogeomorphic types (HGM)	Regulatory benefits potentially provided by wetland							
	Flood Attenuation		Stream-flow regulation	Enhancement of Water Quality				
	Early Wet Season	Late wet season		Erosion control	Sediment Trapping	Phosphates	Nitrates	Toxicants
Floodplain	**	*	0	**	**	**	*	*
Valley bottom-channelled	*	0	0	**	*	*	*	*
Valley bottom unchannelled	*	*	*?	**	**	*	*	**
Hillslope seepage connected to a stream	*	0	*	**	0	0	**	**
Isolated hillslope seepage	*	0	0	**	0	0	**	*

Pan/ Depression	*	*	0	0	0	0	*	*
Rating: 0 Benefit unlikely to be provided to any significant level * Benefit likely to be present as least to some degree ** Benefit very likely to be present (and often supplied to a high level)								

1.1. Buffers or setbacks

Buffer areas are part of the aquatic ecosystem and may not be developed or affected in any way by the construction activities and is rated the same sensitivity as the system. Buffers are a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, to reduce the impact of adjacent land uses on the wetland or riparian area (Figure 6).

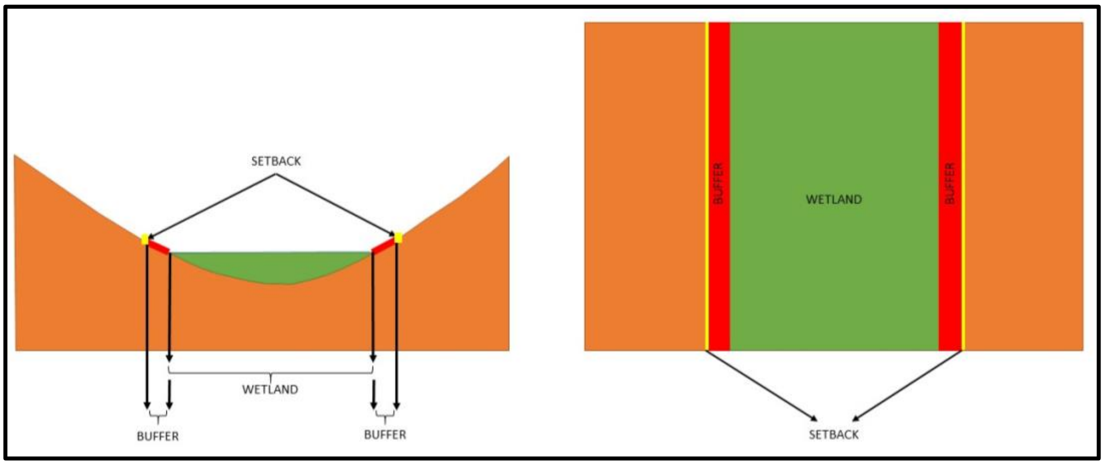


FIGURE 6: LAYOUT OF A TYPICAL BUFFER AROUND A WETLAND WITH THE SETBACK LINE CLEARLY DEFINED

Buffers are a fabricated ecotone. This ensures the wetland functioning is kept at an optimum and the services provided by wetlands are maintained. To ensure the buffer is maintained it must be fenced off prior to the physical construction of the site and the all persons associated with the site contractually bound to the conservation of the area.

1.2. Scope of work

The scope of this project is:

- Follow the protocol as set out in Government Notice no 320 (Government gazette 43110) March 2020),
- Delineation aquatic ecosystems,
- Assessment of the aquatic ecosystem condition(s) on site and within 500 m of the extended study area (ESA),

- Conduct an aquatic ecosystem functional assessment which includes the Present Ecological State (PES) of the wetland feature and riparian features, Ecological Importance and Sensitivity (EIS) and Ecoservices of the systems,
- Determine the environmental impacts of the proposed and or planned activities on the aquatic ecosystems,
- Complete the DWS Risk Assessment (GN4167, NWA act 36 of 1998),
- Calculate buffer zones and mitigation measures to limit the impacts to the aquatic ecosystem,
- Compile all Maps & Shapefiles accompanying the reports. These can be obtained from Limnology Pty. Ltd.[1]

The report layout is given in Figure 7 below.

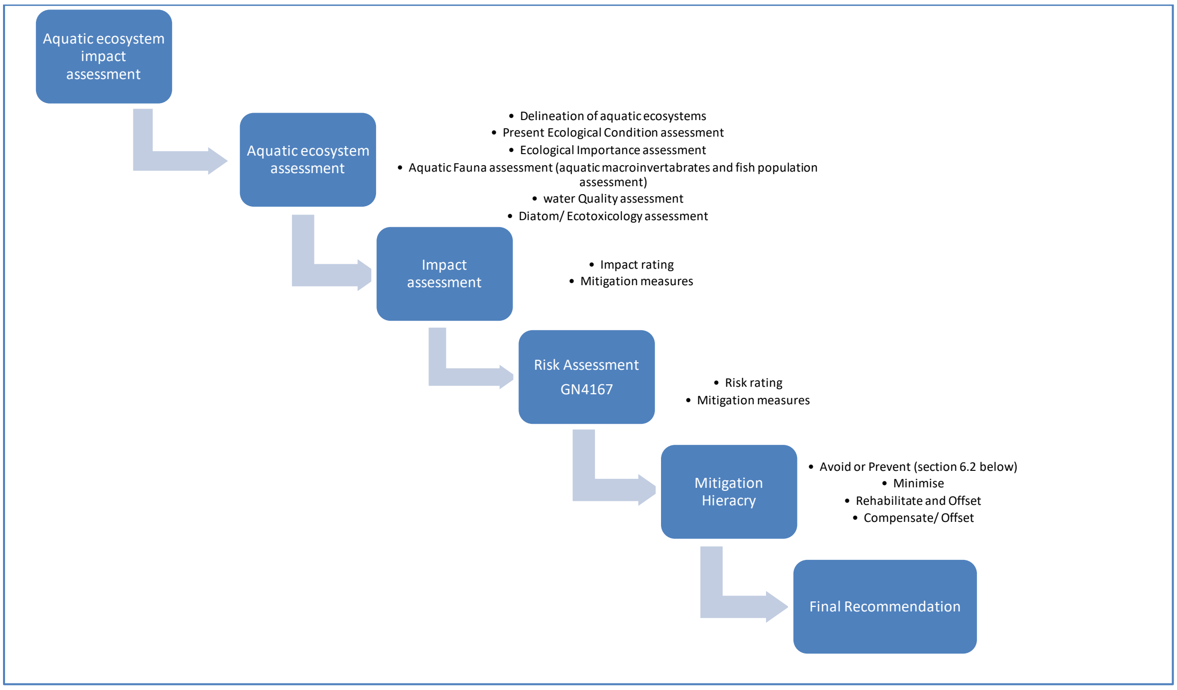


FIGURE 7: REPORT LAYOUT

1.3. Reporting guidelines

Government Notice R982 as published in Government Gazette 38282 dated 4 December 2014 and as amended by Government Notice R517 in Government Gazette 44701 dated 11 June 2021, outlines in Appendix 6 the requirements for specialist reports. On 20 March 2020 "Procedures for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the NEMA when applying for environmental

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authorization" was published in GN 320 (Government Gazette 43110). One of the themes identified and covered by this protocol is Aquatic Biodiversity. It is important to note that the protocol replaces the requirements of Appendix 6 of the EIA Regulations (as amended). The protocol, as published, is outlined below in Table 3 for site verification (low aquatic sensitivity) and Table 4 for aquatic biodiversity impact assessment (very high aquatic sensitivity).

TABLE 3: GN320 SITE VERIFICATION REPORT

<table>
<tr><td>1 The site sensitivity verification must be undertaken by an Environmental Assessment Practitioner or a specialist.</td><td rowspan="5">Not applicable as a full study is completed</td></tr>
<tr><td>2 The sensitivity verification must be undertaken using:
a. A desktop analyses, using satellite imagery;
b. A preliminary on-site inspection; and
c. Any other available and relevant information.</td></tr>
<tr><td>3 The outcome of the site sensitivity verification must be recorded in the form of a report that:</td></tr>
<tr><td>a. Confirms or disputes the current use of the land, and the environmental sensitivity as identified by the screening tool, such as new developments or infrastructures, the change in vegetation cover status etc.;</td></tr>
<tr><td>b. Contains a motivation and evidence (e.g. photographs) of either the verified or different use of the land and environmental sensitivity; and</td></tr>
</table>

TABLE 4: GN320 CONTENT OF SPECIALIST REPORT FOR AQUATIC BIODIVERSITY IMPACT ASSESSMENT

2.1. The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.	Bertus Fourie (Pr. Sci.Nat) Limnologist SACNASP Reg. No: 008394
2.2. The assessment must be undertaken on the preferred site and within the proposed development footprint.	TBC
2.3. The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	
2.3.1. a description of the aquatic biodiversity and ecosystems on the site, including; (a) aquatic ecosystem types; and (b) presence of aquatic species, and composition of aquatic species communities, their habitat, distribution, and movement patterns;	Section 5
2.3.2. the threat status of the ecosystem and species as identified by the screening tool;	Section 5
2.3.4. a description of the ecological importance and sensitivity of the aquatic ecosystem including: (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 5

(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).	
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 5
2.4. The assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered appropriate.	Section 6
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 6
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 6
2.5.2. is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	Section 6
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: (a) impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g., suppression of floods, loss of flood attenuation capacity, unseasonal flooding, or destruction of floodplain processes); (b) will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g., sand movement, meandering river mouth or estuary, flooding, or sedimentation patterns); (c) what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g., at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and (d) to what extent will the risks associated with water uses and related activities change;	Section 6 and impact assessment section
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); (b) quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g., seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river); (c) change in the hydrogeomorphic typing of the aquatic ecosystem (e.g., change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland); (d) quality of water (e.g., due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication);	Section 6 and impact assessment

(e) fragmentation (e.g., road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and (f) the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g., waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	
2.5.5. how will the proposed development impact on key ecosystems regulating and supporting services especially: (a) flood attenuation; (b) streamflow regulation; (c) sediment trapping; (f) phosphate assimilation; (e) nitrate assimilation; (f) toxicant assimilation; (g) erosion control; and (h) carbon storage?	Impact assessment and Risk assessment (GN4167)
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 6
2.6. In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered, in relation to: (a) size of the estuary; (b) availability of sediment; (c) wave action in the mouth; (d) protection of the mouth; (e) beach slope; (f) volume of mean annual runoff; and (g) extent of saline intrusion (especially relevant to permanently open systems).	Not applicable
2.7. The findings of the specialist assessment must be written up in an Aquatic Biodiversity Specialist Assessment Report that contains, as a minimum, the following information:	
2.7.1. contact details of the specialist, their SACNASP registration number, their field of expertise and curriculum vitae;	Appendix C and cover page
2.7.2. a signed statement of independence by the specialist;	Section 2
2.7.3. a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 2
2.7.4. the methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;	Section 3
2.7.5. a description of the assumptions made any uncertainties or gaps in knowledge or data;	Section 3
2.7.6. the location of areas not suitable for development, which are to be avoided during construction and operation, where relevant;	Section 6
2.7.7. additional environmental impacts expected from the proposed development;	Section 6
2.7.8. any direct, indirect, and cumulative impacts of the proposed development on site;	Section 6 and GN4167 risk assessment
2.7.9. the degree to which impacts and risks can be mitigated;	Section 6 and GN4167 risk assessment
2.7.10. the degree to which the impacts and risks can be reversed;	Section 6 and GN4167 risk assessment
2.7.11. the degree to which the impacts and risks can cause loss of irreplaceable resources;	Section 6 and GN4167 risk assessment

2.7.12. a suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies;	Section 6 and GN4167 risk assessment
2.7.13. proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr)	TBC by EAP
2.7.14. a motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a "low" aquatic biodiversity sensitivity and that were not considered appropriate;	Section 6
2.7.15. a substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not; and	Section 6
2.7.16. any conditions to which this statement is subjected.	Section 2 and 6
2.8. The findings of the Aquatic Biodiversity Specialist Assessment must be incorporated into the Basic Assessment Report or the Environmental Impact Assessment Report including the mitigation and monitoring measures as identified, that are to be included in the EMPr.	
2.9. A signed copy of the assessment must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	TBC by EAP
	TBC by EAP

2. Site visit, assumptions and limitations and independence

2.1. Site visit details

See Table 5 for the details of the site visit.

TABLE 5: SITE VISIT DETAILS

Date	17 April 2026
Season	Late summer
Stochastic events	Rainfall

2.2. Assumptions and limitations

To determine the riparian or wetland boundary, indicators (as discussed above) are used. If these are not present during the site visit, it can be assumed that they were dormant or absent and thus if any further indicators are found during any future phases of the project, the author cannot be held responsible due to the indicator's variability. Even though every care was taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time, and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bona fide* information sources, as well as deductive reasoning. No biomonitoring or physical chemical aspects of water found on the study were done. The safety of the delineator is of priority and thus in areas deemed, as unsafe limited time was spent. If the location of the study site is on and near underlying granitic geology the possible presence of cryptic wetlands must be investigated by a suitably qualified soil scientist with field experience.

Access to all portions of the study area and adjoining properties is essential to accurately identify the full spatial extent, connectivity, and functional characteristics of riparian zones and wetlands. Where access to certain properties or portions of the site was restricted, denied, or deemed unsafe, delineation was necessarily limited to areas that were reasonably and safely accessible at the time of the site visit. In areas where physical access was not possible, wetland and riparian boundaries were inferred using available desktop information, including topography, drainage patterns, vegetation visible from accessible vantage points, and professional judgement based on regional ecological characteristics. While these methods provide a reasonable indication of potential aquatic features, the absence of direct field verification may reduce the confidence level of delineation in such areas. Restricted access may result in the under-representation of cryptic, ephemeral, or seasonally expressed wetland indicators, particularly those reliant on soil morphology or subtle hydrological signatures. Consequently, if additional aquatic ecosystem indicators are identified during later project phases, construction activities, or subsequent site visits—especially in previously inaccessible areas—these may necessitate a review and potential revision of the delineation and associated impact assessment. The delineation presented in this report is therefore based on the best available information at the time of assessment and within the constraints of site accessibility. No responsibility can be attributed to the author for limitations arising from access restrictions beyond reasonable control, and the findings should be interpreted with due consideration of these constraints.

Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage.

As aquatic systems are directly linked to the frequency and quantity of rain it will influence the systems drastically. If during dry months or dry seasons studies are done, the accuracy of the report's findings could be affected.

Limnology can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of this report. This report should therefore be viewed and acted upon with these limitations in mind.

2.3. DECLARATION OF INDEPENDENCE

I, **Bertus Fourie,** declare that -

- I am subcontracted as specialist consultant by Limnology for the project,
- I am a SACNASP registered Professional Natural Scientist registered in the field of Ecology and Aquatic Sciences,
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998),

regulations and any guidelines that have relevance to the proposed activity; I will comply with the Act, regulations, and all other applicable legislation;

- I will consider, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan, or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realize that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Bertus Fourie (Pr. Sci.Nat)
Limnologist SACNASP Pr.Sci.Nat. Reg. No: 008394 (Ecology and Aquatic Sciences)
082 921 5445,
Bertusfourie@gmail.com

3. Site location and description

The study site is located from 28°33'39.99"S 25°22'13.91"E (Figure 8). See additional information in Table 6 below.

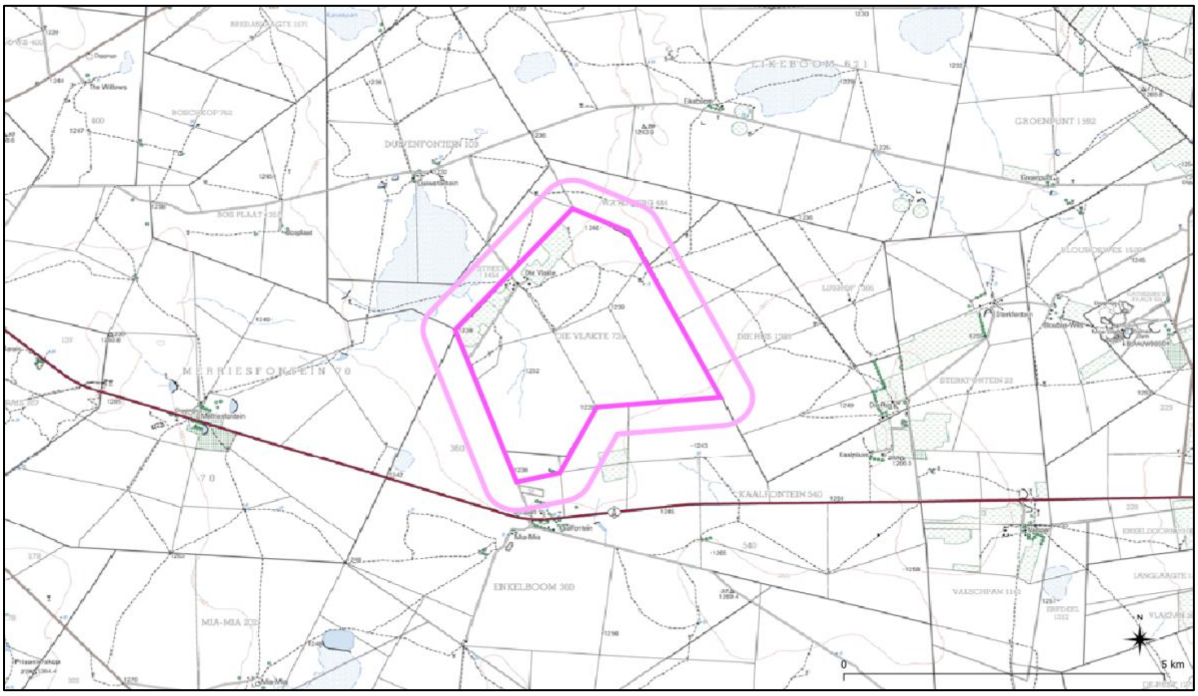
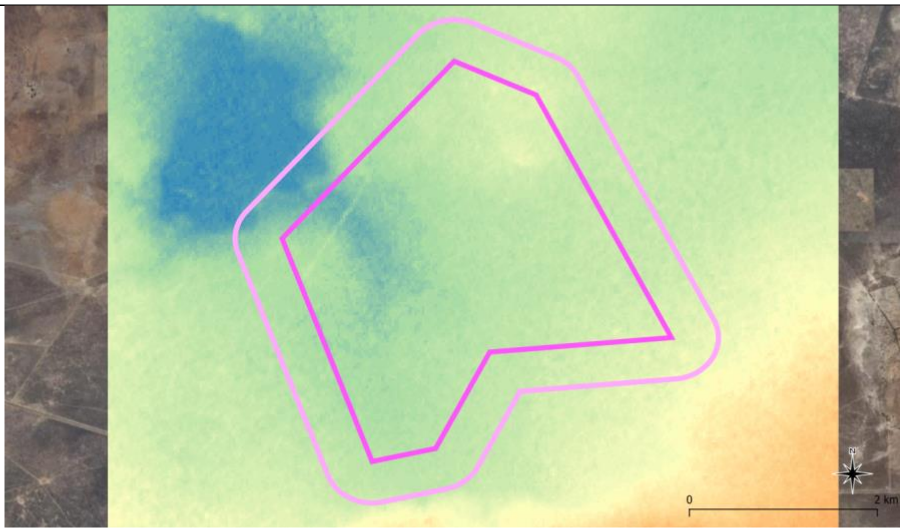
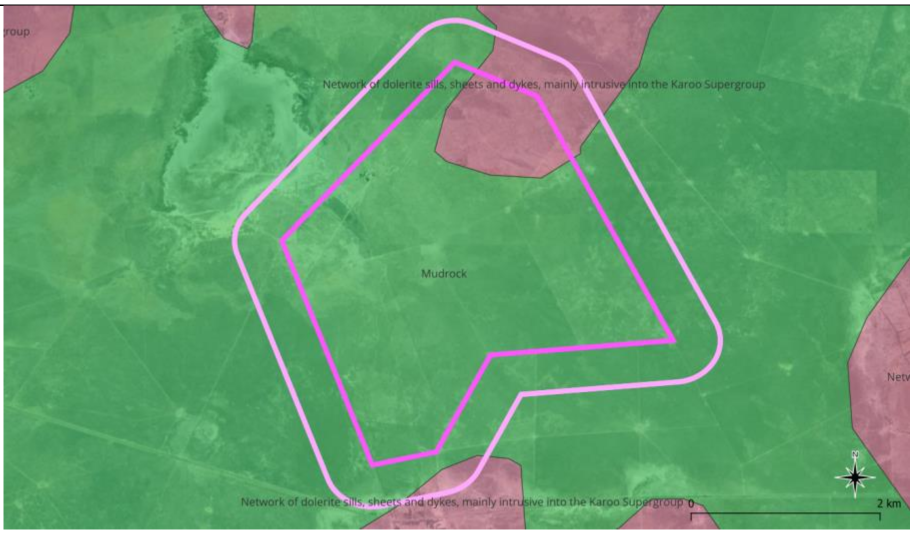


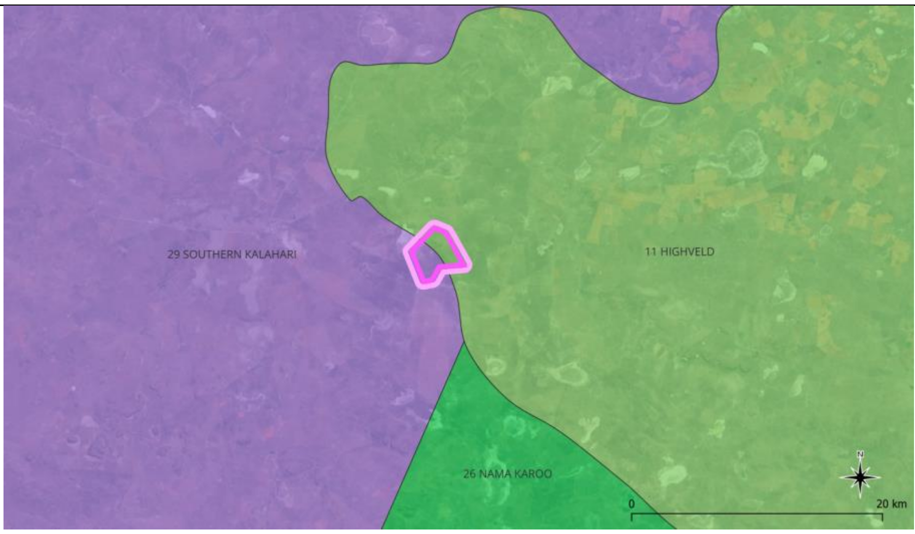
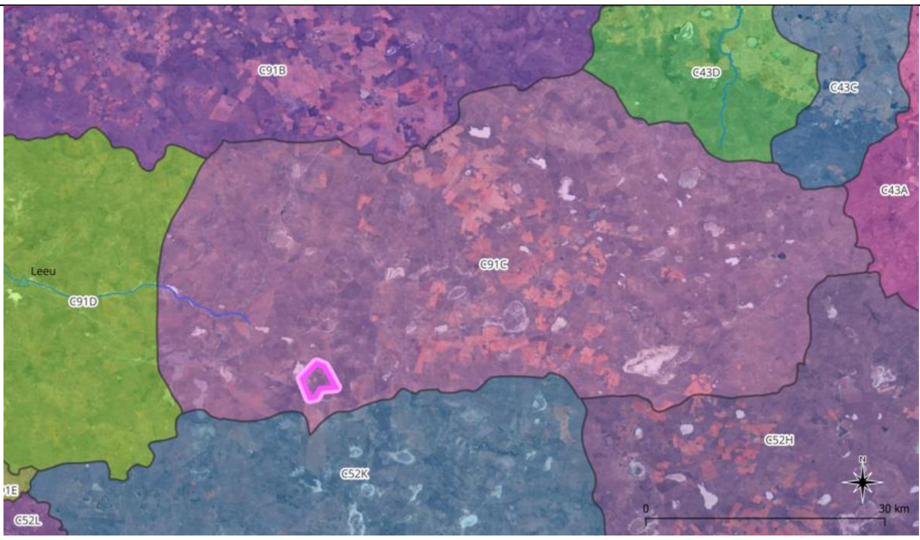
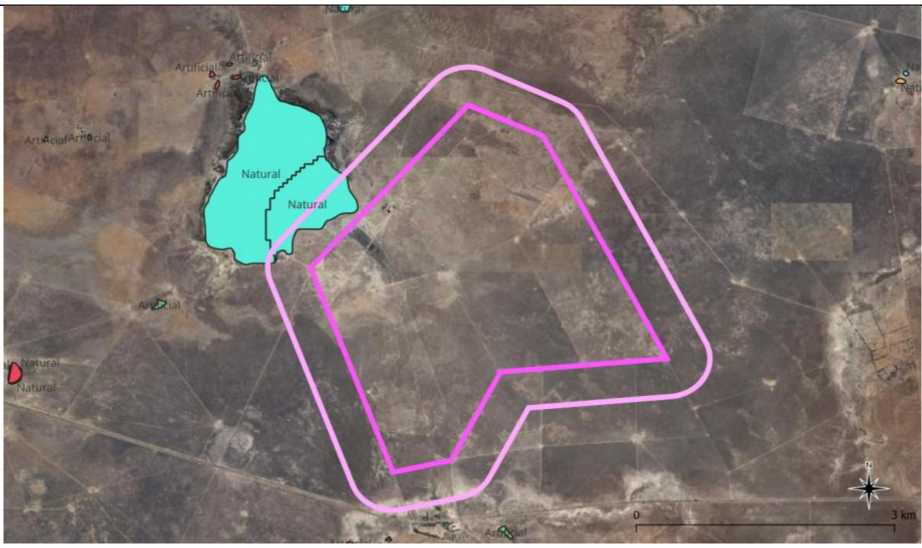
Figure 8: 1:50 000 locality map

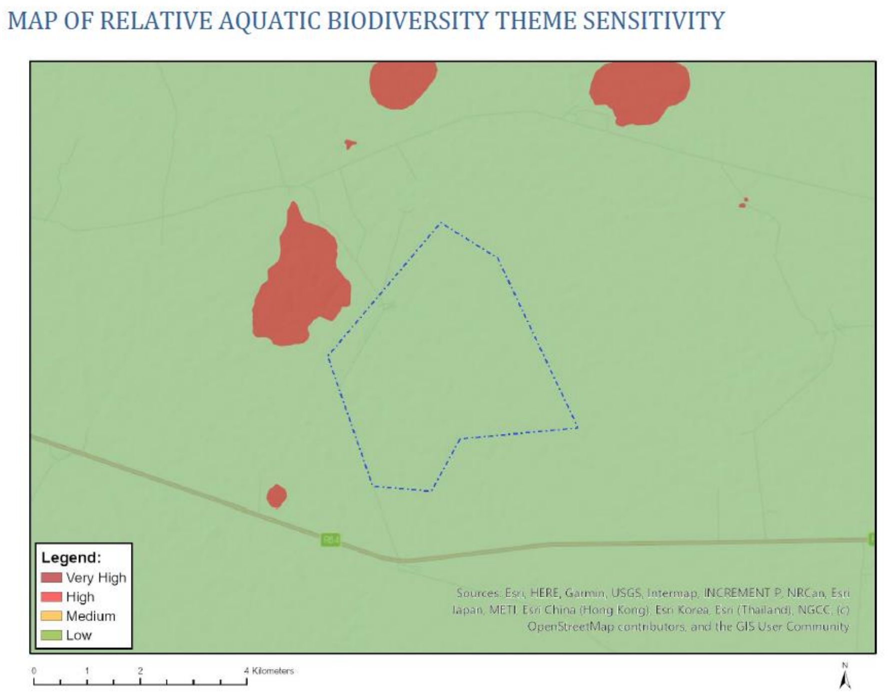
TABLE 6: DESKTOP DATA RELATING TO SITE LOCATION AND REGIONAL SETTING

Proposed activities	New chicken rearing facilities
Topography	

<table>
<tr><td>Vegetation type (Mucina and Rutherford 2005)</td><td>
</td></tr>
<tr><td>Geology</td><td>
</td></tr>
<tr><td>Landtypes</td><td>

Db: Duplex soils (sandier topsoil abruptly overlying more clayey subsoil) comprise >50% of land type; <50% of duplex soils have non-red B horizons</td></tr>
<tr><td>Ecoregion</td><td>Highveld and Southern Kalahari</td></tr>
</table>

	
Quaternary Catchment	
Watercourse	The catchment only drains to the Leeu River to the west
NFEPA wetlands	
NFEPA Fish sanctuary	Not applicable

NFEPA Rivers and River FEPA's	Not applicable
Screening tool classification	
Protected areas	Not applicable

The GIS data is compiled from various sources with data collected since 2010 by the author. Where possible the source of the information is given in Table 7. The data listed here is all data collected, and some could not be applicable to the study sites location.

TABLE 7: GIS DATASET SOURCES

Dataset	Source and approximate date of download
Free State CBA/ESA dataset	Department of Economic, Small Business Development, Tourism and Environmental Affairs (DESTEA). 2015 Free State Terrestrial CBAs [Vector] 2015. Available from the Biodiversity GIS website, downloaded July 2024
Final Vegetation Map of South Africa, Lesotho and Swaziland 2018	South African National Biodiversity Institute. 2018 Final Vegetation Map of South Africa, Lesotho and Swaziland [Vector] 2018. Available from the Biodiversity GIS website, downloaded July, 2024
Surface water dataset:	Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L.B., Nel, J.L., Maherry, A. and Witthüser. K 2018. Strategic Water Source Areas for surface water (Vector data). One of the outputs of the Identification, Delineation and Importance of the Strategic Water

	Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater, WRC Report No TT 754/1/18, Water Research Commission, Pretoria, South Africa.
Groundwater dataset:	Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L.B., Nel, J.L., Maherry, A. and Witthüser. K 2018. Strategic Water Source Areas for groundwater (Vector data). One of the outputs of the Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater, WRC Report No TT 754/1/18, Water Research Commission, Pretoria, South Africa.
NFEPA Maps	Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.
	Moolman (2008) River long profiles aid in ecological planning. PositionIT, (Jan/Feb) and
	Moolman, Kleynhans and Thirion (2002) Channel Slopes in the Olifants, Crocodile and Sabie River Catchments (PDF 3Mb).
	Moolman J. (2012) An assessment of a technique to derive stream longitudinal profiles – a GIS approach. Geography department, University of the Free State. Bloemfontein
Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches	Department of Water and Sanitation (DWS). 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by DWS RQIS-RDM

4. Methods for classification of aquatic ecosystem, the delineation, and Present Ecological State (PES) calculation

4.1. Classification of aquatic ecosystems

To determine the classification of aquatic ecosystems is a very important aspect of the delineation process as wetlands and riparian systems require different delineation methods. To classify the systems the dichotomous key as found in the "Classification system for wetlands and other aquatic ecosystems in South Africa" (Ollis, *et al.,* 2013) is used. Three keys have been developed for the classification of aquatic ecosystems:

- Key 1: Landscape Units
- Key 2: Hydrogeomorphic Units
- Key 3: Hydrological regime
- Key 3a for river flow types and (Table 8),
- Key 3b for hydroperiod category

TABLE 8: GEOMORPHOLOGICAL LONGITUDINAL RIVER ZONES OF SOUTH AFRICAN RIVERS

Longitudinal zone (and zone class)	Characteristic gradient
A. Zonation associated with a normal profile	
Source zone	not specified
Mountain headwater stream	>0.1
Mountain stream	0.040–0.099
Transitional	0.020–0.039
Upper foothills	0.005–0.019
Lower foothills	0.001–0.005
Lowland river	0.0001–0.0010
Additional zones associated with a rejuvenated profile	
Rejuvenated bedrock fall/cascades	>0.02
Rejuvenated foothills	0.001–0.020
Upland floodplain	<0.005

4.2. Wetland Delineation methods

To delineate *any* wetland the following criteria are used as in line with Department of Water Affairs (DWA): A practical field procedure for identification and delineation of wetlands and riparian areas, Edition 1 September 2005. These criteria are:

a) **Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation such as grey horizons, mottling streaks, hard pans, organic matter depositions, iron and manganese concretion resulting from prolonged saturation,
b) The presence, at least occasionally, of **water loving plants (hydrophytes)**,
c) A **high-water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil, and
d) **Topographical location** of the wetland in relation to the landscape.

Also read with the guide is a draft updated report of the abovementioned guideline. The draft is used, as it provides a guideline to delineation of wetland areas: *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas,* prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. DWA (2008) Draft report. These criteria will mainly indicate a systematic as well as functional change in the aquatic ecosystem.

Wetlands occur throughout most topographical locations, with even the small depression wetlands occurring on the crest of the landscape. The topographical location of possible wetlands is purely an indication of the actions and movement of water in the landscape and is not a definitive delineator (Figure 9).

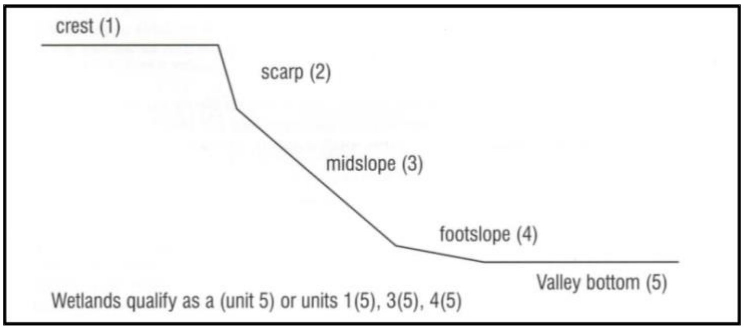


FIGURE 9: DESCRIPTION OF THE TOPOGRAPHY OF AN AREA (FROM DWAF, 2005)

Changes in the presence and frequency of mottling in the soils are the main methods of delineation. This is, as mottles are usually not influenced by short-term changes in the hydrology and vegetation of the wetland (Figure 10). Mottling is formed when anaerobic conditions (increased water saturation) lead to redoximorphic conditions (iron is leached from the soil) and is precipitated in the increased saturation areas of the soil profile.

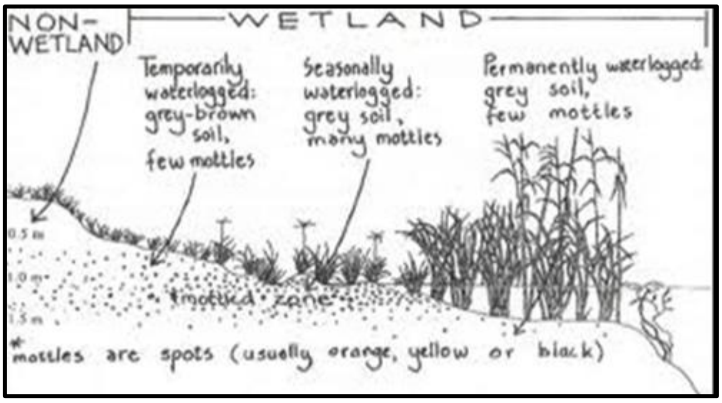


FIGURE 10: CROSS SECTION THROUGH A WETLAND WITH SOIL WETNESS AND VEGETATION INDICATORS.

4.3. Delineation of aquatic ecosystems in dry and difficult conditions

Delineation of aquatic ecosystems are clearly defined by the presence or absence of indicators. Of these indicators, the soil wetness indicator, based on soil morphology, is used extensively in the identification and delineation of wetlands in South Africa (DWAF, 2005). The soils of permanently saturated wetlands in particular are usually easily recognizable by their grey colour and mottled appearance, even when they are not inundated (Day *et al.*, 2010). This permanently saturated conditions are not the norm: seasonal, abiotic (edaphic) variations alter soil hydrology including the vadose zone. The absence of typical wetland indicators does not negate the need for “typical” classification of the system as wetland (as defined by the National Water Act (act 36 of 1998)) but rather a reclassification based on the parameters as set out by the Classification guideline (Rowntree and Wadeson, 1999; Dallas and Fowler, 2000; Ollis, 2013; Cantonati *et al.*, 2020).

To assist with the classification and delineation of the system, various aspects can be assessed based on the training, and experience of the assessor. In the absence of water to drive biotic factors, abiotic factors become primary drivers of assessment. These are listed in Table 9 below.

TABLE 9: ABIOTIC INDICATORS (DAY *ET AL.*, 2010)

Indicator	Condition indicated	Complementary indicator	Confidence
Topography	Indicates potential for accumulation of water in wet season – must be interpreted with other indicators	Biotic and abiotic	Low
Soil Wetness	Presence of gleying, mottling: if present as per DWAF (2005) then	Biotic and abiotic	High

	indicates wetland type (permanent/ seasonal etc.) Absence of above, coupled with sandy soil, and/or arid climate and/or perched wetland conditions: cryptic wetland cannot be ruled out		
	Dry season water table <0.5 m from surface OR impermeable layer <0.5 m from surface indicates wetland presence but not hydroperiod (inundated or not) Dry season water table >0.5 m from surface OR impermeable layer. >0.5 m from surface: no strong conclusions can be drawn	Biotic and abiotic – including soil moisture	Low
Muck layer thick layer (<2 cm deep)	Presence: wetland conditions in recent past/present		Medium
	Absence: inconclusive wetland conditions in past		Medium
Sediment deposits on plants and/or rocks	Presence: indicates minimum levels of inundation – wetland assumed to be seasonally inundated		Medium
	Absence: inconclusive		Low
Biotic crust	Presence: indicates minimum levels of inundation – wetland assumed to be seasonally inundated		Medium
	Absence: inconclusive		Low
Water marks	Presence: indicates minimum levels of inundation – wetland assumed to be seasonally inundated		High
	Absence: inconclusive		Low

In addition to this, other types of sites are listed in Table 10 with the recommended approach (Job, 2009).

TABLE 10: LIST OF TYPES OF SITES THAT ARE DIFFICULT TO DELINEATE

Type of Site	Recommended Approach
Some or all wetland indicators are present but is a non-natural wetland (e.g., some dams, road islands)	- Decide on the relative permanence of the change and whether the area can now be said to be functioning as a wetland. - Time field observations during the wet season, when natural hydrology is at its peak, to help to differentiate between naturally occurring versus human-induced wetland. - Decide appropriate policy/management i.e., can certainly land uses be allowed due to "low" wetland functional value, or does the wetland perform key functions despite being artificial.
Indicators of soil wetness are present but no longer a functioning wetland (e.g., wetland has been drained)	- Look for evidence of ditches, canals, dikes, berms, or subsurface drainage tiles. - Decide whether the area is currently functioning as a wetland.
Indicators of soil wetness are present but no longer a functioning wetland (e.g., relic / historical wetland)	- Decide whether indicators were formed in the distant past when conditions were wetter than the area today. - Obtain the assistance of an experienced soil scientist.
Some, or all, wetland indicators are absent at certain times of year (e.g., annual vegetation or seasonal saturation)	- Thoroughly document soil and landscape conditions, develop rationale for considering the area to be a wetland. - Recommend that the site be revisited in the wet season.
Some, or all, wetland indicators are absent due to human disturbance (e.g., vegetation has been cleared, wetland has been ploughed or filled)	- Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, develop rationale for considering the area to be wetland. - Certain cases (illegal fill) may justify that the fill be removed, and the wetland rehabilitated.

4.4. Delineation of riparian edge

To delineate any riparian area the following criteria are used as in line with Department of Water Affairs (DWA) requirements: A practical field procedure for identification and delineation of wetlands and riparian areas, DWA Edition 1 September 2005.

Also read with the guide is a draft updated report of the abovementioned guideline. The draft is used, as it provides a guideline to delineation of riparian areas with specific emphasis on recent alluvial deposits: "*Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas",* prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare., DWA (2008) (Draft report).

These criteria mainly used will indicate a system as well as individual change in the riparian area. The delineation process requires that the following be considered and deliberated:

- topography associated with the watercourse;
- vegetation; especially changes in the composition of communities found on site,
- alluvial soils and deposited materials.

Important is the changes in the catchment of the area. Any changes in the use, extent of use as well as alien vegetation changes will influence the river condition and the riparian characteristics. Historical imagery, Google Earth as well as the site visit is used to detect and enumerate any changes. The outer boundary of the riparian area is defined as: "the point where the indicators are no longer discernible" (DWA, 2008). Using the desktop delineation GPS points, sampling took place firstly to truth if the desktop GPS points did in fact represent a riparian area. Secondly using vegetation and topographic indicators, the riparian vegetation was identified and demarcated. A second delineation of the non-riparian area was done.

4.4.1. Riverbank morphology

The methods for bank morphology classification was adapted from (Rowntree and Wadeson, 2000; Dallas, 2005). Using the cross-sectional diagram (Figure 11) from (Dallas, 2005) the following features are described:

- *High terrace (rarely inundated):* relict floodplains which have been raised above the level regularly inundated by flooding, due to lowering of the river channel.
- *Terrace (infrequently inundated):* area raised above the level regularly inundated by flooding.

- *Flood bench (inundated by annual flood):* area between active and macro-channel, usually vegetated.
- *Side bar:* accumulations of sediment associated with the channel margins or bars forming in meandering rivers where erosion is occurring on the opposite bank to the bar.
- *Mid-channel bar:* single bar(s) formed within the middle of the channel; flow on both sides.
- *Island (vegetated)*: island formed within the middle of the channel that is vegetated; flow on both sides.
- *Secondary or lateral channel:* a second channel that flows adjacent to the primary channel.
- *Flood plain (inundated by annual flood):* a relatively level alluvial (sand or gravel) area lying adjacent to the river channel which has been constructed by the present river in its existing regime.
- Hillslope abutting on to the active channel.

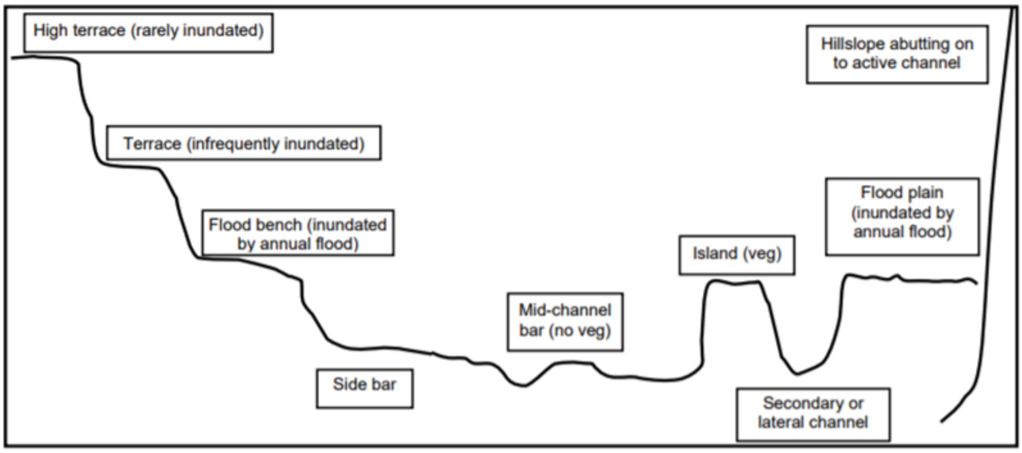


FIGURE 11: CROSS SECTIONAL DIAGRAM SHOWING RELEVANT CHANNEL FEATURES

4.5. Wetland Present Ecological State (PES) calculation method

The methodology for assessing wetland health in "WET-Health Version 2" (Macfarlane, et. al. 2020) involves a multi-step process that includes both desktop-based ("Level 1") and field-based ("Level 2") assessments.

- **Desktop-Based Assessments (Level 1):** These are regional to national-scale assessments that use land cover data to evaluate wetland conditions. Level 1 assessments are divided into two types:
- **Level 1A:** Broad-scale assessments using national land cover data.
- **Level 1B:** Local to regional-scale assessments with refined land cover classes.
- **Field-Based Assessments (Level 2):** These are more detailed evaluations that require fieldwork and are designed for more site-specific studies. This level includes several modules,

such as hydrology, geomorphology, water quality, and vegetation, to provide a comprehensive analysis of wetland health (Figure 12). Field-based assessments involve mapping wetlands, classifying them by hydrogeomorphic (HGM) type, and evaluating the extent and impact of various land cover types within the wetlands and their surrounding areas.

This methodology helps integrate a wide range of data and assessments to understand the ecological state and health of wetlands effectively.

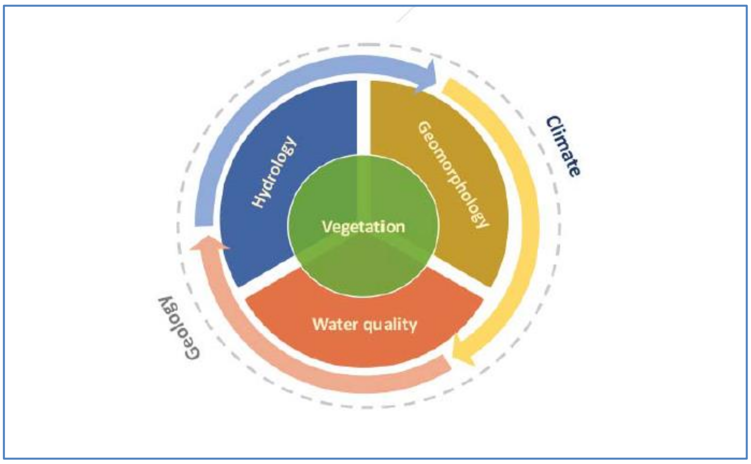


FIGURE 12: SCHEMATIC REPRESENTING THE FOUR KEY COMPONENTS OF WETLAND PES CONSIDERED IN WET-HEALTH VERSION 2.0.

4.6. Riparian Present Ecological State (PES) calculation method

The South African River Health Program (RHP) under the Department of Water Affairs has developed a suite of programs to allow for the calculation of the ecological category for river and riparian areas. Included in this suite of programs is VEGRAI (Riparian Vegetation Response Assessment Index in River Eco classification as developed by Kleynhans *et al* (2007). This program is Microsoft Excel driven and allows for two levels of calculations. For the study site, it was chosen to conduct a level 3 assessment. The program does not give an indication on the impacts itself, but rather an indication on the *extent* of the impacts on the riparian areas. The program provides results in ranges and allows results to be allocated a Present Ecological State (PES) category. See Table 11 for the steps for assessing level 4.

TABLE 11: VEGRAI LEVEL 4 STEPS

1. Preparation	Define reference conditions by reconstructing the natural state using historical data, maps, and expert interpretation. Select sampling sites within Resource Units (RUs) based on impact types and distribution using tools like the Index of Habitat Integrity (IHI).

2. Field Assessment	Delineate three riparian zones: Marginal, Lower, and Upper. For each zone, assess the woody and non-woody vegetation components based on five key metrics: - Cover - Abundance - Species Composition - Recruitment (woody only) - Population Structure (woody only)
3. Scoring and Weighting	Assign a rating (0–5) for each metric comparing present state to reference state. Use weights to reflect the ecological importance of each vegetation component and zone. Calculate weighted scores for each zone and integrate to produce an overall Ecological Category (A–F) for the riparian vegetation.
4. Interpretation	Link vegetation condition to causes such as vegetation removal, exotic invasion, and changes in water quantity/quality. Use results to inform EcoStatus and support Ecological Reserve determinations

TABLE 12: THE DESCRIPTION OF THE HEALTH CATEGORY

DESCRIPTION	IMPACT SCORE RANGE	HEALTH CATEGORY
Unmodified/ natural	0-0.9	**A**
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**
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**
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	**D**
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**
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**

4.7. Present Ecological Score (PES) description

The Ecological Category calculation tools deliver the Present Ecological Score and an overall Ecological Category for the aspects being assessed. A common suite of Ecological Categories (or Present State Categories), ranging from A to F, are typically used in PES assessments of inland aquatic ecosystems in South Africa. See Figure 13 for the PES ecological category (EC) of inland aquatic ecosystems in South Africa, together with the applicable range of impact scores and pes scores for each category (after Kleynhans, 1996; macfarlane et al., 2008). The colour-coding according to that of the River EcoStatus Monitoring Programme (REMP) of DWS.

ECOLOGICAL CATEGORY	DESCRIPTION	IMPACT SCORE*	PES SCORE (%)*
A	Unmodified, natural.	0-0.9	90-00
B	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	80-89
C	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	60-79
D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	40-59
E	Seriously modified. 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	20-39
F	Critically modified. 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	0-19

* The Habitat Integrity methods developed by and for DWS (then DWAF) derive PES Scores that reflect the ecological integrity or intactness of the ecosystem, typically expressed as a percentage, whereas the WET-Health method developed for SANBI by Macfarlane *et al*. (2008) derives "impact scores" (scaled from 0 to 10) that reflect the degree of ecosystem modification

FIGURE 13: DESCRIPTIONS OF THE ECOLOGICAL CATEGORIES TYPICALLY USED FOR PES ASSESSMENTS

4.8. Wetland Ecological Services (WET-EcoServices)

The methodology follows the guidelines as set out by WET-EcoServices (Version 2) - A technique for rapidly assessing ecosystem service supplied by wetlands and riparian areas (WRC project No. K5/2737). The

If the wetland/riparian area has not been mapped, begin by mapping it.

- Identify the Assessment Units within the mapped area, usually defined as Hydrogeomorphic (HGM) units, and map their catchments.
- Define the downstream service area to be assessed based on the size of the catchment area, considering a distance of 10 km for catchments >1000 ha and 5 km for smaller catchments.

Preparations Required Before Going into the Field:

- Familiarize yourself with the indicators that need to be scored, distinguishing between those assessed through desktop study and those requiring field verification.
- Prepare necessary maps, score sheets, and field equipment, including a camera and possibly a GPS for recording features.
- Establish contact with key informants who possess local knowledge of the area to provide insights into the use and importance of the wetland/riparian area.
- Assessing and Scoring the Indicators:

Conduct the field assessment, scoring each indicator on a five-point scale (0-4).

- Use a combination of field observations and local knowledge to assess and score the indicators.
- Ensure that the methods for assessing each indicator, as provided in the guideline, are closely followed to maintain consistency.
- Entering the Scores in the Spreadsheet:

Enter the indicator scores into the first tab of the provided Excel spreadsheet.

- Document any additional notes or justifications for the scores.
- Checking and Refining the Demand and Supply Scores:

Review the calculated supply and demand scores and adjust, if necessary, based on more detailed local information or other relevant evidence.

- Justify any adjustments made to the scores to ensure transparency.
- Presenting and Interpreting the Results:
- Present the results in a summary table, which includes supply, demand, and overall importance scores for each ecosystem service.
- Interpret these results in the context of the assessment objectives, highlighting the relative importance of different ecosystem services and how they may change under future scenarios.

This methodology allows for a rapid assessment of the ecosystem services provided by wetlands and riparian areas, helping to inform decisions related to wetland management, rehabilitation, and conservation

4.9. WET-EcoServices for assessing the Ecological Importance and Sensitivity (EIS) of wetlands

The REC is determined by the Present Ecological State of the water resource and the importance and/or sensitivity of the water resource using the wetland EIS framework (Figure 14).

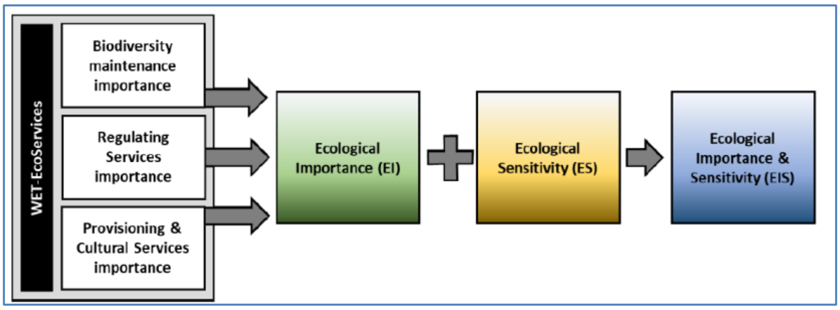


FIGURE 14: SCHEMATIC OF THE RECOMMENDED WETLAND EIS FRAMEWORK

Based on this proposal, the EIS score would be calculated by using the EI score for a system with moderate sensitivity as a starting (benchmark) score and adjusting scores up or down by up to one class based on actual sensitivity. It is hoped that this concept will be taken forward by regulating authorities in due course (Figure 15).

		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

FIGURE 15: PROPOSED TABLE FOR INTEGRATING EI AND ES INTO A COMPOSITE EIS SCORE

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 13):

- 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 13: 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

See Table 14 for the EIS interpretation guideline.

TABLE 14: EIS INTERPRETATION GUIDE

Ecological Importance and Sensitivity Category (EIS)	**Range of Median**	**Recommended Ecological Management Class**
Very high Aquatic ecosystems that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	**>3 and <=4**	**A**
High Aquatic ecosystems that are ecologically important and sensitive. The biodiversity of these floodplains 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**	**B**
Moderate	**>1 and <=2**	**C**

Aquatic ecosystems that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.		
Low/marginal Aquatic ecosystems that is not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	**>0 and <=1**	**D**

4.10. Historical aerial imagery

National Geo-spatial Information (NGI) is the government component (Department of Rural Development and Land Reform) responsible for aerial photography and has an archive of aerial photographs dating back to the 1930' s. The user, although unable to make accurate measurements on the photograph, can perform his or her own interpretation of what exists on the ground. Aerial photographs are also an historic record of what existed at the time the photograph was taken.

The photography is at a variety of scales and has provided complete coverage of the country since the 1950' s. These are all vertical aerial photographs taken from aircraft. Photography is continuously re-flown to provide new photography for ongoing map revision and for sale to users. The data set was obtained from the department in 2012. The photos are divided into job numbers, strings (or line numbers) and finally photo numbers.

4.11. Aquatic macroinvertebrate population assessment (SASS 5)

In South Africa, the River Health Programme (under the Department of Water Affairs) has developed a suite of different programs to rapidly assess the quality of aquatic systems. The South African Scoring System (SASS) 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). 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.

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.

Table 15: SASS5 sampling procedure

Step	Aspect
Selection of Sample Sites	Choose representative sections of the river based on distinct biotopes (like stones, vegetation, and sediment types). Site selection is possibly inferred by the scope of the project and locations must be selected to represent the site.
Sampling Procedure	**Stone and Bedrock Sampling**: Kick stones in current (SIC) for 2 minutes (maximum of 5 minutes). Bedrock sampling for SOOC is 1 minute.
	Vegetation Sampling: Sweep marginal vegetation both inside (IC) and outside (OOC) of the channel for 2 meters total and sweep aquatic vegetation within a 1m² area.
	Sediment Sampling: Stir and sweep gravel, sand, and mud (GSM) substrates for a total of 1 minute.
	Hand-Picking and Observation: Hand-pick organisms from all biotopes for 1 minute, recording each specimen.
Recording Data	Record invertebrate taxa and assign scores based on the SASS score sheet.
	Score each biotope for 15 minutes, but sampling stops if no new taxa are observed after 5 minutes.
	Abundance estimates are categorized as: 1= single individuals A= 2-10 individuals B= 10-100 C= 100-1000 D= over 1000 individuals
Data Analysis	The SASS Score and the Average Score per Taxon (ASPT) are calculated. The ASPT is recognized as the most consistent metric for river health, as it minimizes operator variability.
Quality Control	Ensure consistency by implementing standardized training for operators, minimizing variability in results across different personnel. Standard operating procedure (SOP) and planned task observation (PTO) process must be followed.

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.

4.11.1. 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.

4.12. Macroinvertebrate Response Assessment Index (MIRAI)

Macroinvertebrate Response Assessment Index (MIRAI) (Thirion, C. 2007) is a excel based system to further analyse the SASS5 assessment data to determine the PES value of the SASS5 results. The methodology is given in Table 16 below.

TABLE 16: MIRAI ASSESSMENT STEPS

Steps in order	Aspects
Determine Reference Conditions	Use minimally impacted sites or compile derived reference conditions based on similar ecosystems or historical data.
Site Selection	Choose representative sites that include a range of biotopes, such as stones-in-current, vegetation-in-current, and gravel. Ensure these are critical or compromise sites relevant to the study aim.
Data Collection	Perform a literature review and consult databases and specialists to gather existing macroinvertebrate data for the river.
Habitat Assessment	Evaluate the quality, quantity, and diversity of biotopes using tools like the Invertebrate Habitat Assessment System (IHAS).

Data Input	Fill in the MIRAI data sheet with present and reference conditions for: Abundance Frequency of occurrence Taxa-specific velocity, habitat, and water quality preferences.
Assign Ratings and Weights	Rate changes in taxa abundance and occurrence using a 6-point scale: 0 = No change; 5 = Extreme change. Rank and weight metrics and metric groups based on their importance for determining ecological integrity.
Metric Groups Analysis	Analyse and rate metrics under four categories: Flow modification Habitat modification Water quality modification System connectivity and seasonality (if relevant).
Combine Metric Scores	Combine weighted scores to determine the Present Ecological State (PES) and categorize conditions into classes (A = natural, F = critically modified).
Predictive Use	Modify taxa lists and use the model to predict changes under different scenarios.
Interpret Results	Analyse which metric groups are most impacted (e.g., flow vs. non-flow-related impacts) to inform recommendations for habitat or flow restoration.

4.13. Fish population response assessment.

The fish population response assessment is done using the Fish Response Assessment Index (FRAI), which consists of 8 steps as described by (Kleynhans, 2007c) (Table 17).

TABLE 17: THE EIGHT STEPS OF FRAI AS DESCRIBED BY KLEYNHANS, 2007

Steps 1-8	Procedure
Step 1: Selection of river for assessment	As for study requirements and design
Step 2: Determination of the reference fish assemblage	- Use historical data & expert knowledge - Model: use ecoregions and other environmental information - Use expert fish reference frequency if occurrence database if available
Step 3: Determination of the present state of drivers	- Hydrology - Physico-chemical - Geomorphology *Or* - Index of habitat integrity
Step 4: Selection of representative sampling sites	Field survey in combination with other survey activities
Step 5: Determination of fish habitat condition	- Assess fish habitat potential - Assess fish habitat condition
Step 6: Fish sampling	- Sample all velocity depth classes per site if feasible - Sample at least three stream sections per site. Electronarcosis

Steps 1-8	Procedure
	Sampling is done through electronarcosis in each habitat type (fast-deep, fast-shallow, slow-deep, slow-shallow depending on availability) for 15 minutes at each site as described by Kleynhans (2007). Electronarcosis involves the induction of an electric current in the water, which renders the fish in close proximity to the electrical field immobile for a short period of time, allowing the collection of fish using a scoop net. The specific equipment used is a Samus 725M electrofisher. This sampling method is in line with the methodology recommended for the FRAI protocol as described by Kleynhans (2007c). Each fish collected is identified to species level and the frequency of occurrence of each species is noted on a pre-prepared FRAI fish data sheet. After identification, fish are returned to the river. Passive trapping Using simple baited Frabil minnow traps placed in the fish habitats no less than 15 minutes. The traps were checked after the minimum 15 minutes and all fish removed.
Step 7: Collate and analyse fish sampling data	Transform fish sampling data to frequency of occurrence ratings
Step 8: Execution of FRAI model	- Rate the FRAI metrics in each metric group - Enter species reference frequency of occurrence data - Enter species observed frequency of occurrence data - Determine weights for metric groups - Obtain FRAI value and category - Present both modelled FRAI and adjusted FRAI

4.14. Diatom sampling

Diatoms are a major group of algae, specifically microalgae, that are found in various aquatic environments, including oceans, freshwater lakes, rivers, and even damp soils. They are unicellular, but they can exist as colonies in various shapes, including filaments, ribbons, fans, zigzags, or stellate (star-shaped). Diatoms are unique because of their cell wall, which is made of silica and is called a frustule. The frustule has a variety of shapes, including circles, triangles, squares, ovals, rectangles, and elongated shapes.

Sampling is done in the euphotic zone (the uppermost layer of the water column that receives sunlight), and the substrate should have been underwater for at least 4-6 weeks before sampling. Avoid sampling in shaded areas, close to the bank, or where the stones are covered by filamentous algae and/or sediment.

To collect the sample, choose at least five cobbles or small boulders from a flowing section of the river, or 5-10 stems of macrophytes. Carry the substrata back to the bank, being careful not to disturb the diatoms on the upper surface of the stones.

Collect 20-50 ml of river water in an ice-cream tub or plastic tray. Place the stone or macrophyte over the tub and brush the upper surface vigorously with a new or clean toothbrush to remove the diatoms. Avoid the bottom surfaces and sections with sludge and sediment.

Use a little of the stream water in the tub to rinse the diatoms from the toothbrush and substrate into the tub. Brush and rinse at least three times per substrate. The water in the tub should be brown and turbid.

Mix the brown suspension in the tub and pour it into two sample bottles. Seal and label the bottles and keep them cool. Add preservative (ethanol) to one of the sample bottles, if available. Store the other bottle (refrigerate) until the laboratory analysis is completed by Koekemoer Environmental.

4.15. Water sampling procedure (**FIGURE 16**)

4.15.1. Laboratory sampling

All sampling of water quality is done in accordance with the Department of Water and Sanitation's guide: Quality of domestic water supplies Volume 2: Sampling Guide I (ISBN No: 1 86845 543 2, Water Research Commission No: TT 117/99). See **FIGURE 16** for an image of the sampling procedure as taken from the guide.

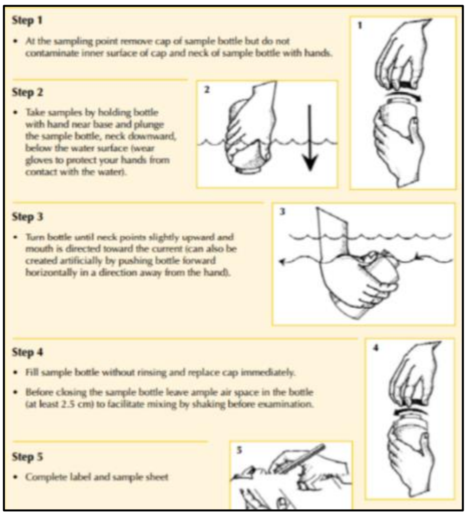


FIGURE 16: WATER SAMPLING PROCEDURE

4.15.2. In situ water quality

In addition to laboratory assessment of water quality, sampling was also completed using a Hanna handheld probe- HI 9813-5 Portable pH, EC, TDS, Temperature (°C) meter. The probe is placed in water and a minimum of one minute is timed. Results are reviewed until readings on the LCD screen is stable. The result is then photographed for record keeping.

4.15.3. Interpretation of physical properties of water

The physical properties of water are based on the temperature, Electrical conductivity (EC)/ Total dissolved solids (TDS) and pH. 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. See Table 18 for a list of physical properties of water and comparative results.

TABLE 18: 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 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.

4.16. Impact assessment

The methodology used to assess the significance of an impact is based on the requirements as set out in EIA Regulations, (GN 982) of 2014 in terms of the NEMA as well as the Proposed National Guideline on Minimum Information Requirements for Preparing EIA for Mining Activities that Require EA, of 2018, GN 86 in terms of NEMA. The impact significance methodology described below also complies to Appendix B of the Operational Guideline to Integrated Water and Waste Management of 2010 in terms of the NWA. In the event of any Section 21c&i water uses in terms of the NWA being assessed, Appendix A of the General Authorisations of 2016, GN 509 in terms of the NWA will be used to construct a risk matrix. Regulation 3(b) of the General Authorisations of 2016, GN 509 in terms of the NWA states that a suitably qualified SACNASP professional member must determine risks associated with this risk matrix.

4.17. Risk assessment matrix (Department of Water and Sanitation)

General Authorisations in terms of section 39 of the national water act 36 of 1998 for water uses as defined in section 21(c) or section 21(i). General notice 509 (2016) as amended in GN 4167 (2023) replaces the need for a water user to apply for a licence in terms of section 40 of the National Water Act 36 of 1998 (NWA), provided that the water use is within the limits and conditions of this General Authorisation (low risk as per the risk matrix). It is important to note the following:

The risk assessment is an excel based program using various risk assessments keys to calculate the overall risk assessment of any proposed activities. The mean of the final risk assessment is use in with the ratings classes of Table 19 to assess the risk.

TABLE 19: RATINGS CLASS

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 29	**(L) Low Risk OR (+) Positive (+ +) Highly positive**	Acceptable as is or with proposed mitigation measures. Impact to watercourses and resource quality small and easily mitigated, or positive.
30 – 60	**(M) Moderate Risk**	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
61 – 100	**(H) High Risk**	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

Risk assessment matrix must be conducted by a suitably qualified SACNASP professional member, and he/she must:

- Consider all relevant phases of proposed activities (construction and operational phases as minimum).
- Consider risks to resource quality with the proposed control measures (as specified) assumed to be in place.

- Consider the present ecological status (PES) and ecological importance and sensitivity (EIS) of the watercourse as receptor of risks posed.
- Rate positive impacts/risks reduction using negative impact intensity scores in the risk assessment matrix.
- Indicate confidence level of scores provided in the last column as a category(low/medium/high).
- On the ram excel spreadsheet, rows that are not needed can be deleted and additional rows can be added if required.

4.17.1. Study site extension-500 meter

The 500 m extended study site requirement refers to the standard buffer applied during risk screening and environmental assessment in terms of General Notice 4167 (GN4167), published by the Department of Water and Sanitation under the National Water Act. This requirement entails that, in addition to the footprint of the proposed water use, an extended area of 500 m must be considered to identify potential hydrological, ecological, and cumulative impacts on nearby water resources, including rivers, wetlands, groundwater-dependent ecosystems, and downstream receptors (Figure 17). The 500 m zone supports a precautionary, risk-based evaluation by ensuring that indirect impacts, connectivity, and sensitivities beyond the immediate development area are adequately assessed, particularly for activities that may affect water flow, water quality, or aquatic habitat integrity.

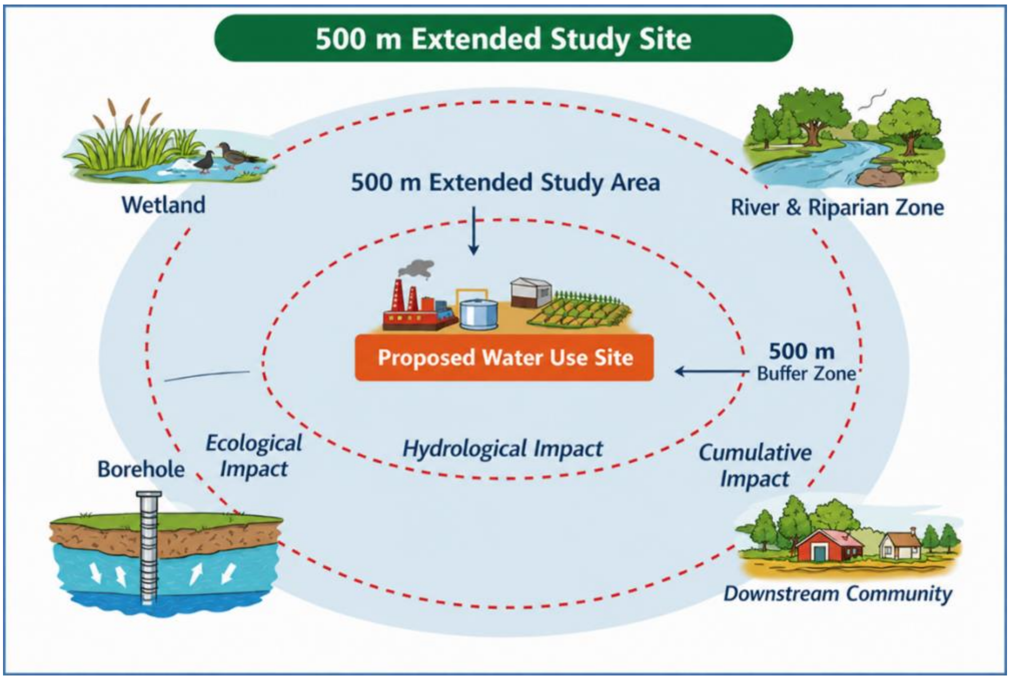


FIGURE 17: 500 METER EXTENDED STUDY SITE DIAGRAM

4.17.2. Wetland importance

Gn4167 sets out the assessment criteria for the wetland importance in Table 20.

TABLE 20: WETLAND IMPORTANCE ASSESSMENT CRITERIA

Low or Very Low EI / EIS / Wetland Importance rating; OR, If EI/EIS has not been determined, Low rating based on presence of: - no areas identified to be of conservation importance (i.e. OESA at most); and/or - only species/habitats of Least Concern on the IUCN Red List or on a regional/national Red List (including freshwater ecosystem types of Least Concern in terms of the NBA); and/or - only species which are common and widespread and/or habitats of low conservation interest; and/or - highly degraded habitat of extremely small size	**Low / Very low** = 2
Medium EI / EIS / Wetland Importance rating; OR, If EI/EIS has not been determined, Moderate rating based on presence of: - CESAs; and/or- species/habitats listed as VU or NT on the IUCN Red List or on a regional/national Red List (including VU/NT freshwater ecosystem types in terms of the NBA); and/or functionality as an important ecological corridor or buffer area	**Moderate** = 3
High EI / EIS / Wetland Importance rating; OR, If EI/EIS has not been determined, High rating based on presence of: - CBA2; and/or - species or degraded habitats (in poor condition) listed as EN or CR on the IUCN Red List or on a regional/national Red List (including EN/CR freshwater ecosystem types in terms of the NBA)	**High** = 4

Very high EI / EIS / Wetland Importance rating; <u>OR</u>, If EI/EIS has not been determined, Very high rating based on presence of: -CBA1; and/or - FEPA; and/or - species or intact habitats (in fair or good condition) listed as EN or CR on the IUCN Red List or on a regional/national Red List (including EN/CR freshwater ecosystem types in terms of the NBA); and/or - KBA or IBA or Ramsar site	**Very high** = 5
EI=Ecological Importance; EIS=Ecological Importance & Sensitivity; OESA=Other Ecological Support Areas; IUCN=International Union for Conservation of Nature; CESA=Critical Ecological Support Area; NBA=National Biodiversity Assessment; VU=Vulnerable; NT=Near Threatened; EN=Endangered; CR=Critically Endangered; CBA=Critical Biodiversity Area; FEPA=Freshwater Ecosystem Priority Area; KBA=Key Biodiversity Area; IBA=Important Bird Area.	

4.17.3. GN4167 exclusions

GN4167 (3) This Notice does not apply:

3(a) to the use of water in terms of section 21 (c) or (i) of the Act for the rehabilitation of a wetland as contemplated in General Authorisation 1198 published in Government Gazette 32805 dated 18 December 2009,

3(b) to the use of water in terms of section 21 (c) or (i) of the Act within the regulated area of a watercourse where the Risk Class is Medium or High as determined by the Risk Matrix (Appendix A). This Risk Matrix must be completed by a suitably qualified SACNASP professional member;

3(c) in instances where an application must be made for a water use license for the authorisation of any other water use as defined in section 21 of the Act that may be associated with a new activity;

3(d) where storage of water results due to the impeding or diverting of flow or altering the bed, banks, course, or characteristics of a watercourse;

3(e) to any section 21 (c) or (i) water use associated with construction/installation or maintenance of main or bulk sewerage pipelines, French drains, pipelines carrying hazardous materials. Notwithstanding this requirement, conservancy tanks of not more than 1 (One) tank per hectare and internal sewerage reticulation in residential and mixed-use developments including minor sewerage connections to main sewers are not excluded from this Notice provided that the maximum flow in the pipelines are below the 120 l/s threshold;

3(f) to any section 21 (c) or (i) water use associated with construction of water- and wastewater treatment works including package plants and septic tanks;

3(g) to any section 21 (c) or (i) water use associated with any hazardous material within (he regulated area of a watercourse; and

3(h) to any section 21 (c) or (i) water use associated with mining activities and associated infrastructure unless it falls within appendix D1 or D2.

4.17.3.1. Generally authorized activities

A list of generally authorized activities for individuals is given in Table 21 and Table 22 for institutions.

TABLE 21: ACTIVITIES LISTED THAT ARE GENERALLY AUTHORIZED FOR ANY PERSON SUBJECT ONLY TO COMPLIANCE TO CONDITIONS 7(7)-(12) OF GN4167 NOTICE. (NO REQUIREMENT FOR A RISK MATRIX ASSESSMENT)

Any person	Activity
Any person	Emergency river crossings for vehicles to gain access to livestock, crops, or residences etc.
Any person	Construction of a single residential house and associated infrastructure (including sewer connections below 120l/s, conservancy tanks or French drains provided the sewerage disposal infrastructure is at least 100 m from any watercourse)
Any person	Maintenance to private roads and river crossings provided that footprint remains the same and the road is less than 4 m wide.
Any person	Erection of fences provided that the fence will not in any way impede or divert flow, or affect resource quality detrimentally in the short, medium to long term.
Any person	Construction of Renewable Energy Projects Solar and associated infrastructure like access road, battery storage area and grid infrastructure (excluding substations) provided that: It will not result in any direct impact/destruction on any watercourses and where the sewerage infrastructure is located more than 100m from any watercourse. Where there will be any direct impacts/destruction of any watercourses the entire project must be subjected to a comprehensive Risk Matrix Assessment to determine the appropriate entitlement for the project. (Read together with General *notice 665 of 6 Sept 2013 General Authorization* section *21 (e) or as amended.*
Any person	Mini-scale hydropower developments with a maximum capacity of 10kW — 300kW *(Read together with General notice 665 of 6 Sept 2013 General Authorisation* section 2J *(e) or as amended.* These hydropower plants will provide basic, non-grid electricity to rural communities and agricultural land and must in no way affect the flow regime, flow volume and/or water quality including temperature.
Any person	Construction or maintenance of floating jetties (temporary and permanent) and slipways. *Constructed jetties other than floating are excluded* from *this appendix and must be subjected to the Risk Matrix.*

TABLE 22: ACTIVITIES LISTED THAT ARE GENERALLY AUTHORIZED FOR INSTITUTIONS SUBJECT ONLY TO COMPLIANCE TO CONDITIONS 7(7)-(12) OF GN 4167 (NO REQUIREMENT FOR A RISK MATRIX ASSESSMENT)

INSTITUTION	ACTIVITIES

ESKOM and other institutions	Construction of new overhead transmission and distribution power lines outside the active channel of a river and/or outside the extent of a wetland, and minor maintenance of roads, river crossings, towers, and substations where footprint will remain the same. The maintenance or replacement of existing overhead and underground cables where it is done in terms of the Emergency Protocol. However, New underground cables and underground and overhead cables within the extent of a wetland must be subjected to the Risk Matrix and are therefore excluded from this appendix.
SANPARKS and provincial conservation agencies	Construction and maintenance of all pipelines (including sewerage) below 500 mm in diameter.
SANRAL and other institutions	All maintenance of bridges and run-up road sections over rivers, streams and wetlands and construction of new bridges and run-up roads over non-perennial rivers done according to SANRAL Drainage Manual or similar norms and standards. For these linear projects where any other part of the project constitutes a section 2f (c) or: (i) water use the Risk Matrix must be applied and could result in the entire project being authorised under one authorisation, either a GA or a WUL 'if “risks” are moderate or high and are therefore excluded from this appendix. (Use of pipe culverts in any form for bridges or crossings is not permitted)
TRANSNET	Maintenance of railway line crossings of watercourses which includes bridges, culverts, and access roads as well as minor maintenance of bridges, culverts, access roads and pump stations where the footprint will remain the same. For these linear projects any other part of the linear project constitutes a section 21 (c) or (i) water use, the Risk Matrix must be applied and could result in the entire project being authorised under one authorisation, either a GA or a WUL if “risks” are moderate or high and are therefore excluded from this appendix.
Gautrain Management Agency	Maintenance of existing infrastructure and expansion to crossings of non-perennial rivers within the existing servitude. Bridges crossing any other watercourses must be subjected to a risk matrix to determine the appropriate entitlement. For these linear projects where any other part of the project constitutes a section 21 (c) or (i) water use the Risk Matrix must be applied and could result in the entire project being authorised under one authorisation, either a GA or a WUL if “risks” are moderate or high and are therefore excluded kom this appendix.
TELKOM and all other communication companies	Installation of all cables where watercourses are crossed by Horizontal Directional Drilling or pipe jacking and/ or conventional installation (trenching) of cables crossing rivers or passing through the regulated area of a wetland and/or pan but outside the extent of the wetland

	and/or pan. However, conventional installation of cables through the extent of a wetland or pan must be subjected to the Risk Matrix and are excluded from this appendix.

4.18. Impact assessment methodology

Impact assessment was done using the main impact assessment methodologies. This is based on the sum of the likelihood consequence and the duration. See Table 23 for the ratings of the significance for the likelihood and consequence ratings.

TABLE 23: ASSESSING SIGNIFICANCE OF LIKELIHOOD IMPACT RATINGS

LIKELIHOOD DESCRIPTORS		CONSEQUENCE DESCRIPTORS	
Frequency of Impact	Almost Impossible 1, Highly Unlikely 2 Unlikely 3 Likely 4 Highly Likely 5	**Severity of Impact**	Non-harmful 1 Potentially Harmful 2 Slightly Harmful 3 Harmful 4 Extremely Harmful 5
Frequency of Activity / Duration of Aspect Rating	Low 1 Temporary 2 Infrequent 3 Regularly 4 Permanent 5	**Spatial Scope of Impact**	Activity specific 1 Site specific (within the site boundary) 2 Local area (within 5 km of the site boundary) 3 Regional 4 National 5
DURATION		SIGNIFICANCE RATING	
Duration of Impact	One day to one month 1 One month to one year 2 One year to ten years 3 Life of operation 4 Permanent 5	(see matrix below)	

Likelihood (Probability of Impact + Sensitivity of receiving environment)	Consequence (Severity + Spatial Scope + Duration)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Using the assessment the significance rating can be extrapolated from the sum of the severity, spatial scope and duration and multiplying it to the sum of the probability of the impact and sensitivity of the receiving environment. This can be used as per Table 24 for the positive and negative mitigation ratings.

TABLE 24: POSITIVE/ NEGATIVE MITIGATION RATINGS

Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
Very High	126 - 150	Critically consider the viability of proposed projects. Improve current management of existing projects significantly and immediately.	Maintain current management
High	101 - 125	Comprehensively consider the viability of proposed projects. Improve current management of existing projects significant	Maintain current management
Medium- High	76-100	Consider the viability of proposed projects. Improve current management of existing projects.	Maintain current management
Medium – Low	51 - 75	Actively seek mechanisms to minimise impacts in line with the mitigation hierarchy	Maintain current management and/or proposed project criteria and strive for continuous improvement.
Low	26 - 50	Where deemed necessary seek mechanisms to minimise impacts in line with the mitigation hierarchy.	Maintain current management and/or proposed project criteria and strive for continuous improvement.
Very low	1-25	Maintain current management and/or proposed project criteria and strive for continuous improvement.	Maintain current management and/or proposed project criteria and strive for continuous improvement.

5. Results

During the site visit a relatively flat study site was observed. The site is dominated by open grassland with a ridge section to the east. The site is currently used for grazing of cattle. The site drains via a unchannelled valley bottom wetland to a large depression wetland to the north of the site. The unchannelled valley bottom wetland is large and seems to collate all the water from the site.

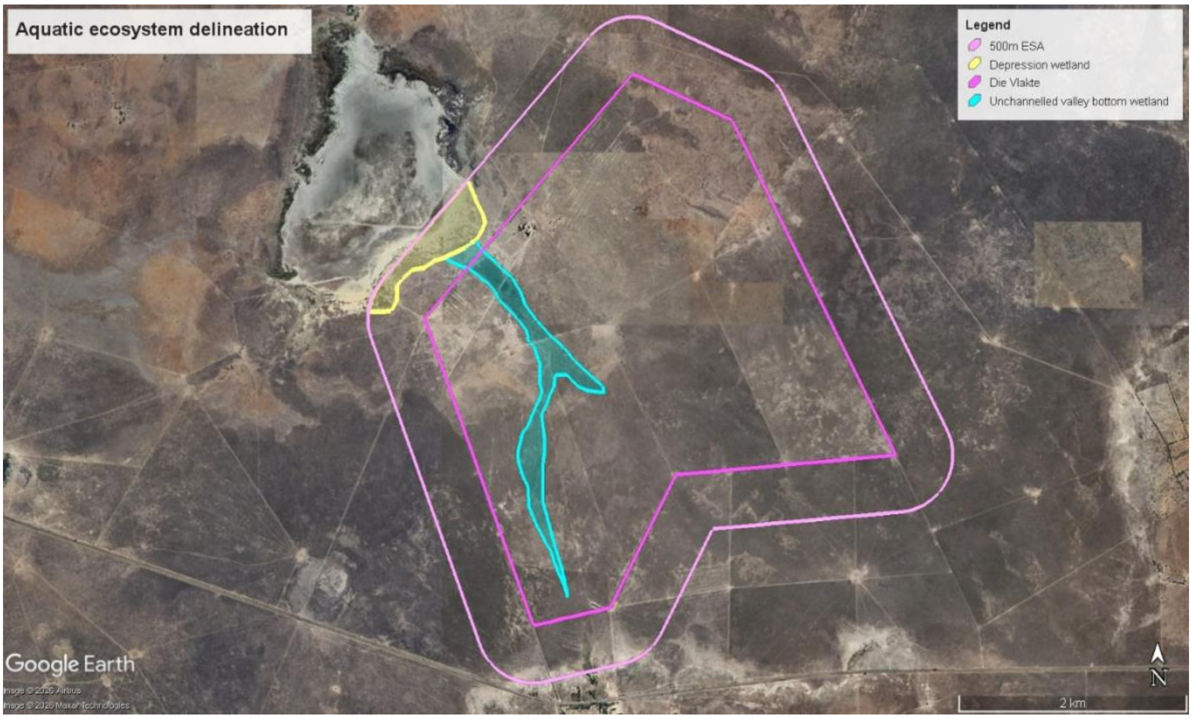


FIGURE 18: AQUATIC ECOSYSTEM DELINEATION

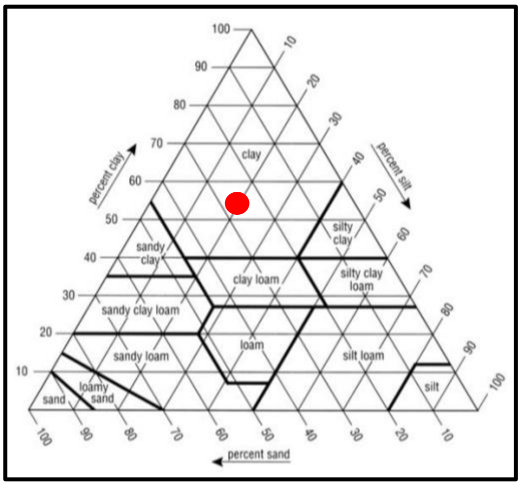
5.1. Description of the aquatic biodiversity and ecosystems on the site

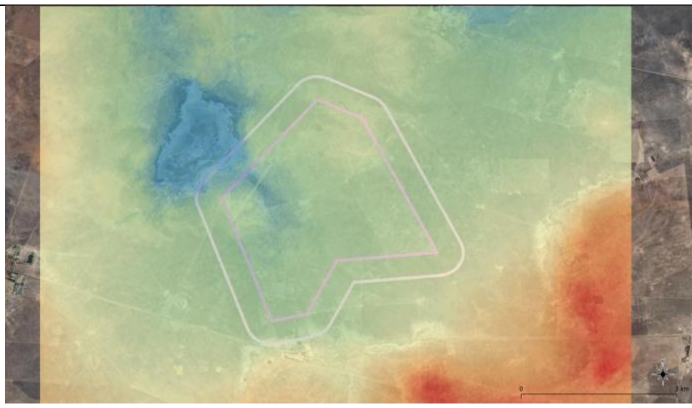
5.1.1. Wetland indicators as in line with DWA 2005

The following indicators were observed on site, confirming wetland conditions (Table 25):

TABLE 25: WETLAND INDICATORS (DWA 2005)

Indicator	Site observation
Wetland (hydromorphic) soils and anaerobic conditions in the soil	The unchannelled valley bottom wetland soils were dark brown to black soils was observed on site (Figure 19). The soil matrix was dense clayed with some signs of sand in the matrix. Release from the soil auger was difficult with some root activity. Using the soil structure classification (as per

	Macvicar & De Villiers, 1977) the soil classification is given in Figure 20  FIGURE 19: SOIL SAMPLE FROM THE WETLAND AREAS.  FIGURE 20: SOIL STRUCTURE CLASSIFICATION (AS PER MACVICAR & DE VILLIERS, 1977) IN RED DOT
The presence, at least occasionally, of water loving plants (hydrophytes)	Many different hydrophytes were observed on site. More common in the unchannelled valley bottom was *Echinochloa pyramidalis and Leersia denudate.*
Topographical location in relation to the landscape.	Colour elevation ramp follows the aquatic ecosystems

	
Open standing water or water near the surface	Limited and not observed

5.1.2. Aquatic ecosystem classification (Ollis *et al* 2013)

The classification of the system was done using the dichotomous key in Ollis *et al.* (2013) (Table 26) with the services provided by the aquatic ecosystems found on site in Table 5. The description of the classification of the aquatic ecosystems is given in Table 27

TABLE 26: SUMMARY OF THE APPLICATION OF LEVELS 1 TO 5 OF THE AQUATIC ECOSYSTEM CLASSIFICATION IN ACCORDANCE WITH THE DICHOTOMOUS KEY FROM OLLIS *ET AL.* 2013

Watercourse	**Key 1** Landscape Unit		**Key 2** HGM Unit			**Key 3a** River Flow types		**Key 3b** Hydroperiod		
	Level 3a (Figure 9)	**Level 3b**	**Level 4a** HGM Type	**Level 4b** River zonation/ Landform/ Outflow drainage	**Level 4c** Landform/ Inflow drainage	**Level 5a** Flow regime	**Level 5b** Non-perennial flow regime	**Level 5 a** Inundation period	**Level 5b** Saturation period	**Level 5 c** Inundation depth class
Unchannelled valley bottom wetland	Valley floor		Unchannelled valley bottom			N/A		**Never/ Rarely inundated**	**Seasonal saturated**	**Unknown depth class**
Depression wetland	Valley floor		Depression	**Exorheic- to be confirmed**	Enter of water into wetland: **Diffused (no channel flow)**	N/A		**Unknown**	**Unknown Saturation period**	**Unknown depth class**

TABLE 27: CLASSIFICATION TYPE DESCRIPTION AND NOTES

Type description	Notes
Depression: An inland aquatic ecosystem with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, groundwater discharge, interflow and (diffuse or concentrated) overland flow. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations.	(1): Depressions may be flat-bottomed (in which case they are often referred to as 'pans') or round bottomed and may have any combination of inlets and outlets or lack them completely. (2): For purposes of the Classification System, natural lakes (including coastal lakes) and dams (i.e., artificial lakes), which are typically drowned valley floors, are depressions.

Unchannelled valley-bottom wetland: A valley-bottom wetland without a river channel running through it. These wetlands are characterised by their location on valley floors, an absence of distinct channel banks, and the prevalence of diffuse flows. Water inputs are typically from an upstream channel and seepage from adjacent valley side slopes if present.	(1): These areas are usually characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment and the presence of vegetation. (2): Preferential flow paths (minor channels) are often present, particularly towards the lower end of the wetland where flow often begins to concentrate.

5.2. Integrity, Functionality and Ecological Importance and Sensitivity

See Table 28 for the summary of findings for the aquatic ecosystems observed on site:

- Depression wetland (Table 28),
- Channelled valley bottom wetland (),

Table 28: Depression Wetland Integrity, Functionality and Ecological Importance and Sensitivity Results

Present Ecological Score

	Wetland PES Summary			
Wetland name	Die Vlakte Depression Wetland			
Assessment Unit	1			
HGM type	Depression without flushing			
Areal extent (Ha)	388,0 Ha			
	Unadjusted (modelled) Scores			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	0,5	0,8	1,2	1,1
PES Score (%)	95%	92%	88%	89%
Ecological Category	A	A	B	B
Combined Impact Score	0,9			
Combined PES Score (%)	91%			
Combined Ecological Category	A			
Hectare Equivalents	354,4 Ha			

Unmodified/ natural

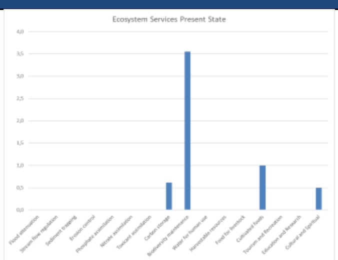
Ecological Importances and sensitivity (EIS)

	Determinant	Score (0-4)
PRIMARY	Rare & Endangered Species	2
	Populations of Unique Species	2
	Species/taxon Richness	1
	Diversity of Habitat Types or Features	2
	Migration route/breeding and feeding site for wetland species	2
	Sensitivity to Changes in the Natural Hydrological Regime	2
	Sensitivity to Water Quality Changes	3
	Flood Storage, Energy Dissipation & Particulate/Element Removal	3
MODIFYING	Protected Status	1
	Ecological Integrity	4
	MEDIAN	2,2
	EIS score	**Moderate**

High

Aquatic ecosystems that are ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.

WET-Ecoservices



The importance of services supplied is very low relative to that supplied by other wetlands. Biodiversity

	maintenance in conjunction with cultivate floods scored the highest and must be seen as conservation objectives for the wetland.

Recommended Ecological Management Class (REMC)

			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

PES=A

EIS=High

REMC= A Maintain

Wetland importance

High

EI / EIS / Wetland Importance rating; <u>OR</u>, If EI/EIS has not been determined, High rating based on presence of: - CBA2; and/or - species or degraded habitats (in poor condition) listed as EN or CR on the IUCN Red List or on a regional/national Red List (including EN/CR freshwater ecosystem types in terms of the NBA)

Table 29: Unchannelled valley bottom Wetland Integrity, Functionality and Ecological Importance and Sensitivity results

Present Ecological Score

	Wetland PES Summary			
Wetland name	Die Vlakte Channelled valley bottom wetland			
Assessment Unit	1			
HGM type	Unchannelled VB wetland			
Areal extent (Ha)	54,6 Ha			
	Unadjusted (modelled) Scores			
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	1,1	0,9	3,9	0,7
PES Score (%)	89%	91%	61%	93%
Ecological Category	B	A	C	A
Combined Impact Score	1,6			
Combined PES Score (%)	84%			
Combined Ecological Category	B			
Hectare Equivalents	45,8 Ha			

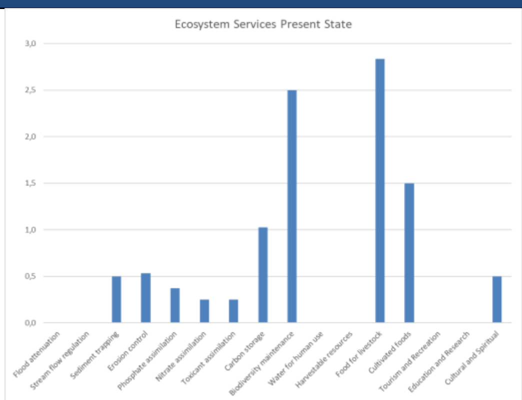
Largely natural with few modifications. A slight change in ecosystem processes is discernible, and a small loss of natural habitats and biota may have taken place.

Ecological Importances and sensitivity (EIS)

	Determinant	Score (0-4)
PRIMARY	Rare & Endangered Species	2
	Populations of Unique Species	2
	Species/taxon Richness	2
	Diversity of Habitat Types or Features	2
	Migration route/breeding and feeding site for wetland species	2
	Sensitivity to Changes in the Natural Hydrological Regime	2
	Sensitivity to Water Quality Changes	2
	Flood Storage, Energy Dissipation & Particulate/Element Removal	2
MODIFYING	Protected Status	1
	Ecological Integrity	2
	MEDIAN	1,9
	EIS score	**Moderate**

Aquatic ecosystems that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

WET-Ecoservices



The most prominent service is food for livestock, followed by water for human use and cultivated foods, highlighting a strong reliance on the system for agricultural production. In contrast, key regulating services such as flood attenuation, streamflow regulation, and sediment trapping are negligible or absent, suggesting a reduced capacity for hydrological buffering and landscape stabilisation. Nutrient assimilation processes (phosphate, nitrate, and toxicant assimilation) are present but at low levels, indicating some functional capacity but likely below optimal ecological condition. Carbon storage and biodiversity maintenance show moderate representation, implying partial ecological functionality, although not at a fully intact state. Cultural services, including tourism, education, and spiritual value, are largely minimal, reflecting limited utilisation or degraded natural appeal. Overall, the graph suggests a system that has been transformed towards production, with reduced ecological resilience and regulatory function, which is consistent with disturbed or moderately degraded wetland or grassland conditions.

Recommended Ecological Management Class (REMC)

			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

PES=B

EIS=Moderate

REMC= B Maintain

Wetland importance

Medium EI / EIS / Wetland Importance rating

If EI/EIS has not been determined, Moderate rating based on presence of: - CESAs; and/or- species/habitats listed as VU or NT on the IUCN Red List or on a regional/national Red List (including VU/NT freshwater ecosystem types in terms of the NBA); and/or - functionality as an important ecological corridor or buffer area

5.3. Presence of aquatic species, and composition of aquatic species communities, their habitat, distribution, and movement patterns

During the site visit no open standing water associated with the habitat provision for aquatic species was observed. The unchannelled valley bottom wetland does have small sections of open water, but these are limited and not connected to a larger aquatic ecosystem directly. It is suspected that herpetological species will utilise these pools but additional faunal assessments are required to confirm.

5.4. Threat status of the ecosystem and species as identified by the screening tool.

The screening tool indicates the likely presence of threatened grassland avifauna, specifically species observed on site *Sagittarius serpentarius* and *Neotis ludwigii*, both of which are highly sensitive to habitat transformation and infrastructure development. Although overall site sensitivity is moderate, the designation of the area as an Ecological Support Area (ESA 1 and ESA 2) suggests an important role in maintaining ecological processes and connectivity. The potential presence of additional species of conservation concern cannot be excluded and must be confirmed through a detailed terrestrial biodiversity and species-specific assessment in accordance with the NEMA Screening Tool protocols.

5.5. Description of the ecological importance and sensitivity of the aquatic ecosystem including:

5.5.1. Description of ecosystem processes

A spatially explicit description of the ecological and hydrological processes associated with aquatic ecosystems on and immediately adjacent to the site, including the identification and delineation of surface and subsurface flow pathways, groundwater–surface water interactions (recharge and discharge zones), and sediment transport processes is given in Table 30. The assessment must consider the role of these processes in maintaining ecosystem functioning, ecological integrity, and connectivity within the broader landscape, in accordance with the requirements of the NEMA Environmental Impact Assessment Regulations and the associated Screening Tool Protocols (GN320).

TABLE 30: MAJOR ECOSYSTEM PROCESSES OF THE SITE

Process	Description on/near site
Faunal components	The site is open grassland with major component expected to be insects and small rodentia. This will create feeding opportunities for other faunal species
Flora components	Mostly open grassland with the ridge area to the east increasing diversity
Surface water flow	Highly limited
Subsurface water	Recharge via rainfall infiltration; discharge into seeps/tributaries
Recharge	Rainfall-driven, enhanced by clay soils and fractured rock aquifers
Discharge	Diffused into depression wetlands
Sediment transport	Episodic, linked to storms and soil disturbance and expected to be highly limited
Nutrient transport	Dark clay soils expected to be limited.
Alien invasive plant species	Limited

5.5.2. Historical ecological condition

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). Google Earth's Timeline function was used as reference imagery. Google Earth imagery from 2005 (Figure 21) to early 2023 (Figure 22) is available and was used to determine the historical land use and whether the site was extensively altered in the past or to detect large changes in the land use of the catchment.

FIGURE 21: THE OLDEST USABLE GOOGLE EARTH IMAGE OF THE SITE FROM 2005

FIGURE 22: GOOGLE EARTH IMAGE FROM 2023

5.6. Review of screening tool data

Incorrect with only the depression wetland listed on site. Review required.

6. Discussion, Impact assessment and general mitigation measures

The assessed wetland units indicate a generally favourable ecological condition and a moderate level of ecological importance (Table 31). The **depression wetland** was assigned a **Present Ecological Score (PES) of A**, indicating an ecosystem that is largely unmodified and in a near-natural state, with negligible loss of natural habitat, biota, or ecosystem functioning. The **unchannelled valley bottom wetland** received a **PES category of B**, reflecting a wetland that remains largely natural but has experienced slight modification in habitat structure or ecological processes. Both wetland types were assigned an **Ecological Importance Score (EIS) of Moderate**, indicating that, while they are not considered exceptionally sensitive or unique at a regional scale, they still provide important ecological functions and should be managed to prevent further degradation. Overall, the findings show that both wetland systems retain meaningful ecological value, with the depression wetland being in a particularly high ecological condition.

TABLE 31: THE PES AND EIS OF THE AQUATIC ECOSYSTEMS

	Present Ecological Score (PES)	Ecological Importance Score (EIS)
Depression wetland	***A***	***Moderate***
Unchannelled valley bottom wetland	***B***	***Moderate***

6.1. Proposed development

The proposed development includes the construction and operation of 4 chicken laying and 2 chicken rearing facilities and associated infrastructure including roads, electrical connections and other aspects. At the current phase of the project, the final locations of the aspects have not yet been finalized (Figure 23).

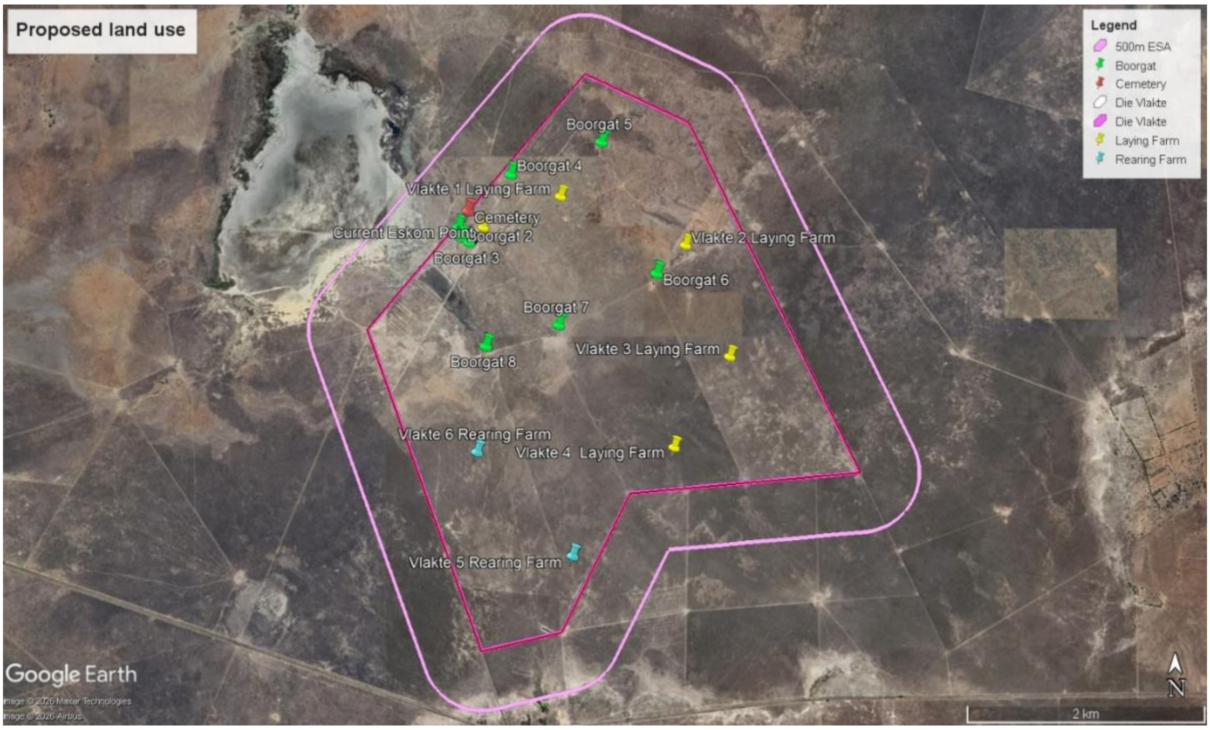


FIGURE 23: PROPOSED LOCATIONS OF THE REARING AND LAYING FARMS

6.1.1. GN4167 (2023) Regulated areas

As per GN4167 (2023) a watercourse is defined as:

- **Extent of a Watercourse**: The outer edge of the 1 in 100-year flood line or the delineated riparian habitat, whichever is the greatest distance from the middle of the watercourse. This definition applies to rivers, springs, natural channels, dams, lakes, and wetlands (including pans).
- **Characteristics**: The term "characteristics of a watercourse" refers to the resource quality within its extent, including the water flow, water quality, habitat condition, and distribution of aquatic biota.
- **Regulated Area**: The regulated area of a watercourse includes the space within 100 meters from the edge of the watercourse in the absence of a defined flood line or riparian habitat, and a 500-meter radius around the boundary of any wetland.

This definition sets the framework for understanding the spatial limits and environmental characteristics that define a watercourse, ensuring the protection and management of water resources as outlined in the National Water Act (act 36 of 1998). To ensure compliance with this regulation, a 500 m regulated area map was generated (Figure 24).

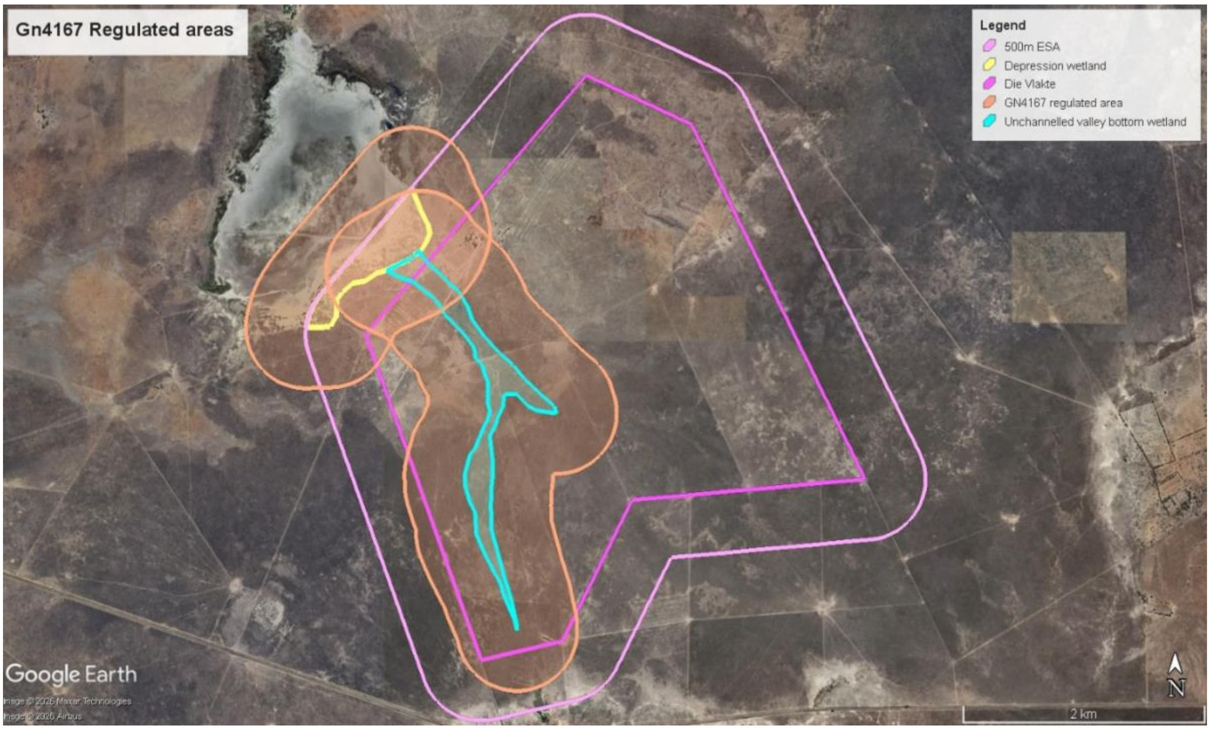


FIGURE 24: 500 METER REGULATED AREA OF THE WETLANDS

6.2. Risk assessment (GN4167)

The excel spreadsheet was completed for the project with the expected impacts assessed as part of expected impacts from the proposed development. See Table 32 for te watercourse and project specifications tab and Table 33 for the calculation of the risk. Only the construction and operational phase was assessed for the development. The average of all the combined risks resulted in a score of 13- a ***LOW*** risk.

TABLE 32: WATERCOURSE AND PROJECT SPECIFICATIONS INFORMATION

PROJECT: Die Vlakte

RISK ASSESSMENT MATRIX for Section 21 (c) and (i) Water Use activities

POTENTIALLY AFFECTED WATERCOURSE/S				
Watercourse number	Watercourse name	Watercourse type	PES	EIS
(1)	Unchannelled valley bottom wetland	Wetland	B	Moderate
(2)	Depression Wetland	Wetland	A	Moderate
(3)				
(4)				
(5)				
(6)				
(7)				
(8)				
(9)				
(10)				

TABLE 33: GN4167 RISK ASSESSMENT

PROJECT: Die Vlakte

RISK ASSESSMENT MATRIX for Section 21 (c) and (i) Water Use activities - Version 2

Name of Assessor: Bertus Fourie **Signature:**

SACNASP Registration Number: 8394 **Date:** May-26

Risk to be scored for all relevant phases of the project (**factoring in specified control measures**). MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

Phase	Activity	Impact	Intensity of Impact on Resource Quality: Abiotic Habitat (Drivers)			Biota (Responses)		Consequence (max = 100)	Likelihood (Probability) of impact	Significance (max = 100)	Risk Rating (without mitigation)	Confidence level
			Hydrology	Water Quality	Geomorph	Vegetation	Fauna					
PRE-CONSTRUCTION (DESIGN)	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS) (How will the proposed activities on site impact on the EIS of the aquatic ecosystem)	Development footprint is outside the setback/ buffer of the wetland and will link to exsting infrastrucure	1	1	1	1	1	**40**	80%	**32**	M	High
		Impact on Present Ecological condition	1	1	1	1	-1	**35**	80%	**28**	L	High
		Impact on Ecological importance and Sensitivity	1	1	1	1	1	**35**	80%	**28**	L	High
	Activities within 500m of a wetland as per GN4167	Direct activities present in the 500m regulated area around the wetlands	0	0	0	0	0	**10**	20%	**2**	L	High
CONSTRUCTION (Completed)	General construction phase aspects and risks	Sediment ingress into wetland	0	0	0	0	0	**4**	20%	**0,8**	L	High
		Increased flow volumes due to surface hardening	0	0	0	0	0	**4**	20%	**0,8**	L	High
		Impact on long term ecosystem health	0	0	0	0	0	**4**	20%	**0,8**	L	High
	Hydrocarbon spill	Refilling of machinery	0	0	0	0	0	**4**	20%	**0,8**	L	High
		Possible spillage into natural area	0	0	0	0	0	**4**	20%	**0,8**	L	High
	General construction phase aspects and risks	Reduced functionality of buffer	0	0	0	0	0	**4**	20%	**0,8**	L	High
		Alien vegetatation establishment and spread	0	0	0	0	0	**4**	20%	**0,8**	L	High
OPERATIONAL	Spills into wetlands	Contamintation of watercourses	1	3	1	2	2	**28**	60%	**16,8**	L	High
		Physical pollution	2	3	1	1	1	**26**	60%	**15,6**	L	High
	Ingress into wetland areas	Compaction of soils	2	2	2	2	2	**20**	100%	**20**	L	High
		Destruction of wetland fauna	2	1	1	3	5	**32**	100%	**32**	M	High
		Destruction of wetland flora	2	1	1	5	3	**32**	100%	**32**	M	High
	Stormwater management	Hydrological impact	5	2	2	2	2	**34**	100%	**34**	M	High
		Streamflow reduction	5	2	3	2	2	**34**	100%	**34**	M	High
		Altered velocities	5	2	3	2	2	**36**	100%	**36**	M	High
DECOMMISSIONING	Decompaction of soil	Ripping of open space areas to reduce compaction	1	1	3	1	3	**16**	100%	**16**	L	High
	Erosion of replaced soils	Replaced surface soils are washed away if not stabilised or planted before the first rainfall	1	1	3	1	3	**16**	100%	**16**	L	High
	Alteration of soil chemical properties	Alteration of soil chemical properties- reducing soil productivity	1	1	3	1	3	**16**	100%	**16**	L	High
	Alien vegetating eradication	Application of herbicides	1	1	1	5	3	**24**	100%	**24**	L	High
											L	

6.3. Impact assessment results

The impact assessment was completed in Table 34 below. The average impact assessment was calculated to 27 (Low) before mitigation and 18 (Very low) after mitigation. The negative impact assessment for the development must be set to "Maintain current management and/or proposed project criteria and strive for continuous improvement". This can be done by implementing the mitigation measures as listed in the table and below.

TABLE 34: IMPACT ASSESSMENT AND MITIGATION MEASURES

Nature	Activity	Before mitigation		Description of mitigation measure	After Mitigation						
		Significance (out of 150)			Frequency of impact	Frequency of Activity/ Duration of Aspect	Severity	Spatial Scale	Duration	Significance (out of 150)	
Hydrology	Increased stormwater runoff from roofs, hardstands and access roads associated with the chicken laying and rearing facilities	80	Medium-High	Separate clean and dirty water systems for the poultry facilities. Incorporate attenuation and energy dissipation into the stormwater management plan. Prevent concentrated discharges into adjacent aquatic ecosystems and monitor wetlands/drainage lines for erosion or inundation impacts.	3	5	2	2	4	64	Medium – Low
	Base flow alteration due to abstraction and operational water demand	30	Low		1	2	1	1	4	18	Very low
	Quantity of water changes in the hydrological regime due to water use, runoff routing and drainage infrastructure	21	Very low		1	1	1	2	4	14	Very low
	Change in hydrogeomorphic processes due to cut-and-fill, platforms and drainage works	15	Very low		1	1	2	1	1	8	Very low
	Quality of water deterioration from sediment, manure, litter, wash water and hydrocarbon contamination	15	Very low		1	1	3	1	1	10	Very low
	Local impoundment or ponding of water due to stormwater controls and infrastructure	36	Low		1	2	1	1	4	18	Very low
Geomorphology alteration	Increased concentrated flows from the developed poultry facility footprint	80	Medium-High	Avoid damming or concentrating runoff into wetlands. Disperse flows where appropriate, install energy dissipation measures and maintain stable outlet structures.	3	2	2	2	4	40	Low
	Altered flow paths caused by platforms, drains, berms and road crossings	80	Medium-High	Monitor drainage lines and wetlands for altered flow paths, erosion or channelisation. Keep infrastructure outside sensitive areas and direct runoff through approved control measures only.	2	3	3	2	4	45	Low
Chemical alteration water	Phosphate enrichment from manure, litter storage and contaminated runoff	16	Very Low	Store manure and litter on impermeable surfaces where required, remove waste regularly, maintain clean and dirty water separation, and use vegetated treatment/attenuation systems with indigenous species where appropriate.	1	1	1	2	4	14	Very low
	Nitrate enrichment from manure, litter storage and contaminated runoff	16	Very Low		1	1	1	2	4	14	Very low
	Toxicant contamination from disinfectants, veterinary products, fuels and chemicals	16	Very Low		1	1	1	2	4	14	Very low
	Carbon storage losses from vegetation clearance and soil disturbance	16	Very Low		1	1	1	2	4	14	Very low
Biota	Disturbance to aquatic and semi-aquatic fauna from construction and operation of the poultry facilities	16	Very Low	Avoid works within aquatic features, especially during the rainy season. Prevent contaminated runoff, control noise and lighting where relevant, and implement environmental awareness training for staff and contractors.	1	1	2	1	1	8	Very low
	Habitat loss or degradation adjacent to aquatic ecosystems	24	Very Low	Maintain connectivity and buffer areas around aquatic ecosystems, confine disturbance to the approved footprint, and rehabilitate temporarily disturbed areas.	1	2	2	1	1	12	Very low
	Impact to aquatic and wetland flora through disturbance and contaminated runoff	16	Very Low	Manage stormwater velocities, prevent contaminated runoff from entering aquatic habitats, and provide environmental awareness training to minimise incidental damage to wetland vegetation.	2	1	2	1	1	12	Very low
Fragmentation	Disruption of ecological goods and services through infrastructure development	6	Very Low	Keep the development footprint outside sensitive aquatic areas and maintain stormwater, buffer and rehabilitation measures so that ecological functioning is not fragmented.	1	1	1	1	1	6	Very low
The loss or degradation of all or part of any unique or important features	No unique aquatic features identified within the development footprint; indirect impacts remain possible if poorly managed	2	Very Low	Maintain buffers and stormwater controls and ensure that construction and operation remain within the authorised footprint.	1	1	1	0	0	2	Very low
		27	Low		1	2	2	1	3	18	Very low

6.4. Mitigation of proposed impact

The mitigation of the impacts to the system is based on the perceived impacts for the proposed activities. The most effective mitigation is the awareness of possible issues before they occur. To ensure the issues are mitigated it is recommended that an Aquatic environmental control officer (AECO) is appointed for the duration of the project. The AECO will be tasked with assessing field conditions and ensure impacts to the aquatic ecosystem is managed.

6.4.1. Mitigation of impacts using buffers

The buffer calculation tool (Macfarlain et al, 2014) was used. Two buffers are recommended: one for construction and one for operation. The construction is not applicable to the development, and the final buffer must be applied. The final buffer was calculated to 58 meters (Figure 25) for the depression wetland and Figure 26.

	Buffer Segment 1
Final aquatic impact	
Construction Phase	15
Operational Phase	58
Final aquatic impact buffer requirement	58
Rationale for any increases in final buffer requirements	

FIGURE 25: DEPRESSION WETLAND BUFFER REQUIREMENTS

	Buffer Segment 1
	Final aquatic impact b
Construction Phase	15
Operational Phase	60
Final aquatic impact buffer requirement	60
Rationale for any increases in final buffer requirements	

FIGURE 26: UNCHANNELLED VALLEY BOTTOM WETLAND BUFFER REQUIREMENTS

Using this information, the final buffer was set to 58 and 60 meters. See Figure 27 for the buffer recommendations on site.

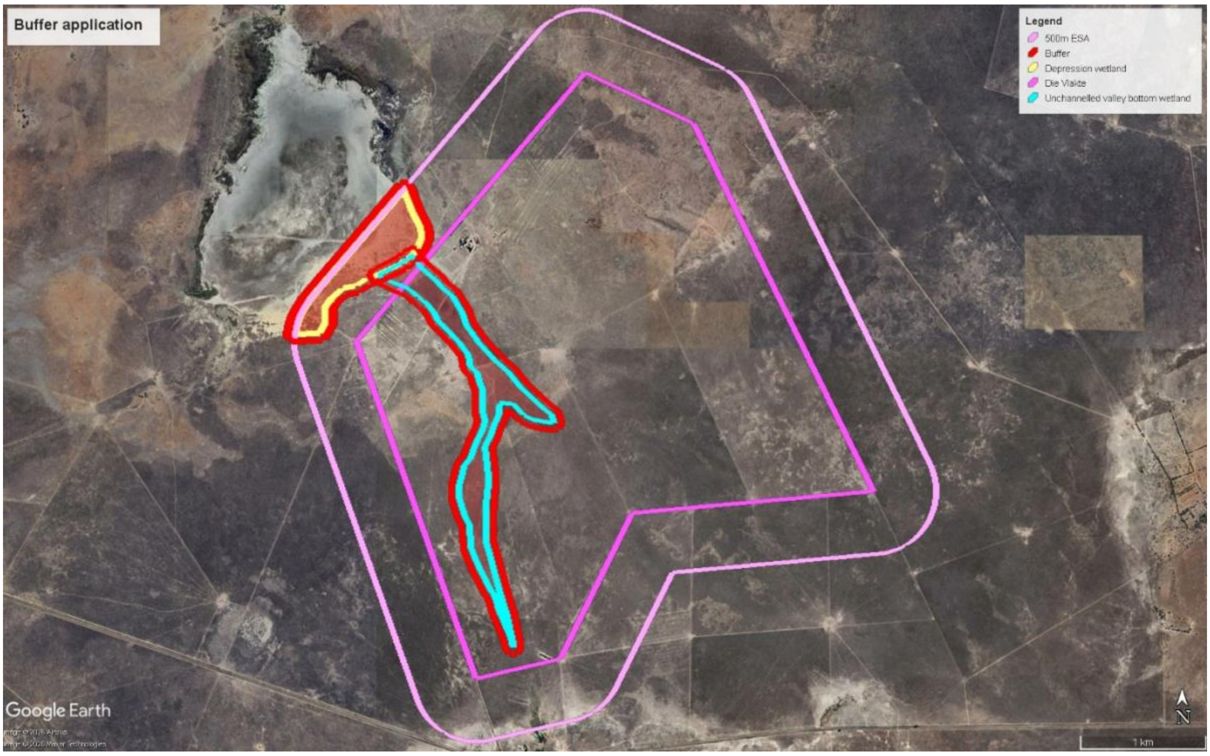


FIGURE 27: PROPOSED BUFFERS OF THE STUDY SITE

6.5. Mitigation and management hierarchy

The Mitigation Hierarchy presented in the National Framework for Biodiversity Offsets, adapted to wetlands is as follows (WRC Report no TT 658/16). Four main mitigations are proposed: Avoid or Prevent, Minimise, Rehabilitate and Offset (Figure 28).

These aspects are based on the premise of avoidance, minimisation and compensation backed by monitoring (Figure 29) to reduce the impact of the activities.

These measures will reduce the risk of disrupting catchment processes and help maintain the hydrological expression and ecological functioning of associated aquatic ecosystems. If the mitigation and impact reduction relationships are correctly applied the biodiversity impacts can be mitigated as per Figure 30.

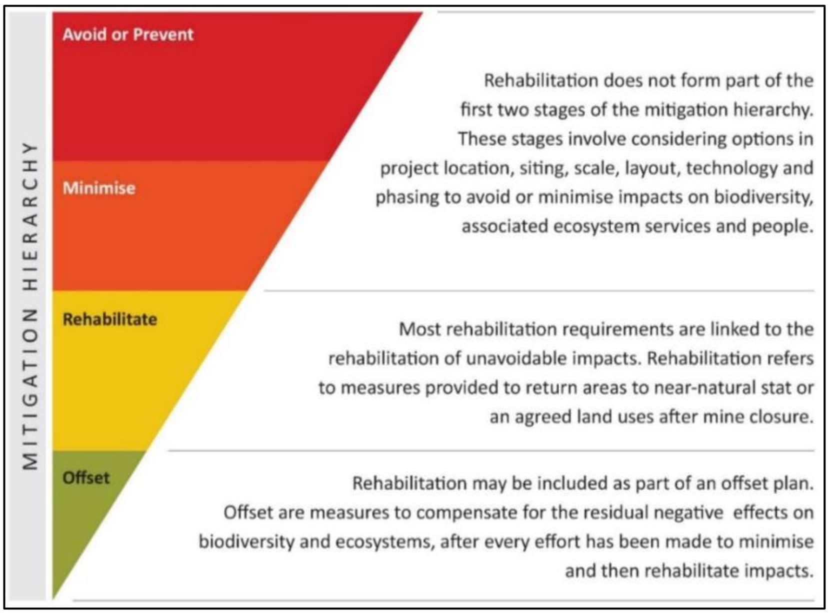


FIGURE 28: MITIGATION HIERARCHY

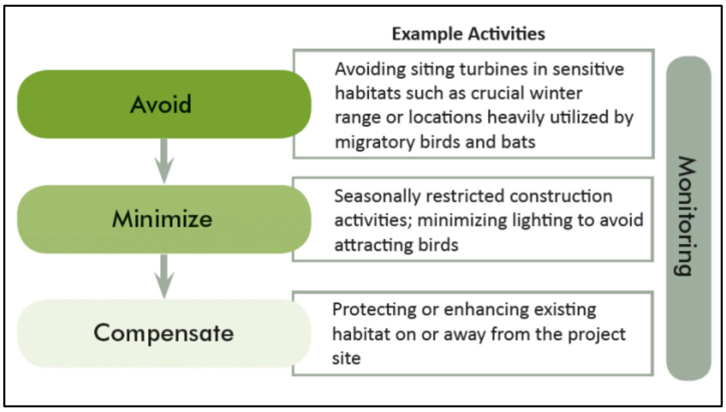


FIGURE 29: RELATIONSHIP OF IMPACT REDUCTION

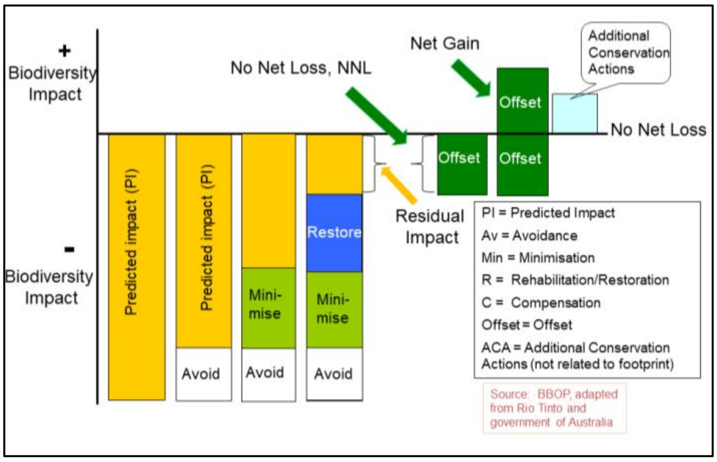


FIGURE 30: RELATIONSHIPS OF POSITIVE AND NEGATIVE BIODIVERSITY IMPACTS

See Table 35 for the summary of the various actions of mitigation hierarchy of the project.

TABLE 35: SUMMARY OF THE MITIGATION HIERARCHY OF THE PROJECT

			Mitigation
Risk assessment	See above		
Impact assessment	See above		
	Avoid or prevent	**NO GO:** The site remains in situ **Avoid:** Mitigate impacts based on expected impacts	
		Minimise	Development has several impacts on the surrounding environment and particularly on an aquatic ecosystem. The installation of services for the proposed chicken laying and rearing facilities may alter natural surface and subsurface water flow patterns within the catchment, which could in turn influence local recharge and discharge processes and affect the hydrological functioning of nearby aquatic ecosystems. To mitigate these impacts, all service infrastructure, including water supply lines, stormwater controls, sewer connections, electricity trenches, and access-related drainage features, should be carefully planned and positioned to avoid natural drainage pathways, wetland areas, seepage zones, and riparian habitats. Trenching and excavation should be limited as far as possible, and disturbed areas must be backfilled, compacted appropriately, and rehabilitated promptly to restore natural flow conditions. Clean and dirty water should be separated through an effective stormwater management system, and runoff from roofs, yards, and operational areas

		should be directed in a controlled manner to prevent concentration of flows, erosion, ponding, or unintended diversion of water. Where service crossings of aquatic ecosystems are unavoidable, they should be designed to maintain pre-development hydrological connectivity and not impede subsurface seepage or overland flow with the guidance of the author.
	Rehabilitate Offset/ compensate	Not applicable
	Go/ No Go	Go- the development footprint is very small

6.5.1. Mitigate and Minimise

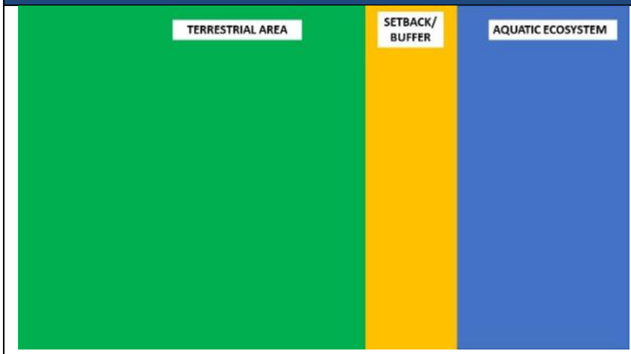
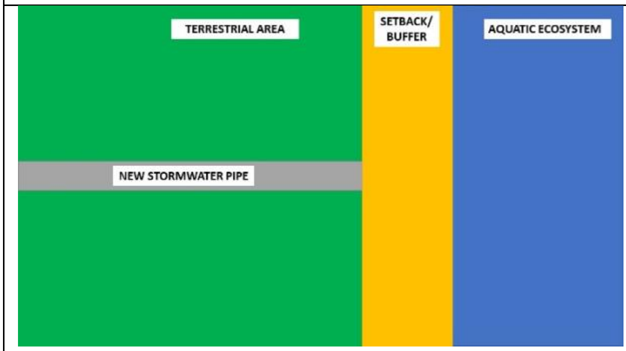
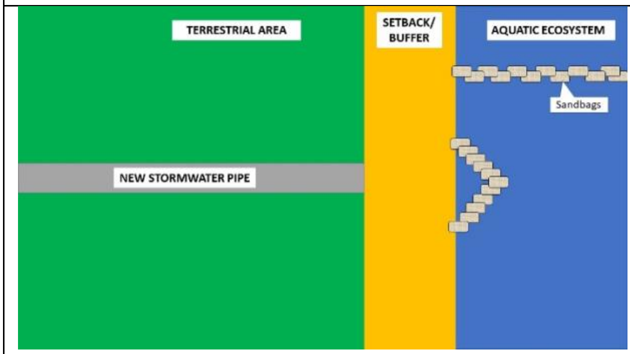
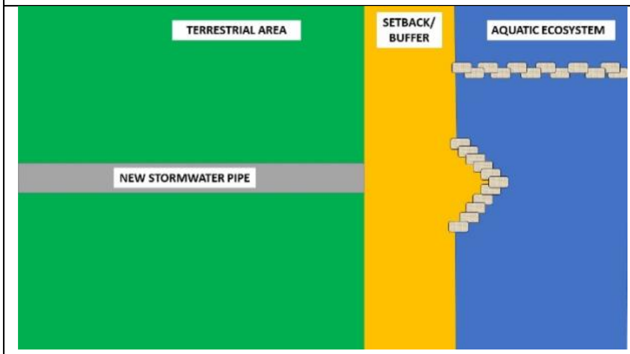
The development footprint is outside the setbacks as set in Figure 27. The main concerns requiring mitigation are:

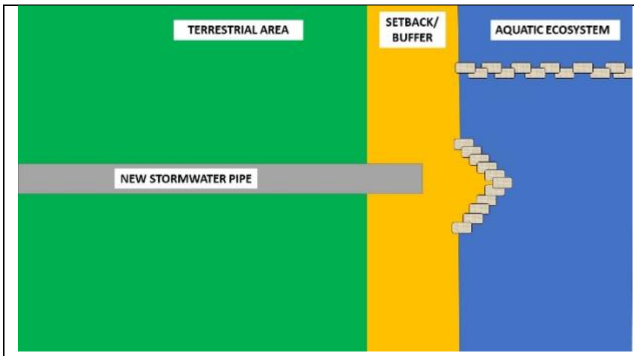
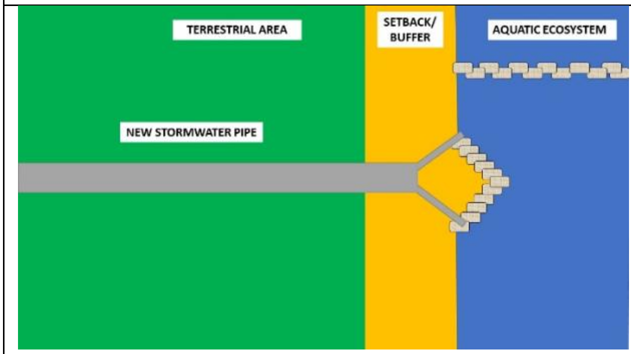
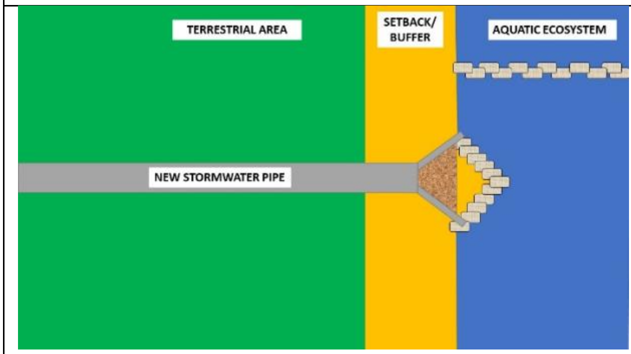
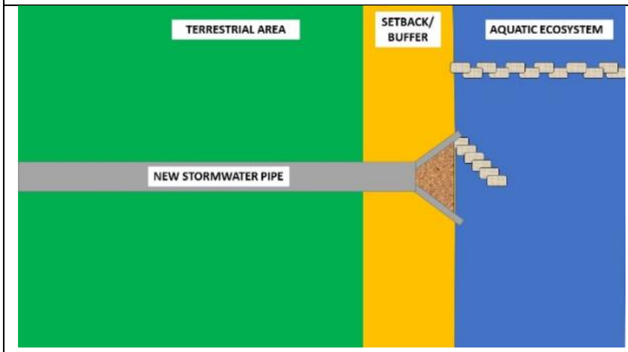
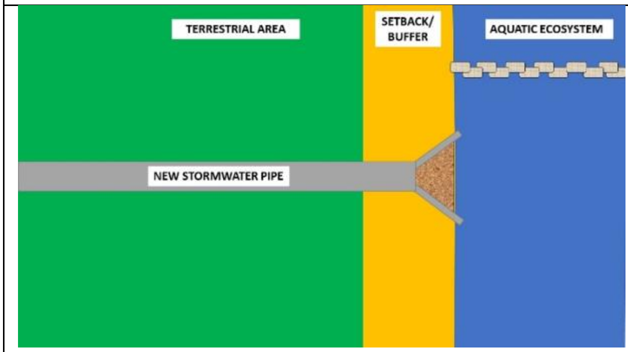
- Position all service infrastructure outside wetlands, drainage lines, seepage areas, and riparian buffers as far as possible.
- Avoid placing roads, pipelines, cables, and buildings in natural flow paths or low-lying areas where water accumulates.
- Limit excavation and trenching to the smallest footprint required for construction.
- Backfill and compact trenches properly after installation to prevent preferential flow paths and subsidence.
- Rehabilitate all disturbed areas immediately after construction to restore natural surface contours and runoff patterns.
- Install stormwater controls to prevent concentrated runoff, erosion, and sediment transport from disturbed areas.
- Separate clean and dirty water systems to prevent contamination of surrounding soils and aquatic environments.
- Ensure that culverts, crossings, and drainage structures maintain natural surface water movement and do not block or divert flows.
- Prevent ponding around farm infrastructure through proper site grading and controlled drainage design.
- Monitor surrounding wetland or drainage features during and after construction for signs of erosion, altered flow, or excessive sedimentation.Reshaping of area post services installation,
- Attenuation of stormwater,
- Inclusion of phytoremediation aspects into the Sustainable urban drainage systems (SuDS)

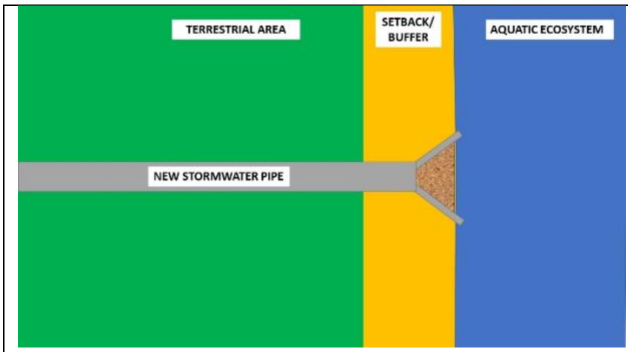
6.5.2. Storm water releases

The release of storm water into the aquatic ecosystem is part of many developments. This ensures the risk of flooding of the development is managed. The releases of storm water into aquatic ecosystems can be detrimental to the aquatic ecosystem as the increased flows will alter the drivers of the system. The mitigation of this is difficult, and attention is given to the installation. This is as the activities are within the confines of the regulated sensitive areas. To ensure the impact of the construction phase of the storm water outlet is managed the following steps are recommended in Table 36.

TABLE 36: STORM WATER RELEASE POINT CONSTRUCTION MITIGATION

Image	Description
	The aquatic ecosystem setback must be defined. Construction crews must be trained to ensure they understand how their activities can impact on the ecosystem.
	The new storm water pipe trench is dug up to the edge of the setback. Levels are checked and confirmed. Any alterations due to in situ conditions must be planned and authorised during this phase.
	Sand bags must be placed as indicated
	The area where the wing wall will be constructed must be drained of water

<table>
<tr><td>
</td><td>The excavations can start to ingress into the setback once the AECO has cleared the activity</td></tr>
<tr><td>
</td><td>Construction works of the wing walls can be competed once the AECO has cleared the activity</td></tr>
<tr><td>
</td><td>Placement of water energy dissipators can commence once the activity is cleared by the AECO</td></tr>
<tr><td>
</td><td>One section of the sandbags must be removed to facilitate sectional inundation of the area around the wing walls</td></tr>
<tr><td>
</td><td>The sandbags can be removed</td></tr>
</table>

	The AECO needs to sign off on the final construction.

6.6. Go- No go opinion

Go/No-Go Opinion: From an aquatic ecology perspective, the proposed chicken laying and rearing farm development at Die Vlakte 731 can be supported as a **go** option, but only subject to strict compliance with all recommended mitigation, buffer, stormwater, rehabilitation, and monitoring requirements. The delineation confirmed the presence of a depression wetland and an unchannelled valley bottom wetland on site, both of which retain ecological and hydrological importance and therefore require protection from direct and indirect development impacts. The proposed development footprint may be considered acceptable provided that no infrastructure, service installation, stormwater discharge, or operational disturbance is allowed within the delineated aquatic ecosystems or their required buffers, and that an Aquatic Environmental Control Officer oversees implementation during all relevant phases.

Should the recommended setbacks, mitigation hierarchy, and aquatic protection measures not be implemented and maintained, the risk to hydrological functioning and wetland integrity would increase to an unacceptable level, in which case the development should be regarded as a **no-go** for those affected areas.

6.7. Environmental laws

The following environmental laws could be applicable to the study site. These are only recommendations and to ensure compliance, a lawyer specialising in environmental law should be consulted:

- National Environmental Management Act, 1998 (Act No. 107 of 1998)
- The National Water Act, 1998 (Act No. 36 of 1998) with specific reference paid to Section 21 of the National Water Act, 1998 (Act No.36 of 1998)
- The National Water Act, 1998 (Act No. 36 of 1998) General Notice 1199 - development within 500 meters of a wetland

- The National Water Act, 1998 (Act No. 36 of 1998) General Notice 1198 - Rehabilitation of a wetland area
- Regulation No. 543 – 545, 2010 of the National Environmental Management Act, 1998 (Act No. 107 of 1998)
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003);
- National Environment Management Waste Act, 2008 (Act No. 59 of 2008);
- National Veld and Forest Fire Act, 1998 (Act No.101 of 1998);
- Mountain Catchment Act, 1970 (Act No. 63 of 1970);
- National Heritage Recourses Act, 1999 (Act No. 25 of 1999);
- World Heritage Convention Act, 1999 (Act No. 49 of 1999);
- Municipal Systems Act, 2000 (Act No. 32 of 2000);
- Integrated Coastal Management Act, 2008 (Act No. 24 of 2008);
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983);
- Land Use Planning Ordinance 15 of 1985 and the planning ordinances depending on the province in South Africa where construction will take place.

7. Conclusion and recommendations

The aquatic ecosystem delineation and assessment for Die Vlakte 731 identified two wetland systems associated with the proposed chicken laying and rearing farm development, namely a depression wetland and an unchannelled valley bottom wetland. The assessment found that both systems remain in a generally favourable ecological condition, with the depression wetland rated as PES A and the unchannelled valley bottom wetland rated as PES B, while both wetlands were assigned a Moderate Ecological Importance and Sensitivity score. These findings indicate that the aquatic ecosystems on site retain meaningful ecological and hydrological value and continue to contribute to local ecological functioning, including water movement, recharge and discharge processes, and limited sediment and nutrient regulation. The proposed development therefore has the potential to proceed, provided that it is carefully planned and implemented in a manner that avoids direct encroachment into delineated aquatic features and their associated buffers, and that all mitigation, stormwater control, rehabilitation, and monitoring measures are strictly applied. From an aquatic ecological perspective, the development may be considered acceptable only if the delineated wetland areas and recommended no-go buffer zones are maintained, service installation and associated infrastructure are located outside sensitive areas as far as possible, and the long-term hydrological and ecological functioning of the wetlands is not compromised.

A summary of findings is given in **Table 37**.

TABLE 37: SUMMARY OF FINDINGS

Aquatic ecosystem classification	Depression wetland Unchannelled valley bottom wetland
Present Ecological Score (PES)	Depression wetland= A Unchannelled valley bottom wetland= B
Ecological importance and sensitivity (EIS)	Depression wetland= Moderate Unchannelled valley bottom wetland= Moderate
Recommended Ecological Management Class (EIS/REMS)	High
Buffers (calculated) (Figure 32)	Depression wetland= 58 meter Unchannelled valley bottom wetland= 60 meters
Risk assessment GN4167	Low Risk- requires review once final engineering drawings for crossings have been completed

Sensitivity of aquatic ecosystems	High (red) (**Figure 32**)
Does the specialist support the development?	Yes- largest impact will be during construction with minimal impact during operational

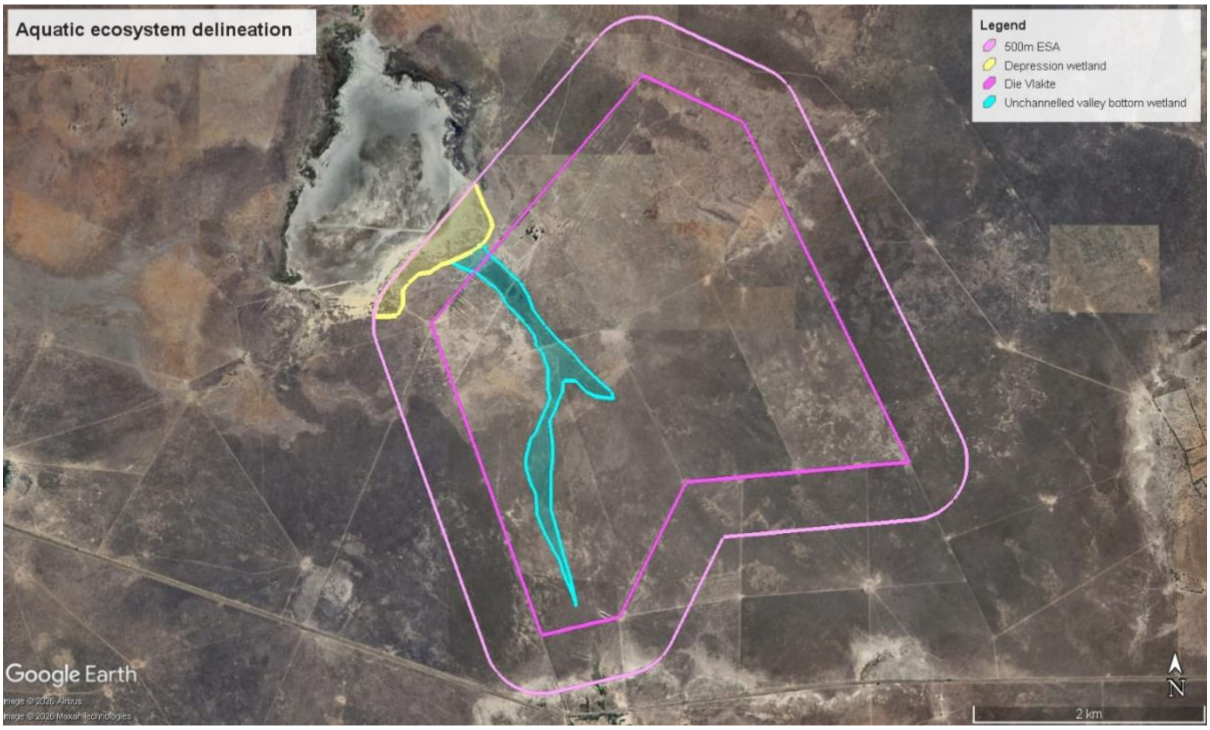


FIGURE 31: THE AQUATIC ECOSYSTEM DELINEATION MAP OF THE STUDY SITE

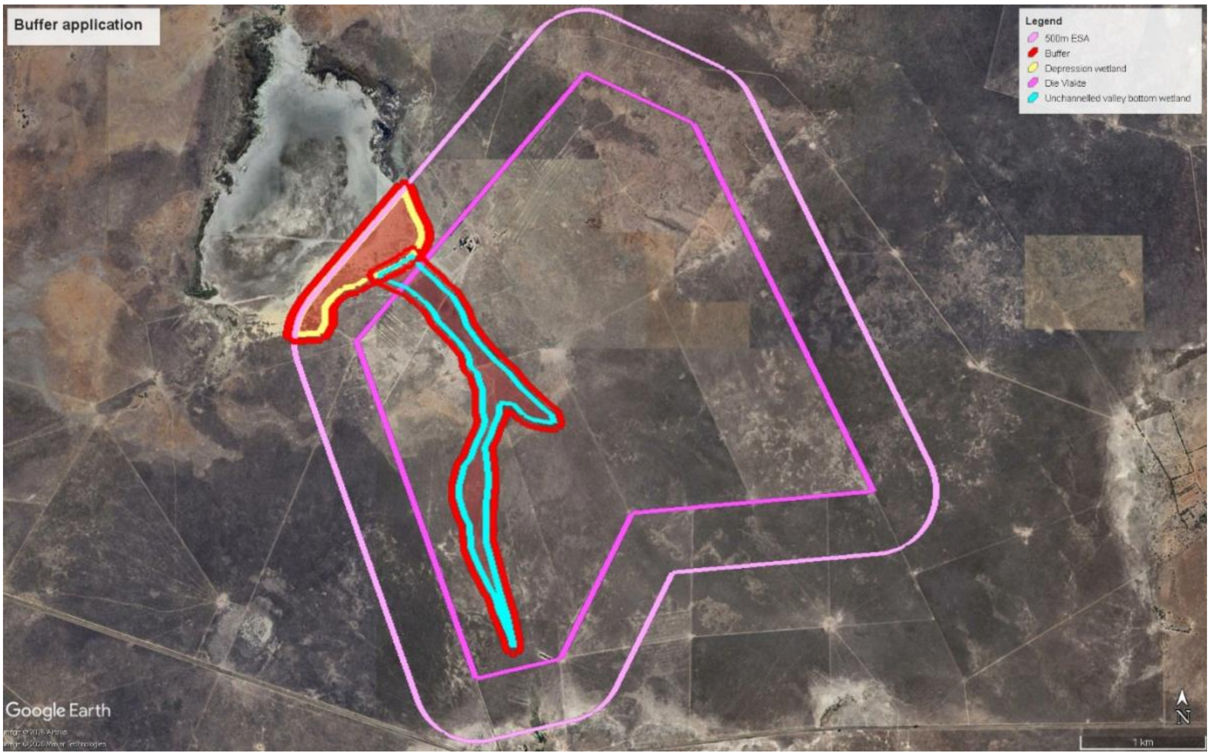


FIGURE 32: THE AQUATIC SENSITIVITY MAP OF THE STUDY SITE

7.1. General mitigation measures[2]

The following general mitigation measures are proposed[3]:

- An alien vegetation eradication programmed should be implemented on the site to remove the alien vegetation from the wetland areas.
- An environmental control officer (ECO), specialising in aquatic systems (AECO) must be appointed throughout the project to ensure the longevity of the impacted aquatic system.
- The use of cement lined channels must be avoided at all costs and lining must be done with Loffel stones (or Amourflex stones) or similar products. This is to prevent the loss of habitat to aquatic organisms living in the system.
- The ramps for the in- and out flows from the construction site must be lined with Reno mattresses and or gabions to prevent structure undermining and to ensure flow is dispersed and mitigated. Vertical steps should not exceed 200 mm, to ensure aquatic fauna movement and migration.
- The use of gabion structures, well keyed into the surrounding bank walls and secured to the ground is recommended where required.
- If any construction activity must occur within the riparian areas, then it must commence from upstream proceeding downstream with proper sedimentation barriers in place to prevent sediments and pollution moving downstream from the site. This includes non-perennial systems.
- The removal and translocation of impacted hydrophytes must be done prior to construction commencing.
- Due to the perennial nature of the system, construction should preferably commence during the dry months.
- All sensitive areas together with the associated buffer zones should be fenced during the construction phase to prevent any human activity from encroaching onto these areas.

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[2] A full list is included here albeit *not all is* applicable to the site. It is the onus of the owner of the development to ensure compliance to this list and the applicability of the recommendations.

[3] The contractor appointed for construction must be contractually bound to the requirements and mitigating measures listed in this document and any other documents relating to the construction (ecological management plan, rehabilitation plant etc.).

Monitoring of the fences is of paramount importance to ensure no infringement of the fences occurs.

- Removal of debris and other obstructing materials from the site must take place and erosion-preventing structures must be constructed. This is done to prevent damming of water and increasing flooding danger.
- Removed soil and stockpiling of soil must occur outside the extent of the watercourse to prevent siltation and increased runoff during construction. This includes the buffer zones and 1:100-year flood lines.
- Proper toilet facilities must be located outside the sensitive areas: The impact of human waste on the system is immense. Chemical toilets must be provided which should always be well serviced and spaced as per occupational health and safety laws and placed outside the buffer and 1:100-year flood lines.
- Spill kits must be stored on site: In case of accidental spills of oil, petroleum products etc., good oil absorbent materials must be on hand to allow for the quick remediation of the spill. The kits should also be well marked, and all personnel should be educated to deal with the spill. Vehicles must be kept in good working order and leaks must be fixed immediately on an oil absorbent mat. The use of a product such as Sunsorb is advised.
- No plant machinery may be stored or left near the aquatic areas, when not in use.
- Frequent inspection of the site must be done to ensure that no harmful practices occur on site.
- A photo collection must be taken from fixed demarcated spots to detect changes in the construction area over time. These photographs must be dated and should include the entire site.
- No construction personnel can collect, harvest, or kill any species of fauna and flora on the site.
- Any species of fauna encountered during the construction phase should be moved to a safe location where no harm can be bestowed on the species.
- If water is sprayed on the construction surface for any reason during the construction process, utmost care must be taken to ensure the runoff water does not pollute the system or any of the associated catchment areas. A storm water cut-off drain should be constructed between the construction area and the aquatic system to ensure that storm water flowing through the construction area cannot flow into the aquatic system. The water from the cut-off drain must be collected in a sedimentation pond before entering the aquatic system.

- Any new erosion gullies must be remediated immediately.
- Construction should commence during the dry season or when flows are at their lowest where reasonably possible.
- Regular inspection of erosion preventing devices is needed.
- Construction camps: Plant parking areas and material stockpiles must be located outside the extent of the wetland.
- Access routes should be demarcated and located properly so that no damage to the system can occur. These roads must always be adhered to. A large turning place must be provided for larger trucks and machinery. No grading of temporary access roads is allowed as this will create dust and water runoff problems.
- Increased runoff due to removal of vegetation and increased soil compaction must be managed to ensure the prevention of siltation and the maximum stream bank stability.
- The velocity of storm water must be attenuated and spread. As far as possible the link between the stream and the local environment must be maintained. This is to ensure water movement into the soils and ensuring the survival of associated vegetation.
- Storm water leaving the site downstream must be clean and of the same quality as in situ before it enters the construction site (upstream). Preconstruction measures must be in place to ensure sediments are trapped.
- The overall alluvial characteristics of the drainage line (balance between sand, gravel, and stone) must be like before construction to ensure natural systems of flooding and sedimentation deportation and conveyance occur.

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9. Appendix A: Glossary of terms:

Buffer zone- The area of land next to a body of water, where activities such as construction are restricted to protect the water.

Detritus- Decaying organic matter found in the top layer of soil or mixed with wetland waters; a food source for many small wetland organisms.

Endangered species- Any species of plant or animal that is having trouble surviving and reproducing. This is often caused by loss of habitat, not enough food, or pollution. Endangered species are protected by the government to keep them from becoming extinct.

Ecosystem- A network of plants and animals that live together and depend on each other for survival.

Emergent- Soft stemmed plants that grow above the water level.

Erosion- Process in which land is worn away by external forces, such as wind, water, or human activity.

Freshwater- Water without salt, like ponds and streams.

Gleyed soil- Mineral wetland soil that is or was always wet; this results in soil colours of grey, greenish grey, or bluish grey.

Habitat- The environment in which an organism lives.

Hydric soil- Soil that is wet long enough for anoxic (oxygen less) conditions to develop. The water in the soil forces air out. This soil type is found in wetlands.

Hydrocarbon Oils, fuels and paints made using fossil fuels (including crude oils, coal etc.)

Hydrophyte- A plant, which grows in water.

Mesotrophic soil- Soils with a moderate inherent fertility. An indicator of soil fertility is its base status, which is expressed as a ratio relating the major nutrient cations (calcium, magnesium, potassium, and sodium) found there to the soil's clay percentage.

Organic material- Anything that is living or was living; in soil it is usually made up of nuts, leaves, twigs, bark, etc.

Organism- A living thing.

Peat- Organic material (leaves, bark, nuts) that has decayed partially. It is dark brown with identifiable plant parts and can be found in peatlands and bogs.

Pollution- Waste, often made by humans, that damages the water, the air, and the soil.

Precipitation- Rain, sleet, hail, snow.

Riparian- Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

Redoximorphic conditions- a soil property, associated with wetness, which results from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively. Mottling are common redoximorphic features of soils.

Runoff- Rainwater that flows over the land and into streams and lakes; it often picks up soil particles along the way and brings them into the streams and lakes.

Salinity- The amount of salt in water.

Saturation-The condition in which soil contains as much water as it can hold.

Silt- One of three main parts of soil (sand, silt, and clay); silt is small rock particles that are between .05 mm and .002 mm in diameter.

Submerged aquatic vegetation- Plants that live entirely under water.

Topsoil- The top layer of soil; it is full of organic material and good for growing crops.

Water table- The highest level of soil that is saturated by water.

Watershed - All the water from precipitation (rain, snow, etc.) that drains into a particular body of water (stream, pond, river, bay, etc.)

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."

10. Appendix B: Acronyms

AECO	Aquatic Environmental Control Officer
ASPT	Average Score Per Taxon
CERM	Comprehensive Ecological Reserve Methodology
DSS	Decision Support System
DWA	Department of Water Affairs
DWS	Department of water and sanitation
EC	Ecological Category
ECO	Environmental control officer
EIS	Ecological Importance and Sensitivity

EWR	Environmental Water Requirements
FRAI	Fish Response Assessment Index
FROC	Fish reference of occurrence
GSM	Gravel, Sand, Mud
GDARD	Gauteng Department of Agriculture and Rural Development
IERM	Intermediate Ecological Reserve Methodology
IHAS	Invertebrate Habitat Assessment System
IHI	Index of Habitat Integrity
MIRAI	Macro-Invertebrate Response Assessment Index
MVIC	Marginal Vegetation in Current
MVOOC	Marginal Vegetation out of Current
NFEPA	National Freshwater Ecosystem Priority Areas
PES	Present Ecological State
REC	Recommended Ecological Category
REMC	Recommended Ecological Management Class
RERM	Rapid Ecological Reserve Methodology
RHP	River Health Programme
SASS5	South African Scoring System (Version 5)
SIC	Stones in current.
SOG	Soap, oil and grease
SOOC	Stones out of current
TPH	Total petroleum hydrocarbons
TWQR	Target water quality range
VEGRAI	Vegetation Response Assessment Index
Wetland IHI	Wetland index of habitat integrity tool
WMA	Water Management Area
WUL	Water use licence (approved license)
WULA	Water use licence application (license application)

11. Appendix C: CV of author (short)

Curriculum Vitae

Bertus Fourie

Personal Information

Surname:	Fourie
Full names:	Albertus Jacobus (Bertus)
Email:	bertusfourie@gmail.com
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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 specialising in Environmental Education& Freshwater management. Project title: *Ndumo Game count: A critical review of game count data 1999-2009.*
National Diploma	Nature Conservation, 2005
Matric	2001
SACNASP	Professional Natural Scientist (Reg. No: 008394) in **Ecology** and **Aquatic Sciences**

Accreditation:

SASS 5 (Dickens & Graham, 2002) Valid 2021-2024

Training:

Mine closure and land rehabilitation short course	University of Pretoria, 2020
Freshwater fish identification course	South African Institute of Aquatic Biodiversity, 2016
Wetland Rehabilitation	Centre for Environmental Management, University of Fre
Introduction to wetland soils and delineation	South African soil surveyor's organization (SASSO)
Wetland Management: Introduction and Delineation	Centre for Environmental Management, University of Fre
SASS 5 training	Nepid consultants (2011), Ground Truth (2013)
Environmental Law for Environmental Managers:	Centre for environmental studies (CEM) @ Northwest Un

Work Experience

Limnology (Pty) Ltd, 2015-present	Director/Aquatic Ecologist
Galago Environmental, 2010-2015	Aquatic Ecologist
Aquamulch, June 2007-December 2009	Rehabilitation Specialist and Implementation Manager
Ndumo Community Project, 2005 – May 2007	Environmental Education Facilitator/Project Manager

11.1. Copies of certificates (relevant to report)