Office 101A Windermere Centre, 163-177 Lilian Ngoyi Road, 4001
PO Box 37069, Overport, Durban, 4067

Tel: +27 (0)31 3032835
Fax: +27 (0)86 692 2547

WATERCOURSE DELINEATION AND HABITAT ASSESSMENT

PROPOSED SAND MINE EXPANSION ON PORTION 4 OF THE FARM ZANDBERG FONTEIN 97 SITUATED IN ROBERTSON TOWN WITHIN THE ROBERTSON DISTRICT MUNICIPALITY, WESTERN CAPE PROVINCE

10 December 2021

Prepared by:
Afzelia Environmental Consultants (PTY) Ltd.
P.O. Box 37069, Overport, DURBAN, 4067
Tel: 031 303 2835
E-mail: info@afzelia.co.za

Prepared for:
Greenmined Environmental (PTY) Ltd.
Postnet Suite 62, Private Bag x15, Somerset West, 7129
Tel: 021 851 2873
Email: christine.f@greenmined.co.za

DECLARATION (AUTHOR)

I, **Brian Mafela,** declare that -

- I act as the independent specialist in this matter;
- I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014 (as amended in 2017);
- I performed the work relating to the application in an objective manner, even if it results in views and findings that are not favourable to the applicant;
- I declare that there were no circumstances that compromised my objectivity in performing such work;
- I have expertise in conducting the specialist assessment relevant to this application, including knowledge of the National Environmental Management Act (Act 107 of 1998) (NEMA), regulations and any guidelines that have relevance to the proposed activity;
- I comply with the NEMA Act, regulations and all other applicable legislation; and
- I disclosed 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 report are true and correct.
- I am aware that a person is guilty of an offence in terms of Regulation 48 (1) of the EIA Regulations, 2014, if that person provides incorrect or misleading information. A person who is convicted of an offence in terms of sub-regulation 48(1) (a)-(e) is liable to the penalties as contemplated in section 49B (1) of the National Environmental Management Act, 1998 (Act 107 of 1998).

Specialist signature

Date: 10 December 2021

Specialist:	Brian Mafela		
Company:	Afzelia Environmental Consultants		
Qualification:	BSc. (Hons) Forest Resources and Wildlife Management		
Postal address:	P.O. Box 37069, OVERPORT, Durban		
Postal code:	4067	**Cell:**	(+27) 74 325 8961
Telephone:	(031) 303 2835	**Fax:**	086 692 2547
E-mail:	brian@afzelia.co.za		
Professional affiliation(s) (if any)	SACNASP (Ecological Science: 100214/15)		

EXECUTIVE SUMMARY

Afzelia Environmental Consultants (Pty) Ltd was appointed by Greenmined Environmental (Pty) Ltd on behalf of the Developer/Applicant, Zandberg Sandput (Pty) Ltd, to undertake a Wetland Functionality and Habitat Impact Assessment for the proposed expansion of an existing sand mine on Portion 4 of the farm Zandberg Fontein 97. The farm is situated approximately 8km southwest of the Town of Robertson within the Langeberg Local Municipality, which falls under the jurisdiction of the Robertson District Municipality, Western Cape Province.

The site can be found using the following GPS coordinates: 33°50'44.63"S 19°48'35.87"E or by clicking the following Google Maps link; https://goo.gl/maps/Hp66PaFbbqoiddZJ7. The Developer/Applicant is proposing to apply for an amendment to his existing General Authorisation to include a Phase 3 mining area to be sited along the western boundary of the Phase 2 Mining Area. The Phase 1 and 2 mining areas are registered with the Department of Water and Sanitation (DWS) and the Developer/Applicant was issued a General Authorisation with the following registration number 20005996. Review of aerial imagery and contour lines of the Phase 3 development area indicated a likelihood of a watercourse being present on site. Afzelia was therefore appointed to delineate and assess any onsite watercourses within and around the Phase 3 mining area. This assessment was commissioned to delineate and assess any watercourse occurring within and around Site Alternative 3.

Following completion of the desktop delineation exercise the specialist undertook a ground truthing exercise on the 27th November and confirmed the absence of a watercourse (i.e. wetland or river habitat) within Site Alternative 3. Development of a sand mine within Site Alternative 3 will therefore not result in the transformation of any watercourse.

Furthermore, infield and desktop watercourse delineation confirmed the presence of two wetland habitats within the 500m DWS regulated area. These were an artificial wetland habitat and an unchannelled valley bottom wetland. The artificial wetland habitat (Unit AW1) was evaluated as being at a high risk of being impacted by the proposed development whilst the unchannelled valley bottom wetland (Unit UCVB1) was at a low risk. Nevertheless, both wetlands were assessed. Also recorded within the study area was an artificial off-stream dam (Unit AD1). The dam was being used as a source of water.

Results of present ecological state (PES), ecological importance and sensitivity (EIS) and ecosystem services assessments for both wetland habitats are summarised in Table A.

Table A: Summarised PES, EIS and EcoServices assessment results.

HGM Unit	PES Results	EIS Results	EcoServices Results
AW1	The PES of Wetland Unit AW1 was not assessed because it is artificial in nature and therefore lacks a baseline from which to draw any comparison.	Low EIS	The wetland was found to be ideal for the provision of (i) cultivated foods and (ii) water for human consumption only.
UCVB1	The wetland was found to be largely natural (Class B) which means a slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	Moderate EIS	The wetland was found to be ideal for the provision of (i) streamflow regulation, (ii) biodiversity maintenance, (iii) water for human consumption and (iv) tourism and recreation services.

Anticipated adverse impacts linked with the operation of the sand mine are expected to be of medium impact significance (Table B on the next page). Direct disturbance of the wetland habitat, water pollution and proliferation of invasive alien plant were identified as major environmental risks. Implementation of recommended standard best practice mitigation measures

(listed in Section 4.3 of this report) will lower the impact significance ratings. All impacts will be reduced to either a negligible or low impact significance. All operational activities will need to be set back by 15m from all delineated watercourses in order to reduce the impact of the development on watercourses.

Table B: Summarised impact significance assessment results.

Impact	Operational Phase	
	Poor / No Mitigation	Good Mitigation
a) Transformation of watercourse habitat	N/A	N/A
b) Direct disturbance of watercourse habitat	27 Medium	8 Negligible
c) Increased sediment input in watercourses	15 Low	12 Low
d) Increased flood peaks in watercourses	N/A	N/A
e) Increased pollutants input in watercourses	33 Medium	10 Low
f) Weeds and invasive alien plant proliferation in watercourses	34 Medium	12 Low

From a watercourse point of view, all three (3) site alternatives pose similar threats to delineated wetland habitats. This is because all three sites are situated almost equidistant to the closet wetland habitat (Unit AW1) and will require similar means of mining the sand. The impact significance assessment undertaken for Site Alternative 3 (See Table B for summarised results and Section 8.2 for detailed results) applies for Site Alternatives 1 and 2.

In terms of the Department of Water and Sanitation (DWS) Risk Assessment and in accordance with the definitions contained in the National Water Act, No. 36 of 1998 (NWA), the operation of the Zandberg sand mine was assessed as a Low Risk activity in terms of adversely impacting onsite wetlands. The excavation, stockpiling and loading of sand onto trucks was identified as a major threat that requires mitigation. The low risk rating qualifies the development for authorisation under the provisions of the General Authorisation (GA). Special conditions listed below are recommended and must be included in the GA to be issued by DWS.

a) The water user must ensure that the slope of the sand dune following completion of sand mining:
    i. is structurally stable;
    ii. does not induce sedimentation or erosion.
b) Prior to the carrying out of any works, the water user must ensure that all persons entering the construction site, including contractors and casual labourers, are made fully aware of the conditions and related management measures specified in the GA, Environmental Authorisation (EA) and the Environmental Management Programme (EMPr).
c) The water user must ensure that a 15m buffer is maintained around Wetland Unit AW1.
d) The water user must ensure that any construction camp, storage, washing and maintenance of equipment, storage of construction materials, or chemicals, as well as any sanitation and waste management facilities:
    i. are located outside the 1 in 100-year flood line or 30m from any delineated wetland habitat; and
    ii. are removed within 30 days after the completion of any works.
e) The water user must ensure that adequate erosion control measures (bund, berms, sand bags etc.) are installed on all areas susceptible to erosion or runoff.
f) During the construction phase of the project, the water user must appoint an Environmental Control Officer to undertake monthly site visits. The environmental audit report must discuss non-compliances of the GA, EA and the approved EMPr.
g) During the construction phase of the project, the appointed Environmental Control Officer must take monthly fixed-point photographs.
h) All environmental audit reports must be made available to the responsible authority upon written request.

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INDEMNITY

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1. INTRODUCTION

1.1 Project Background & Locality

Afzelia Environmental Consultants (Pty) Ltd was appointed by Greenmined Environmental (Pty) Ltd on behalf of the Developer/Applicant, Zandberg Sandput (Pty) Ltd, to undertake a Watercourse Delineation and Habitat Assessment for the proposed expansion of an existing sand mine on Portion 4 of the farm Zandberg Fontein 97. The farm is situated approximately 8km southwest of the Town of Robertson within the Langeberg Local Municipality, which falls under the jurisdiction of the Robertson District Municipality, Western Cape Province. A locality map of the study area is provided as Figure 1.1.

The site can be found using the following GPS coordinates: 33°50'44.63"S 19°48'35.87"E or by clicking the following Google Maps link; https://goo.gl/maps/Hp66PaFbbqoiddZJ7.

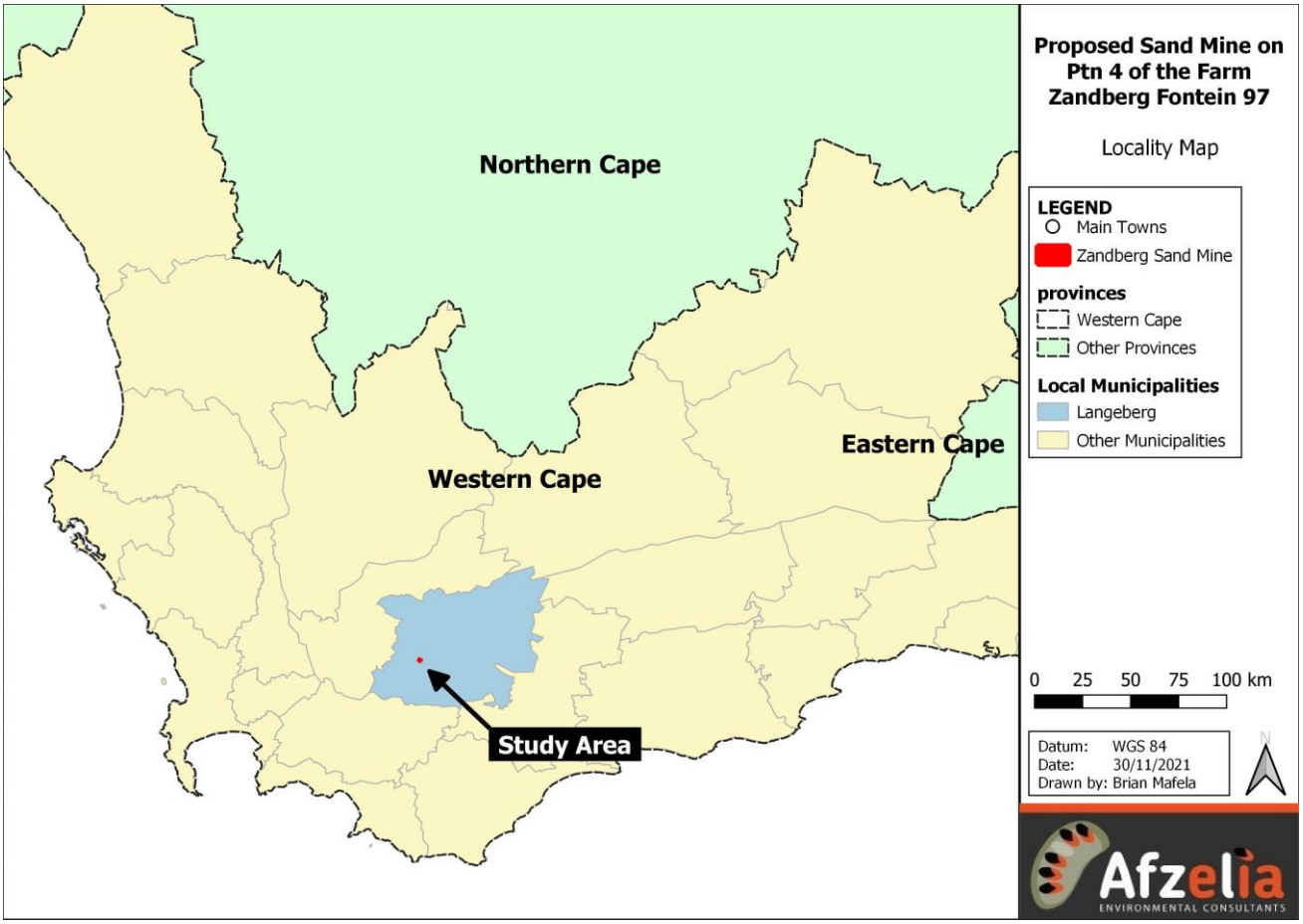

Figure 1.1: Locality of the study area within the Langeberg Local Municipality, Western Cape Province.

1.2 Project Description & Site Alternatives

The Developer/Applicant is proposing to apply for an amendment to his existing General Authorisation to include a Phase 3 mining area to be sited along the western boundary of the Phase 2 Mining Area. The Phase 1 and 2 mining areas are registered with the Department of Water and Sanitation (DWS) and the Developer/Applicant was issued a General Authorisation with the following registration number 20005996. Review of aerial imagery and contour lines of the Phase 3

development area indicated a likelihood of a watercourse being present on site. Afzelia was therefore appointed to delineate and assess any onsite watercourses within and around the Phase 3 mining area.

Three (3) alternative sites were put forward for consideration and Site Alternative 3 was chosen by the Developer/Applicant as the preferred site. An aerial map of the development area is provided in Figure 1.2. According to the botanical study undertaken by Nkurenkuru Ecology and Biodiversity (Pty) Ltd (2021), the entire farm, Portion 4 of the farm Zandberg Fontein 97, is characterised by the Breede Sand Fynbos vegetation type of pristine condition. Furthermore, Site Alternatives 1 and 2 were confirmed to contain numerous species of conservation concern. For this reason, Site Alternative 3 was treated as the main focus of this assessment whilst Site Alternatives 1 and 2 were only investigated briefly as they were unlikely to be pursued further. Details of the three (3) site alternatives are provided in Table 1.1 below.

Table 1.1: Details of Site Alternatives 1, 2 and 3.

Site Alternatives	Preference	Size	Centroid GPS Coordinates	Comments
Site Alternative 1	Not Preferred	3.99 Ha	33°50'52.86"S 19°48'35.88"E	Does not have adequate sand.
Site Alternative 2	Not Preferred	4.00 Ha	33°50'37.71"S 19°48'34.33"E	Site alternative 2 is of high conservation value because it contains threatened plant species.
Site Alternative 3	Preferred	4.00 Ha	33°50'44.83"S 19°48'35.71"E	Preferred.

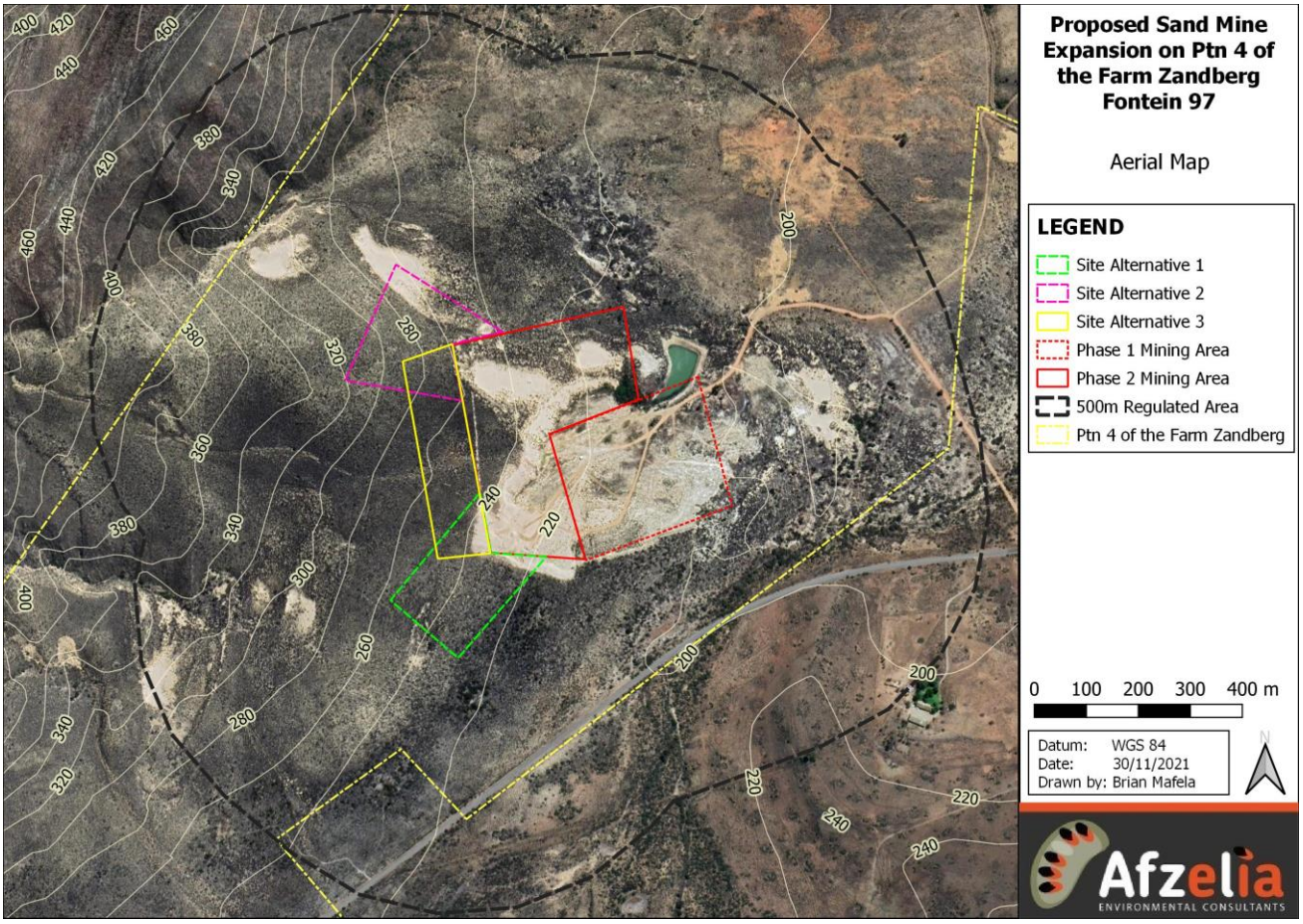

Figure 1.2: Aerial map of the study area and the three (3) site alternatives.

1.3 Terms of Reference

The Watercourse Delineation and Habitat Assessment was undertaken as per the following terms of reference:

i. Undertake a desktop review of the site's biophysical attributes using available literature and GIS information.
ii. Review conservation planning tools such as NFEPA datasets, Conservation Plans and provide a discussion on how they impact the project.
iii. Undertake infield delineation of wetlands and riparian habitats within the study area using techniques detailed in the delineated guideline: A practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1 (DWAF, 2005).
iv. Undertake an assessment of the present ecological state (PES) of wetlands using a WET-Health Level 1 Assessment (Macfarlane et al, 2008).
v. Undertake an assessment of the functions and ecosystem services provided by wetlands using the WET-EcoServices Level 2 Assessment (Version 2) (Kotze *et al*. 2020).
vi. Undertake an assessment of the ecological importance and sensitivity (EIS) of wetlands using the EIS Assessment tool (Rountree & Kotze, 2013).
vii. Identify potential operational phase impacts and mitigation measures.
viii. Undertake an impact significance assessment.
ix. Undertake a Department of Water and Sanitation (DWS) Risk Assessment in order to determine the risk level of the proposed development and whether the proposed development requires General Authorisation (GA) or a Water Use Licence (WUL).

2. METHODOLOGY

2.1 Desktop Review

The specialist undertook a desktop review of the site and associated watercourses (wetlands, streams and rivers) prior to undertaking fieldwork. This entailed reviewing available literature and GIS data on water resource conservation, reviewing site details and undertaking desktop mapping of all watercourses within and around the study area. All desktop mapped watercourses were revised following fieldwork on site. The following information was used in undertaking a desktop assessment:

i. The latest Google Earth imagery was used to identify likely wetland and riparian vegetation and delineate the approximate wetland and riparian boundary at a desktop level.
ii. The NFEPA GIS dataset and the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was used to identify the prioritised catchment, rivers and wetlands.
iii. The Threatened Ecosystem GIS dataset was used to identify conservation important vegetation types.
iv. South African Geological GIS dataset was used to identify the underlying geology at the site.

2.2 Wetland Assessments

For the purpose of this assessment, wetlands are considered as those ecosystems defined by the National Water Act 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."*

Below is a list of assessments undertaken as well as assessment tools, methodologies and protocols that were used to assess wetland habitats:

i. **Wetland Delineation:** A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1' (DWAF, 2005a). Additional information is provided in Appendix 8.1.1.
ii. **Wetland Classification:** Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.* 2013). Additional information is provided in Appendix 8.1.2.
iii. **Present Ecological State (PES):** WET-Health Level 1 Assessment tool (Macfarlane *et al.* 2008). Additional information is provided in Appendix 8.1.3.
iv. **Wetland Functional Assessment:** WET-EcoServices Level 2 Assessment tool (Version 2) (Kotze *et al.* 2020). Additional information is provided in Appendix 8.1.4.
v. **Ecological Importance and Sensitivity (EIS):** DWAF EIS tool (Rountree & Kotze, 2013). Additional information is provided in Appendix 8.1.5.
vi. **Buffer Zone Determination:** Buffer Zone Guideline for Wetlands, Rivers and Estuaries tool (Macfarlane *et al*. 2014).

2.3 Impact Significance Assessment

The significance (quantification) of potential environmental impacts identified during the assessment have been assessed as per the "Guideline Documentation on EIA Regulation" (Department of Environmental Affairs and Tourism, 2014). To determine the significance of impacts identified for a project, there are several parameters that need to be assessed. These include four factors, which, when plugged into a formula, will give a significance score. The four parameters are described as follows:

i. **Duration**, which is the relationship of the impact to temporal scale. This parameter determines the timespan of the impact and can range from very short term (less than a year) to permanent.
ii. **Extent**, which is the relationship of the impact to spatial scales. Each impact can be defined as occurring in minor extent (limited to the footprint of very small projects) to International, where an impact has global repercussions (an example could be the destruction of habitat for an IUCN Critically Endangered listed species).
iii. **Magnitude**, which is used to rate the severity of impacts. This is done with and without mitigation, so that the residual impact (with mitigation) can be rated. The Magnitude, although usually rated as negative, can also be positive.
iv. **Probability**; which is the likelihood of impacts taking place. These include unlikely impacts (such as the rate of roadkill of frogs, for example) or definite (such as the loss of vegetation within the direct construction footprint of a development).

Each of the abovementioned aspects are rated according to Table 2.1 below.

Table 2.1: Table of evaluation criteria ranking.

	Score	Label	Criteria
Duration	1	Very short term	0 -1 years
	2	Short term	2 – 5 years
	3	Medium term	5 – 15 years
	4	Long term	>15 years
	5	Permanent	Permanent
Extent	1	Minor	Limited to the immediate site of the development
	2	Local	Within the general area of the town, or study area, or a defined Area of Impact
	3	Regional	Affecting the region, municipality, or province
	4	National	Country level
	5	International	International level
Magnitude	0	Negligible	Very small to no effect on the environment
	2	Minor	Slight impact on the environment
	4	Low	Small impact on the environment
	6	Moderate	A moderate impact on the environment
	8	High	The impacts on the environment are large
	10	Very high	The impacts are extremely high and could constitute a fatal flaw
Probability	1	Very improbable	Probably will not happen
	2	Improbable	Some possibility, but low likelihood
	3	Probable	Distinct possibility
	4	Highly probable	Most likely
	5	Definite	The impact will occur

Once each of these aspects is rated, the overall significance can be scored (based on the score for effect). The significance is calculated as per the following formula:

Significance Points = (Magnitude + Duration + Extent) x Probability

The results of the assessment are then interpreted using the below rating system which categorises the scores into 5 categories ranging from low to high impact significance. A description of each category is provided in Table 2.2. with the

layout of all possible scores and their overall significance presented in Table 2.3.

Table 2.2: Significance weighting.

Score	Label	Motivation
<10	Negligible	The impact is very small to absent
10-19	Low	where this impact would not have a direct influence on the decision to develop in the area
20-49	Medium	where the impact could influence the decision to develop in the area unless it is effectively mitigated
50 -69	High	where the impact must have an influence on the decision process to develop in the area
≥70	Very high	Where the impact may constitute a fatal flaw for the project

Table 2.3: Possible significance scores based on Effect and Likelihood ratings.

Likelihood	Effect																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Very improbable (1)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Improbable (2)	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Probable (3)	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
Highly probable (4)	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
Definite (5)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

Each impact was assessed based on the methodology above, and a table produced, indicating the scores and the overall significance rating both without and with mitigation. Where relevant, mitigation measures are recommended.

2.4 Assumptions and limitations

The following assumptions and limitation are applicable to this study:

i. Desktop wetland delineation was undertaken using 20m contours, latest aerial imagery and the latest Google Earth Imagery. Any wetland vegetation changes may have influenced the accuracy of the delineation.
ii. The slope gradient was calculated using 20m contour lines which might not be very accurate.
iii. The handheld GPS device used has an accuracy of 3m.
iv. All literature and datasets used were accurate at the time of compiling this report.
v. Vegetation descriptions provided for wetland units are not comprehensive but serve to provide a general description of the wetland habitat.

3. RESULTS AND DISCUSSION

3.1 Results of Desktop Investigations

3.1.1 Biophysical Attributes

The biophysical attributes of the study area are summarised in Table 3.1 below.

Table 3.1: Summary of the biophysical attributes of the study area.

Elevation	230 – 290m a.m.s.l.
Ecoregion (DWA, 2007)	19.06 (Southern Folded Mountains) Low mountains, high mountains and slightly undulating plains.
MAP (Schulze, 1997)	426.4 mm (winter rainfall seasonality)
MAT (DWA, 2007)	16 – 18 °C
Rainfall intensity	36.6 (Zone 1)
PET (Schulze, 1997)	2082.2 mm
Median Annual Simulated Run-off (Schulze, 1997)	76.6 mm
Geology (Department of Agriculture Land Types Database)	Cape Supergroup rocks overlain by much younger Tertiary to Quaternary aeolian sands and sand dunes. The sands were probably derived from the weathering of the Cape Supergroup sandstones.
Soil	Sand
Soil Erodibility Score (K-factor) (Schulze, 2007)	0.46 – 0.48 (moderate erodibility)

3.1.2 Quaternary Catchment and Drainage Setting

The study area falls within the DWS quaternary catchment H40J which forms part of the Breede-Gouritz Water Management Area (WMA). The catchment is drained by the perennial Bree River and its two main right-bank tributaries, the Willem Nels River and the Hoops River. It is worth noting that the study area is over 1km away from any of the mentioned rivers. The river network within the quaternary catchment is shown in Figure 3.1.

Overland flows within the study area are limited owing to the study area being characterised by deep sand. Normally, rainfall seeps into the ground and then moves through the landscape as interflow. The drainage network within the 500m regulated area is provided in Figure 3.2.

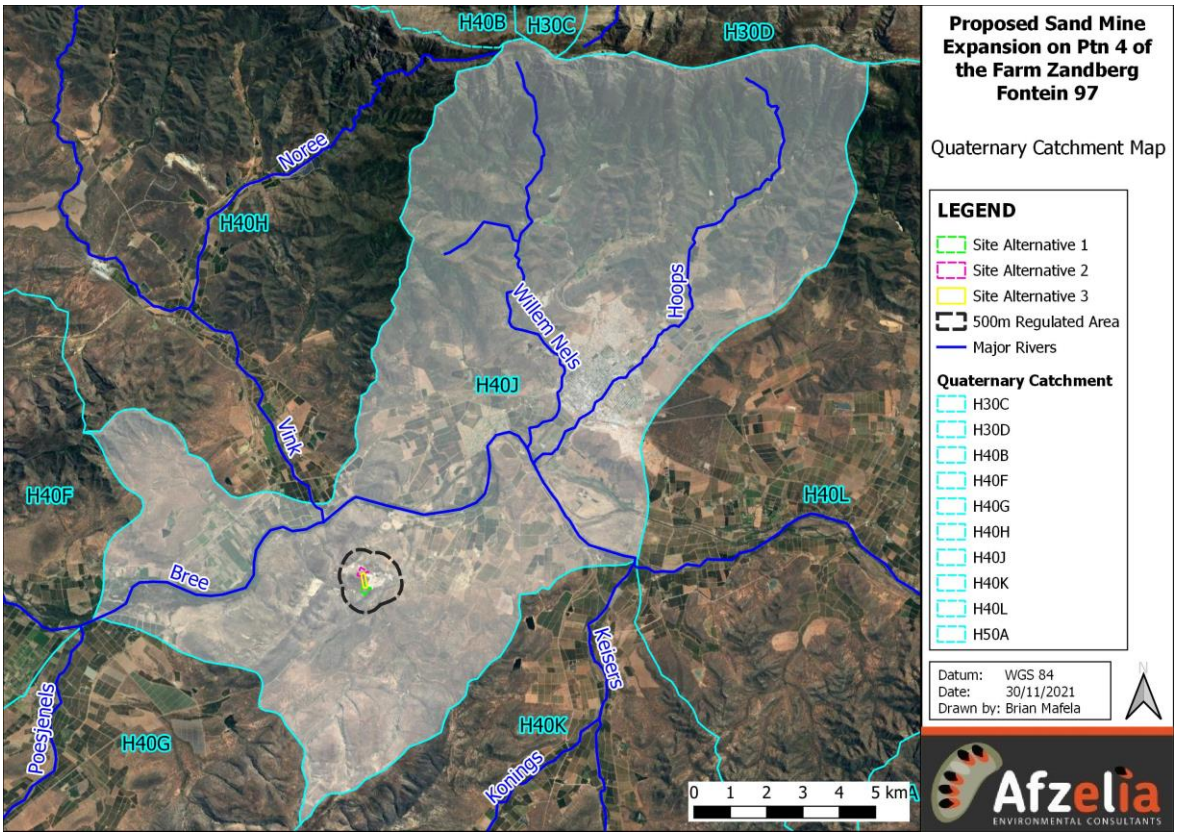

Figure 3.1: Quaternary catchment of the study area.

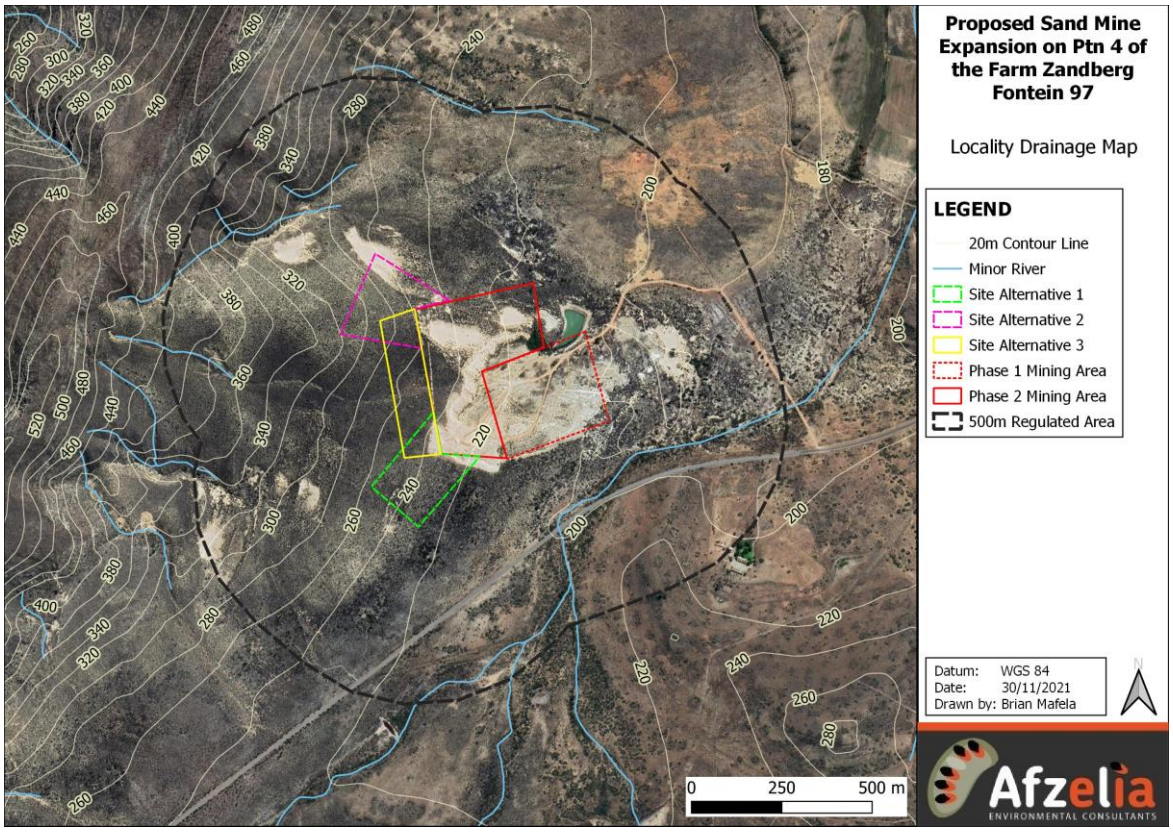

Figure 3.2: Drainage setting of the study area.

3.2 National and Provincial Conservation Guidelines

Summarised results from the interrogation of national and provincial conservation guidelines are provided in Table 3.2 below.

Table 3.2: Summarised results of national and provincial conservation guidelines.

Conservation Guideline	Results / Findings	Implication on the Project
National Freshwater Ecosystem Priority Areas (NFEPA)	The proposed development occurs within sub-quaternary catchment No. 9043 identified as a Rehab FEPA which means the catchment is highly suitable for the re-introduction of threatened fish species that once occurred there (Nel *et al*, 2011) (Figure 3.3). No prioritised wetlands (Wetland FEPAs) were identified within the 500m regulated area (Figure 3.3).	This project is unlikely to compromise the conservation of downstream aquatic resources and associated conservation-important biota.
Threatened Ecosystems: Vegetation Types	The study area was characterised by three terrestrial vegetation types. These are the Breede Sand Fynbos considered of **Vulnerable** nationally, Robertson Karoo considered of **Least Concern** nationally, and the North Sonderend Sandstone Fynbos considered of **Least Concern** nationally (Skowno et al. 2018). A map is provided in Figure 3.4. No aquatic vegetation type was modelled to occur within the 500m regulated area of the development.	No recognised aquatic vegetation community stands to be impacted by the proposed development.
Western Cape Biodiversity Spatial Plan (WCBSP)	The footprint of the all site alternatives was identified as a Critical Biodiversity Area 1 (Figure 3.5). CBAs are areas that are required to meet biodiversity targets for species, ecosystems or ecological processes and infrastructure.	Implementation of this project has a potential to compromise biodiversity conservation targets for species, ecosystems or ecological processes and infrastructure. It is of paramount importance to mitigate all anticipated impacts.

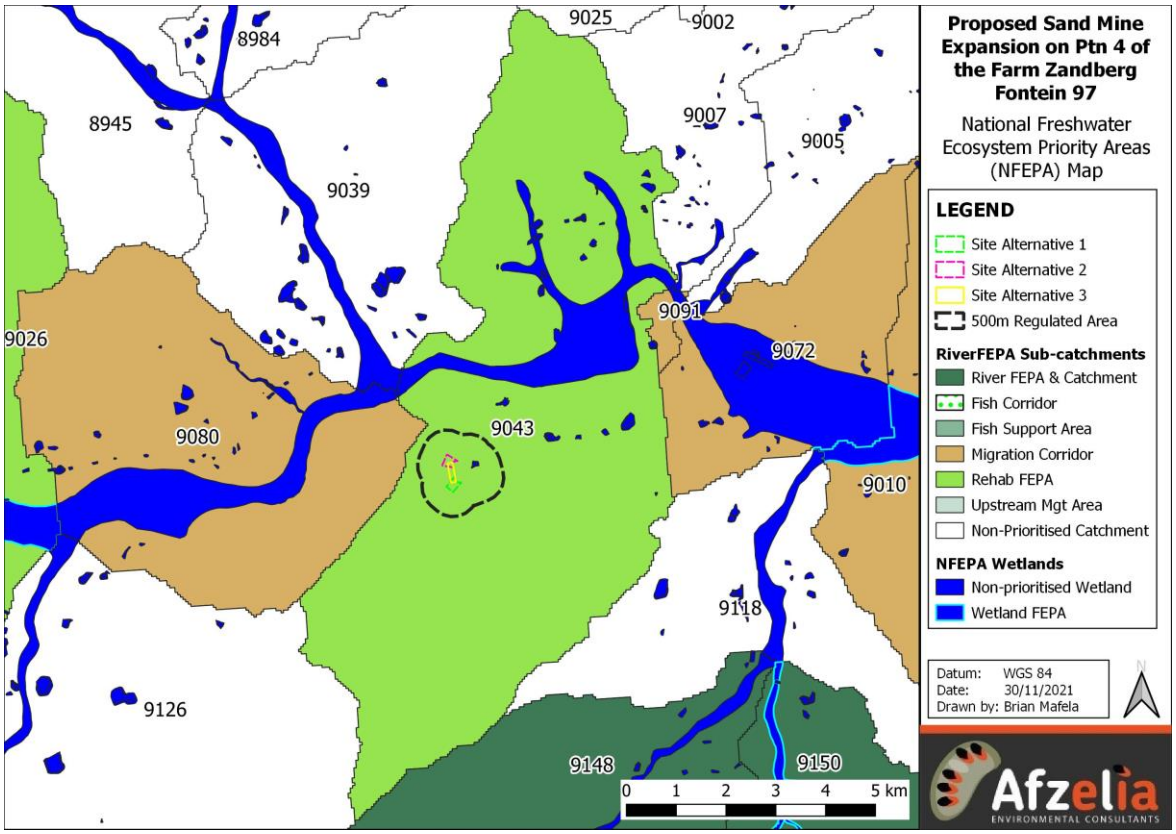

Figure 3.3: Freshwater Ecosystem Priority Area map.

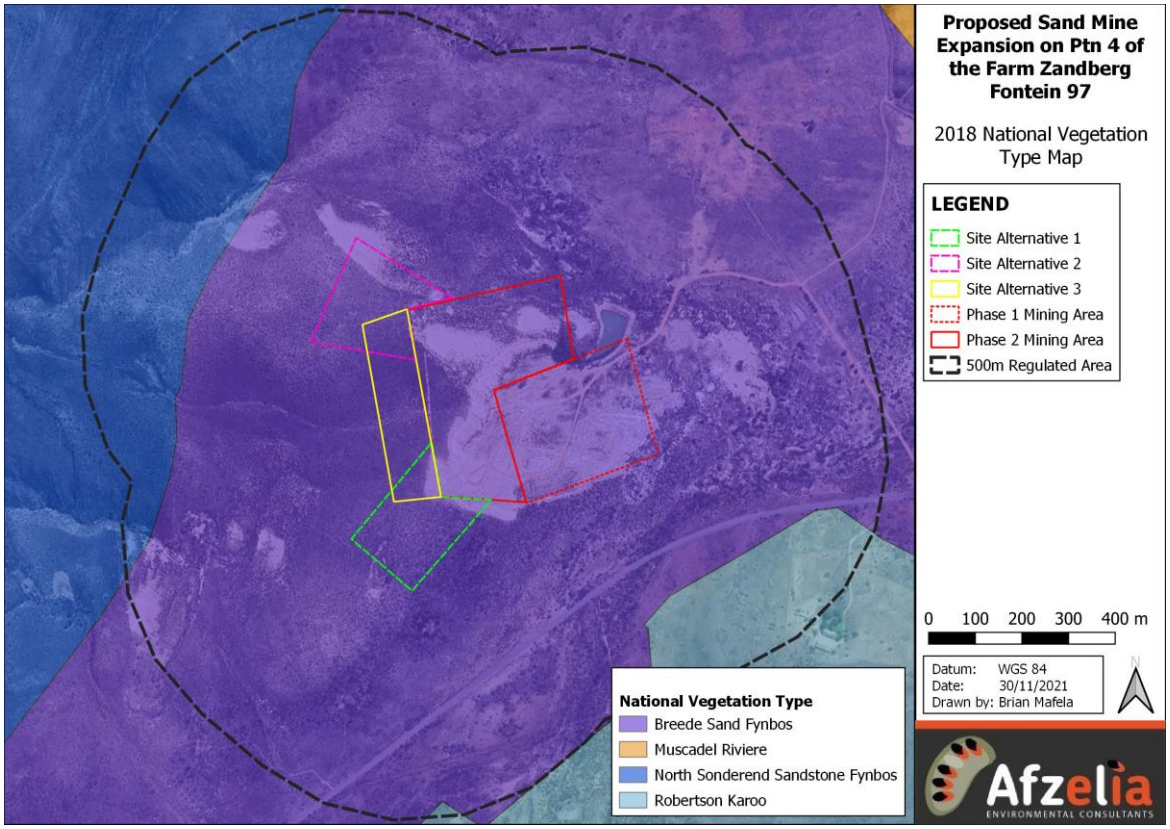

Figure 3.4: Provincial vegetation type map for the study area.

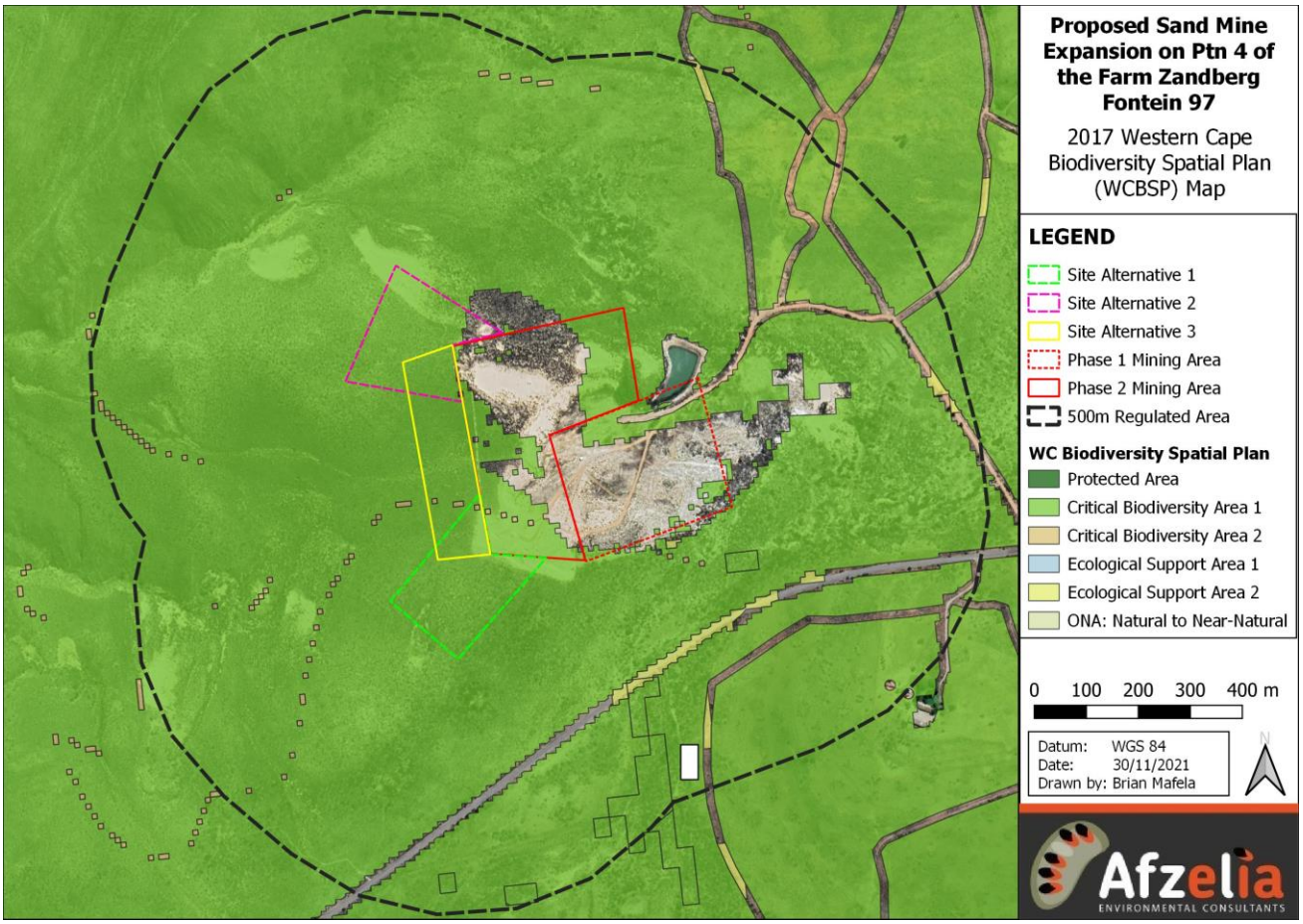

Figure 3.5: Eastern Cape Biodiversity Conservation Plan for the study area.

3.3 Wetland Habitat Delineation

Following completion of the desktop delineation exercise the specialist undertook a ground truthing exercise on the 27th of November 2021. This entailed infield watercourse delineation using soil and vegetation sampling techniques as well as recording of diagnostic topographic features such as breaks in slope, river banks, bedrock outcrops, etc. Numerous soil samples and topographic features were recorded using a handheld GPS device and used to delineate watercourses and develop a map of onsite watercourses. Delineated watercourses were then sub-divided and classified into hydrogeomorphic (HGM) units as per Ollis *et al*. (2013).

Infield and desktop watercourse delineation confirmed the presence of two wetland habitats within the 500m DWS regulated area (Figure 3.6). These were an artificial wetland habitat and an unchannelled valley bottom wetland (Unit UCVB1). The artificial wetland habitat (Unit AW1) was evaluated as being at a high risk of being impacted by the proposed development whilst the unchannelled valley bottom wetland (Unit UCVB1) was at a low risk. Nevertheless, both wetlands were assessed. Also recorded within the study area was an artificial off-stream dam (Unit AD1). The dam was being used as a source of water.

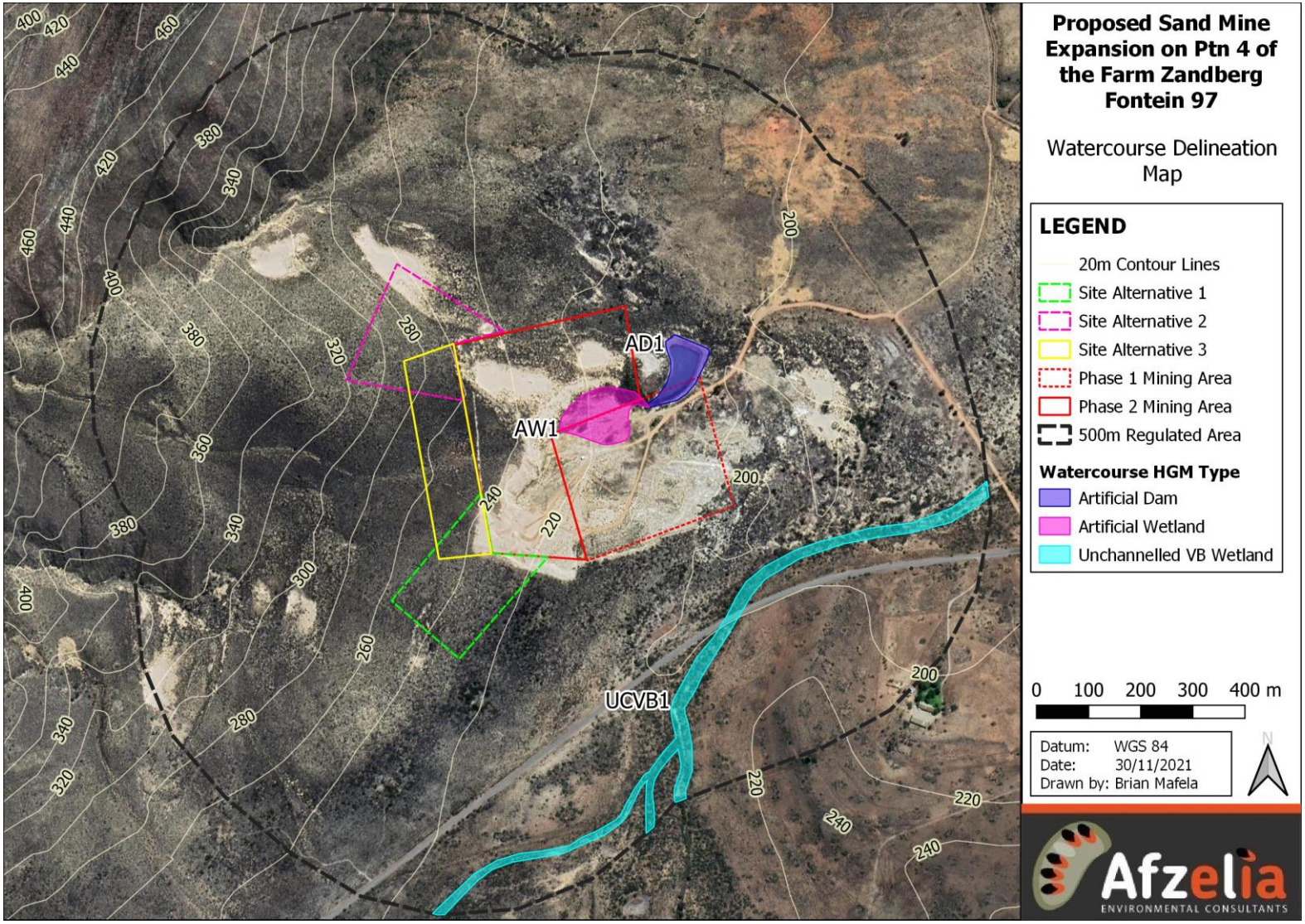

Figure 3.6: Watercourse delineation and classification map.

3.4 Watercourse Delineation within Site Alternative 3

During a site visits on the 27th of November 2021, the specialist walked several transects within and around Site Alternative 3 and sampled both the soil and vegetation community at several strategic points within the landscape. Infield sampling was done in accordance with methods contained in the DWAF (2005) delineation manual "*A practical field procedure for the identification and delineation of wetlands and riparian areas.*" The following three (3) specific indicators were used to determine the presence of a wetland (i) the terrain indicator, (ii) soil wetness indicator and (iii) vegetation indicator whilst the following four (4) specific indicators were used to determine the presence of a riparian zone (i) landscape position, (ii) alluvial soils and recent deposited material, (iii) topography associated with riparian areas, and (iv) vegetation associated with riparian areas.

Infield soil sampling was done along transects placed across low lying areas. All soil sampled extracted using a Dutch auger exhibited no sign of redoximorphic features which result from prolonged anaerobic conditions. A map that shows the location of the soil sampling points has been included as Figure 3.7. The two important redoximorphic features that the specialist was looking out for are mottling, which is the development of distinct iron or manganese depositions, and gleying, which is the development of grey colours in the soil from the leaching of iron oxide. The lack of redoximorphic features confirmed that the soil is never saturated throughout the year. Instead all soil samples extracted from the landscape exhibited a dark, organic-rich topsoil layer above a uniform golden-brown colour which is typical of aerobic conditions of terrestrial soils.

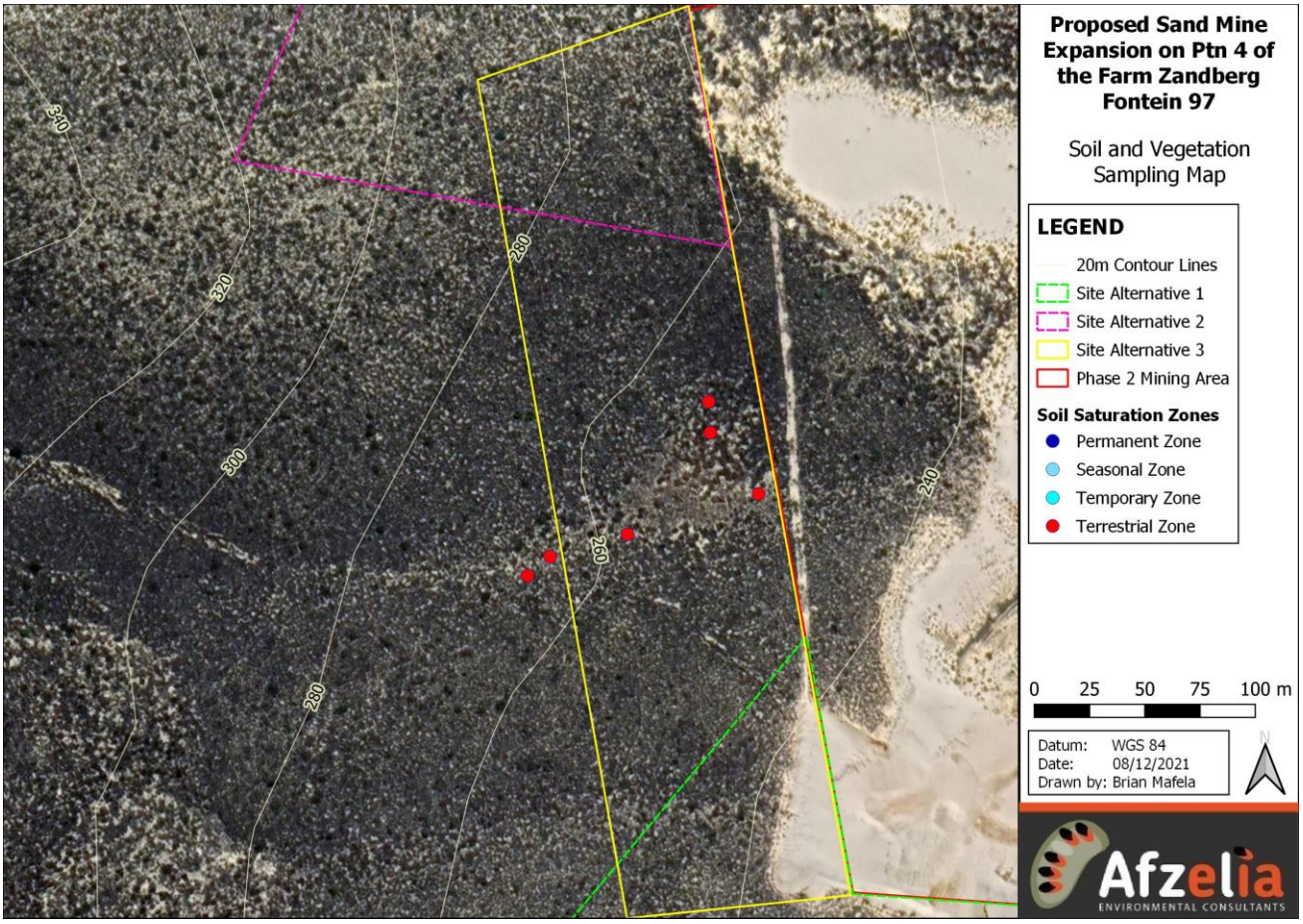

Figure 3.7: Soil and vegetation sampling points within Site Alternative 3.

Furthermore, careful analysis of the topsoil and vegetation within low-lying areas revealed the lack of signs of runoff and

alluvium (sand deposited by flowing water). The lack of significant surface runoff was attributed to the high permeability of the dune sand and thick scrub vegetation that characterises the study area (See Photos 1 - 4). During a rainfall event the vegetation breaks up water droplets and the deep dune sand soaks up the water. The lack of free-flowing water meant key features typical of river and riparian zones were not present. Such features include a distinct river channel (macro or active channel), river bed and banks, and flood benches. Instead the study area was characterised by a very subtle concave low-lying area.

Hydrophilic plant species, which is a key diagnostic feature of wetlands and riparian zones particularly in sandy landscapes such as coastal aquifers, was not recorded within the study area. Low-lying areas within Site Alternative 3 were characterised by a terrestrial vegetation community which was the same as the rest of the site. All plant species recorded were dry-land species that do not grow in wetland areas.

Photo 1: View looking across the mined dune. The yellow dashed line depicts the location of the low-lying area within Site Alternative 3. Note the depth of the dune sand.

Photo 2: View looking across the face of mined dune and the vegetation community atop the dune. The yellow dashed line depicts the location of the low-lying area within Site Alternative 3.

Photo 3: View looking upslope of the low-lying area. Note the brown grass that contributes significantly to the appearance of a drainage line on the aerial imagery of the study site.

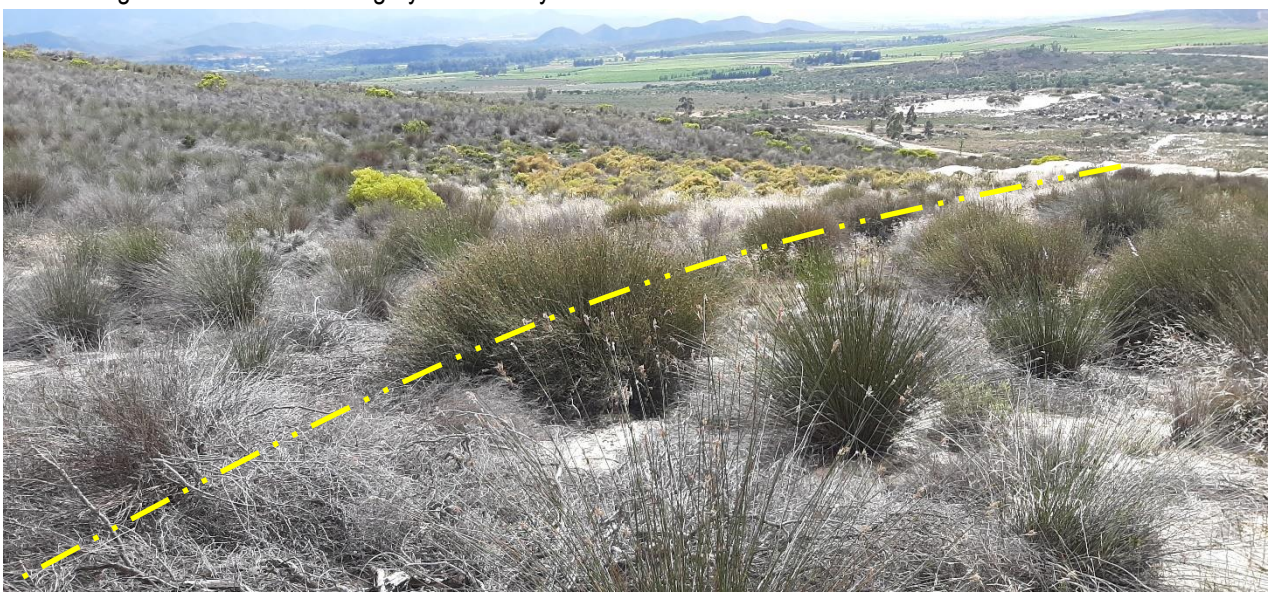

Photo 4: View looking downslope of the low-lying area.

3.5 Watercourse Description and Classification

The general characteristics and classification of the Wetland Units AW1 and UCVB1 are described in Tables 3.3 and 3.4, respectively.

Table 3.3: General characteristics of infield delineated artificial wetland (Unit AW1).

Level 1	Level 2		Level 3	Level 4: HGM Unit		
System	***DWA Ecoregion***	***NFEPA Wet/Veg Group***	***Landscape Unit***	***4A***	***4B***	***4C***
Inland	19.06 (Southern Folded Mountains)	Southwest Sand Fynbos	Artificial Bench	Artificial wetland	N/A	N/A
Aspect	**Description**					

<table>
<tr><td>General Description</td><td colspan="4">Wetland Unit AW1 is an artificial wetland that owes its existence to the exposure of the water table by sand mining activities. Due to sand mining activities the soil profile is now shallow with only a top layer of sand above a weathering Sandstone. Subsurface flows within the wetland area are believed to to be strong particularly during the rainy season in winter.</td></tr>
<tr><td rowspan="3">Hydrology</td><td>5A: Inundation</td><td colspan="2">5B: Saturation</td><td>5C: Depth of Inundation</td></tr>
<tr><td>Never Inundated</td><td colspan="2">Seasonally saturated</td><td>N/A</td></tr>
<tr><td colspan="4">Inflow drainage characteristics: Interflow and groundwater inflow.
Movement of water through the wetland: Subsurface and occasionally, diffuse overland flows.
Outflow drainage characteristics: Infiltration and evapotranspiration.</td></tr>
<tr><td rowspan="3">Soil</td><td colspan="2">Upper layer Substratum type</td><td colspan="2">Lower layer Substratum type</td></tr>
<tr><td>6A: Primary categories</td><td colspan="2">6B: Secondary categories</td><td>6A: Primary categories</td></tr>
<tr><td>Sand</td><td colspan="2">Sandstone</td><td>Sand</td></tr>
<tr><td colspan="5">Soil samples extracted from the wetland exhibited low chroma orange soil mottles within the soil matrix. The soil matrix had a golden-brown colour which is indicative of the youthful age of the wetland.</td></tr>
<tr><td rowspan="3">Vegetation</td><td colspan="3">Vegetation Form</td><td rowspan="2">6E: Vegetation Status</td></tr>
<tr><td>6B: Primary veg form</td><td>6C</td><td>6D</td></tr>
<tr><td>Herbaceous</td><td>Reed and Sedges</td><td>N/A</td><td>Indigenous</td></tr>
<tr><td colspan="5">The wetland was characterised by herbaceous vegetation community with poor ground cover. Typical species recorded include Phragmites australis, Ficinia radiata, F. truncate and Elegia tectorum.</td></tr>
</table>

Photographs of the artificial wetland (Unit AW1) are presented on the next page.

Photo 5: Overview of the artificial wetland habitat (Unit W1).

Photo 6: *P. australis* growing at the break in slope where groundwater breaks ground.

Photo 7: Soil sample extracted from the artificial wetland habitat. Note the low chroma orange mottles in the soil matrix.

Table 3.4: General characteristics of infield delineated unchannelled valley bottom wetland (Unit UCVB1).

Level 1	Level 2		Level 3	Level 4: HGM Unit		
System	***DWA Ecoregion***	***NFEPA Wet/Veg Group***	***Landscape Unit***	***4A***	***4B***	***4C***
Inland	19.06 (Southern Folded Mountains)	Southwest Sand Fynbos	Valley floor	Unchannelled valley-bottom wetland	N/A	N/A
Aspect	**Description**					
General Description	Wetland Unit UCVB1 was identified as an unchannelled valley bottom wetland with a narrow width (2 – 4m wide). The wetland is situated on a low-lying area with very gentle valley side slopes. Some excavation to improve through flows were noted at the road crossing point.					
Hydrology	***5A: Inundation***		***5B: Saturation***		***5C: Depth of Inundation***	
	Never Inundated		Seasonally saturated		N/A	
	Inflow drainage characteristics: Dominated by interflow and groundwater inflow. **Movement of water through the wetland**: Subsurface and diffuse overland flows.					

	Outflow drainage characteristics: Subsurface flows and evapotranspiration.			
Soil	***Upper layer Substratum type***		***Lower layer Substratum type***	
	6A: Primary categories	***6B: Secondary categories***	***6A: Primary categories***	
	Sand	Sandstone	Sand	
	Soil samples extracted from the wetland exhibited low chroma orange soil mottles nested within a grey soil matrix. Recorded soil mottles were moderately sized and in high abundance which is typical of seasonally saturated soils.			
Vegetation	***Vegetation Form***			***6E: Vegetation Status***
	6B: Primary veg form	***6C***	***6D***	
	Herbaceous	Reed and Sedges	N/A	Indigenous
	The wetland was characterised by herbaceous vegetation with the most characteristic being *P. australis* and sedges.			

Photographs of the unchannelled valley bottom wetland (Unit UCVB1) are presented below.

Photo 8: View looking upstream of Wetland Unit UCVB1.

Photo 9: *P. australis* growing within the wetland habitat.

Photo 10: The two photos show soil samples extracted from the wetland habitat. Note the grey soil matrix and low chroma orange mottles.

3.6 Ecological Condition and Ecological Importance and Sensitivity Assessments

A summary of the assessment results and impact descriptions is provided in Table 3.5 below.

Table 3.5: PES and EIS assessment results for Wetland Units AW1 and UCVB1.

Unit	Component & Score			Score & Category	Impact Description / Rationale
AW1	PES	Hydro	N/A	N/A	The PES of Wetland Unit AW1 was not assessed because it is artificial in nature and therefore lacks a baseline from which to draw any comparison.
		Geo	N/A		
		Veg	N/A		
	EIS	EI	1.15	1.15 Low	**EIS: Low** A score of 1.15 indicated that the wetland was of low EIS. This is consistent with field observations which confirmed that the wetland lacks conservation-important aquatic biota or biota that can be considered sensitive to changes induced by anthropogenic impacts.
		ES	1.00		
	Ecosystem Services				In terms of supply of ecosystem services, Wetland Unit AW1 was found to be ideal for the provision of (i) cultivated foods and (ii) water for human consumption (Figure 3.8). This was attributed to exposure of the water table by mining activities. Other services were supplied at a low level. Carbon storage and biodiversity maintenance were identified as key services on high demand in the area.

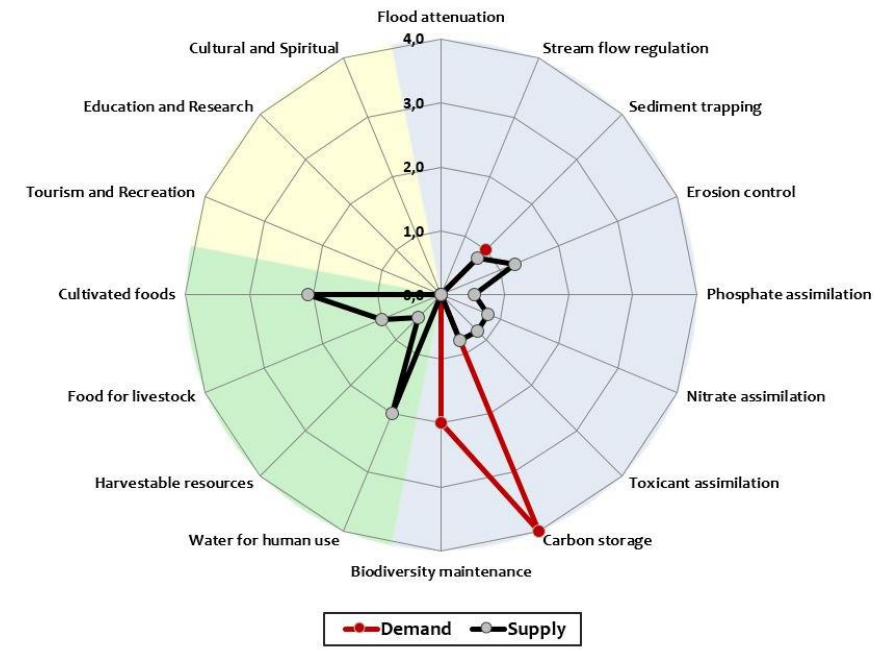

Figure 3.8: Ecosystem services scores for Wetland Unit AW1.

UCVB1	**PES** Hydro 1.5 Geo 2.1 Veg 2.2	**1.9** **B Class**	**PES: Largely Natural** The wetland was found to be largely natural which means a slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place. Key impacts recorded include: (i) excavation of the wetland channel to improve drainage at the road crossing, (ii) habitat transformation and flow impedance caused by the road infrastructure, and (iii) limited invasive alien plant infestation.
	EIS EI 1.90 ES 1.65	**1.90** **Medium**	**EIS: Moderate** Wetland Unit UCVB1 was evaluated as being of medium EIS. This was attributed to the largely intact and natural vegetation community which is somewhat sensitive to disturbances and water quality impacts. The wetland habitat likely harbours faunal species sensitive to water quality impacts.
	Ecosystem Services	Wetland Unit UCVB1 was particularly good at supplying servies such as streamflow regulation, biodiversity maintenance, water for human consumption and tourism and recreation services (Figure 3.9). The supply of abovementioned services was attributed to low degradation of the wetland habitat and high soil saturation from groundwater infow. Carbon storage and biodiversity maintenance were identified as key services on high demand in the area.	

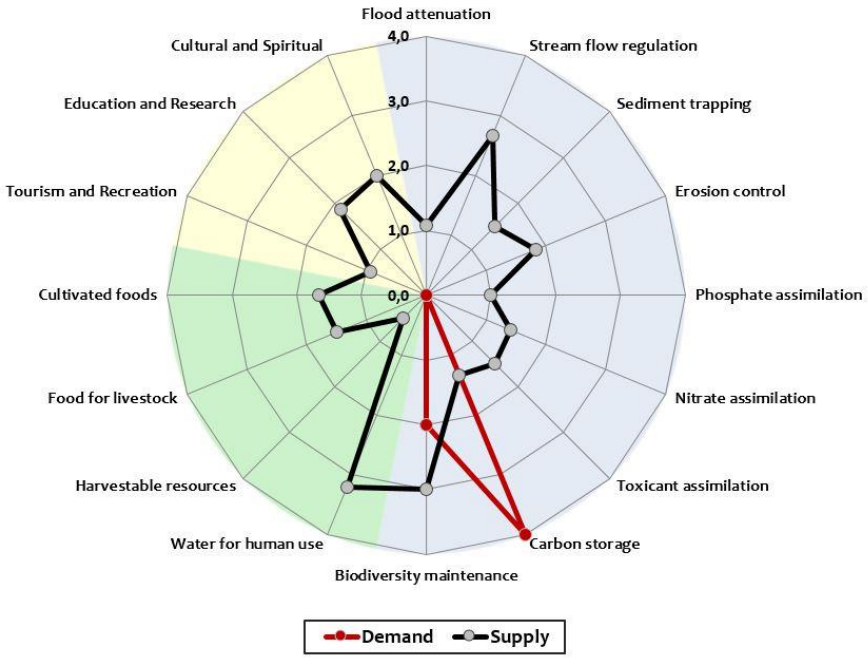

Figure 3.9: Ecosystem services scores for Wetland Unit UCVB1.

4. IMPACT ASSESSMENT & MITIGATION

4.1 Impact Identification, Description & Significance Assessment

All impacts to watercourses linked with the operation of the Zandberg sand mine are discussed in Table 4.1 below. Only operational phase impacts are discussed in this report because the activity will not have a construction phase.

Table 4.1: Description of operation phase impacts and a summary of the impact significance results.

Impact	Impact Description	Impact Significance[1]	
		Poor / No Mitigation	Good Mitigation
a) Transformation of watercourse habitat	Transformation of artificial wetland habitat (Unit AW1) during the operational phase of the sand is unlikely and therefore this impact was not assessed further.	N/A	N/A
b) Direct disturbance of watercourse habitat	Poorly managed operational activities are likely to result in direct disturbance of the site. Such activities include driving and parking of heavy vehicles within the wetland habitat as well as stockpiling of excavated sand within the wetland habitat will result in destruction of wetland vegetation and soil compaction. The loss of vegetation will reduce the wetland's functionality in terms of biodiversity maintenance. Any aquatic biota such as amphibians that depend on wetland vegetation such as reeds will be most impacted.	27 Medium	8 Negligible
c) Increased sediment input in watercourses	Excavation of sand on windy days will likely result in sand being carried by wind and deposited within the artificial wetland habitat particularly if excavation is being undertaken in close proximity to the wetland habitat. The amount of sand deposited on the wetland is likely to be very limited and therefore less likely to result in a significant impact on the health and functionality of the wetland.	15 Low	12 Low
d) Increased flood peaks in watercourses	The operation of the sand mine will not generate any significant runoff owing to the high permeability of the sandy soil. Therefore, this impact was not assessed further.	N/A	N/A
e) Increased pollutant input in watercourses	Key sources of pollutants during the operational phase include mis-handling of sewage from chemical toilets, leakage of oil from heavy vehicles or spillage of hydrocarbons when refuelling construction vehicles on site. Nutrient based pollutants such as sewage will increase the nutrient load thus increasing the risk of the overgrowth of nutrient loving plants resulting in the development of monotypic stands of vegetation. On the other hand, spillage of oils and hydrocarbons will result in the mortality of aquatic biota (plants, microorganisms and small animals) sensitive to water quality changes. Such an outcome will then impact the functionality of affected wetland habitats.	33 Medium	10 Low
f) Weeds and invasive alien plant	Any temporary removal or disturbance of vegetation during the operational phase will increase the likelihood of IAP invasion. The colonization of areas by weeds and IAPs poses a risk to indigenous	34 Medium	12 Low

[1] *Detailed results of the impact assessment are provided in Appendix 8.3.*

proliferation in watercourses	plant communities and habitat characteristics. IAPs can have far reaching detrimental effects on native biota and have been widely accepted as being the leading cause of biodiversity loss. Overtime IAP will spread throughout the wetland and change the vegetation community.		

4.2 Comment on Site Alternatives

From a watercourse point of view, all three (3) site alternatives pose similar impacts to delineated wetland habitats. This is because all three sites are situated almost equidistant to the closet wetland habitat (Unit AW1) and will require similar means of mining the sand. The impact significance assessment undertaken for Site Alternative 3 (See Sections 4.1 for summarised results and 8.2 for detailed results) applies for Site Alternatives 1 and 2.

4.3 Mitigation Measures

4.3.1 Wetland Buffer

A buffer zone is a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another (Macfarlane *et al.* 2014). According to Macfarlane *et al*. (2014), buffers surrounding water resources serve the following functions:

i. Maintaining basic aquatic process;
ii. Reducing impacts on water resources from upstream activities and adjoining land uses.
iii. Providing habitat for aquatic and semi-aquatic species.
iv. Providing habitat for terrestrial species.
v. Providing a range of ancillary societal benefits.

The Wetland and River Buffer tool (Macfarlane et al. 2014) was used to establish the required buffer width for delineated wetlands. The results of the tool which takes into account wetland properties (e.g. buffer slope, soil properties, groundcover within the buffer, sensitivity of receiving watercourses etc.) suggested a final buffer width of 15m for all wetland units. A map showing the extent of the buffer is provided as Figure 4.1.

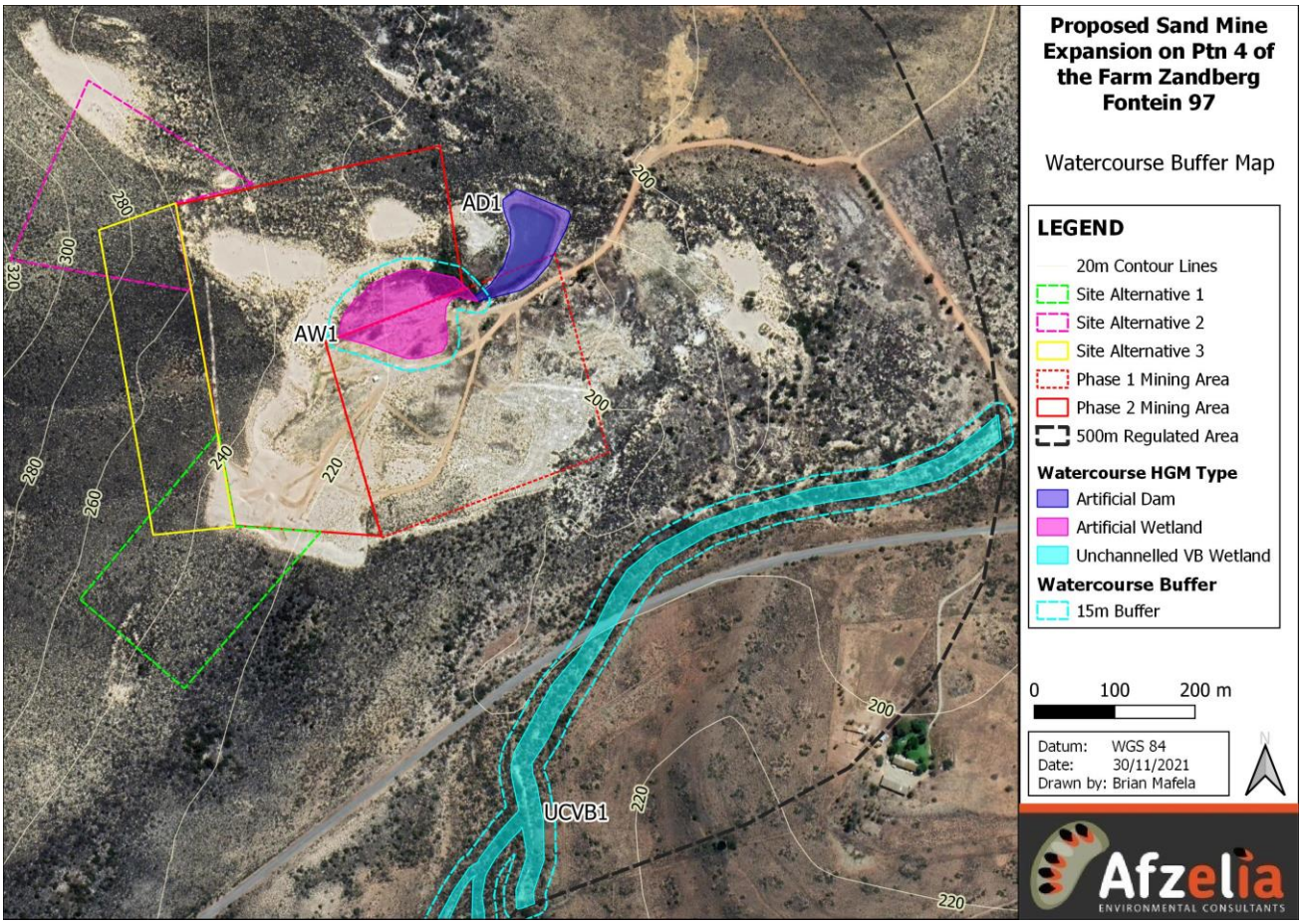

Figure 4.1: Watercourse buffer map.

4.3.2 Finalisation of Plans

The following plans will need to be completed and approved prior to commencement of construction:

i. An EMPr must be compiled for the construction phase by an environmental assessment practitioner and the EMPr must incorporate all of the below listed mitigation measures.

4.3.3 Demarcation of Artificial Wetland Unit AW1

i. Prior to commencement of operation, the wetland buffer area must be demarcated using pegs and an orange safety net.
ii. The demarcation fence must be signed off by the Environmental Control Officer (ECO).
i. The fence must be maintained throughout the construction phase.
iii. The use of heavy equipment within the watercourse habitat should be avoided or minimised.

4.3.4 Soil Management

i. Prior to commencing with earthworks, the topsoil must be stripped and stockpiled separately from subsoil.
ii. Topsoil must be kept for use during rehabilitation of landscaped areas.
iii. Topsoil must be stockpiled in stockpiles not exceeding 2m in height.
iv. All stockpiles must be kept free of weeds and invasive alien plants.

v. Topsoil removed during the initial cut must be stockpiled preferably on a flat / gently sloping surface to minimise run-off during rain events and away from the active construction site.
vi. If soil stockpiles are at risk of being eroded, they must be secured with sandbags around the base of the soil stockpile.
vii. All stockpiles must be established outside the 15m buffer of all watercourses and on flat ground.

4.3.5 Pollution Prevention Measures

i. Any soil contaminated by hydrocarbons (fuel and oils), asphalt, bitumen, binding agents, concrete and/or any other chemical must be removed and the affected area rehabilitated immediately.
ii. Chemical toilets must be provided to workers during the operational phase. A single chemical toilet must be provided for every 10 employees.
iii. Chemical toilets must be serviced regularly by a registered service provider and waybills must be retained as proof of servicing.
iv. If fuel it to be stored on site it must be stored in a bunded structure with a roof. The bund must be able to contain at least 110% of the volumes of fuel.
v. Mixing and/or decanting of all chemicals and hazardous substances must take place on a tray, shutter boards or on an impermeable surface.
vi. Drip trays should be utilised at all dispensing areas.
vii. A chemical spill kit must be present onsite at all times and once used it must be disposed of at a registered hazardous landfill site.
viii. All solid waste must be collected and placed in bins.

4.3.6 Invasive Alien Plant Control

i. The control and eradication of a listed invasive alien species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs in.
ii. All invasive alien plants must be removed from the construction area.
iii. Mechanical control methods such as digging, hoeing, pulling out of weeds and invasive plants are recommended.
iv. Use of chemical treatment methods must be kept to a minimum.
v. Where chemical treatment methods are used, the contractor must ensure that he uses watercourse friendly herbicides.
vi. The methods employed to control and eradicate a listed invasive species must also be directed at the new growth, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.

5. DWS RISK ASSESSMENT

5.1 Water Use Risk Assessment

The General Authorisation (GA) for the impeding or diverting the flow of water in a watercourse (Section 21 c) or altering the bed, banks, course or characteristics of a watercourse (Section 21 i) as contemplated in the National Water Act (Act No. 36 of 1998) was implemented to replace the need for a water user to apply for a licence provided that the water use is within the limits and conditions of this GA. However, only projects with a risk class of "low" as determined by the risk matrix qualify for a GA. In order to determine the risk level of the project, the DWS Risk Assessment Matrix was applied.

The operation of the Zandberg sand mine was assessed as a Low Risk activity in terms of adversely impacting onsite wetlands. The excavation, stockpiling and loading of sand onto trucks was identified as a major impact that requires mitigation. The low risk rating qualifies the development for authorisation under the provisions of the GA. A summary of the DWS Risk assessment results is provided in Table 5.1.

Table 5.1: Summarised Risk Matrix assessment results.

Phase & Activity	Aspect	Significance & Risk Rating	Mitigation Measures	Revised Risk Rating	PES & EIS of watercourse
Operational Phase: Operation of the sand mine	Excavation, stockpiling and loading of sand	52 Low	Mitigation Measures are listed in Section 4.3	N/A	See Section 3.5 of this report
	Movement of trucks	36 Low		N/A	

5.2 Special Conditions for the General Authorisation

Special conditions listed below are recommended and must be included in the GA to be issued by DWS.

a) The water user must ensure that the slope of the sand dune following completion of sand mining:
   i. is structurally stable;
   ii. does not induce sedimentation or erosion.
b) Prior to the carrying out of any works, the water user must ensure that all persons entering the construction site, including contractors and casual labourers, are made fully aware of the conditions and related management measures specified in the GA, Environmental Authorisation (EA) and the Environmental Management Programme (EMPr).
c) The water user must ensure that a 15m buffer is maintained around Wetland Unit AW1.
d) The water user must ensure that any construction camp, storage, washing and maintenance of equipment, storage of construction materials, or chemicals, as well as any sanitation and waste management facilities:
   i. are located outside the 1 in 100-year flood line or 30m from any delineated wetland habitat; and
   ii. are removed within 30 days after the completion of any works.
e) The water user must ensure that adequate erosion control measures (bund, berms, sand bags etc.) are installed on all areas susceptible to erosion or runoff.
f) During the construction phase of the project, the water user must appoint an Environmental Control Officer to undertake monthly site visits. The environmental audit report must discuss non-compliances of the GA, EA and the approved EMPr.
g) During the construction phase of the project, the appointed Environmental Control Officer must take monthly fixed-point photographs.
h) All environmental audit reports must be made available to the responsible authority upon written request.

6. CONCLUSION

This assessment was commissioned to delineate and assess any watercourse occurring within and around Site Alternative 3. The specialist undertook a site investigation on the 27th November 2021 and confirmed the absence of a watercourse (i.e. wetland or river habitat) within Site Alternative 3. Development of a sand mine within Site Alternative 3 will therefore not result in the transformation of any watercourse.

Furthermore, this investigation confirmed the presence of two wetland habitats (Units AW1 and UCVB1) within the impact zone of the sand mine. Wetland Unit AW1 was found to be of low EIS and poor functionality whilst Unit UCVB1 had an ecological condition considered largely natural (Class B), of moderate EIS and of moderate functionality. Both wetland habitats were evaluated as worth conserving.

Anticipated adverse impacts linked with the operation of the sand mine are expected to be of medium impact significance (Table 6.1 below). Detailed results are presented in the Appendix 8.2. Direct disturbance of the wetland habitat, water pollution and invasive alien plant infestation were identified as major risks. Implementation of recommended standard best practice mitigation measures (listed in Section 4.3 of this report) will lower the impact significance ratings. All impacts will be reduced to either a negligible or low impact significance. All operational activities will need to be set back by 15m from all delineated watercourses in order to reduce the impact of the development on watercourses.

Table 6.1: Summarised impact significance assessment results.

Impact	Operational Phase	
	Poor / No Mitigation	Good Mitigation
a) Transformation of watercourse habitat	N/A	N/A
b) Direct disturbance of watercourse habitat	27 Medium	8 Negligible
c) Increased sediment input in watercourses	15 Low	12 Low
d) Increased flood peaks in watercourses	N/A	N/A
e) Increased pollutants input in watercourses	33 Medium	10 Low
f) Weeds and invasive alien plant proliferation in watercourses	34 Medium	12 Low

From a watercourse point of view, all three (3) site alternatives pose similar impacts to delineated wetland habitats. This is because all three sites are situated almost equidistant to the closet wetland habitat (Unit AW1) and will require similar means of mining the sand. The impact significance assessment undertaken for Site Alternative 3 (See Sections 4.1 for summarised results and 8.2 for detailed results) applies for Site Alternatives 1 and 2.

In terms of the Department of Water and Sanitation (DWS) Risk Assessment and in accordance with the definitions contained in the National Water Act, No. 36 of 1998 (NWA), the operation of the Zandberg sand mine was assessed as a Low Risk activity in terms of adversely impacting onsite wetlands. The excavation, stockpiling and loading of sand onto trucks was identified as a major impact that requires mitigation. The low risk rating qualifies the development for authorisation under the provisions of the GA.

It is the opinion of the specialist that the proposed development meets environmental requirements as far as watercourses are concerned and therefore should be approved provided all other environmental requirements are met.

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8. APPENDICES

8.1 Wetland Assessments

8.1.1 Wetland Delineation

Onsite wetland delineation was undertaken as per procedures described in 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1' (DWAF, 2005a). This document requires the delineator to give consideration to the following 4 indicators in order to find the outer edge of the wetland zone:

i. The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
ii. The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
iii. The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation. Signs of wetness are characterised by a variety of aspects. These include marked variations in the colours of various soil components, known as mottling; a gleyed soil matrix or the presence of Fe/Mg concretions. It should be noted that the presence of signs of wetness within a soil profile is sufficient to classify an area as a wetland area despite the lack of other indicators.
iv. The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

8.1.2 Wetland Classification

All natural-occurring wetland units were classified according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013) which categorise wetlands into 6 distinct hydrogeomorphic (HGM) units. See Table 8.1 for a description of each HGM Unit.

Table 8.1: Description of wetland HGM units.

HGM Type	Description
Channelled valley bottom wetland	A mostly flat wetland area with a river channel running through it located along a valley floor, often connected to an upstream or adjoining river channel.
Unchanneled valley bottom wetland	A mostly flat wetland area without a river channel running through it located along a valley floor, often connected to an upstream or adjoining river channel.
Floodplain	A wetland area on the mostly flat or gently-sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by overtopping of the channel bank.
Seep	a wetland area located on gently to steeply sloping land and dominated by colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend onto a valley floor.
Flat	A level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat.
Depression	a wetland or aquatic ecosystem with closed (or near-closed1) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates.

Illustrations of the different wetland HGM types is provided in Figure 8.1.

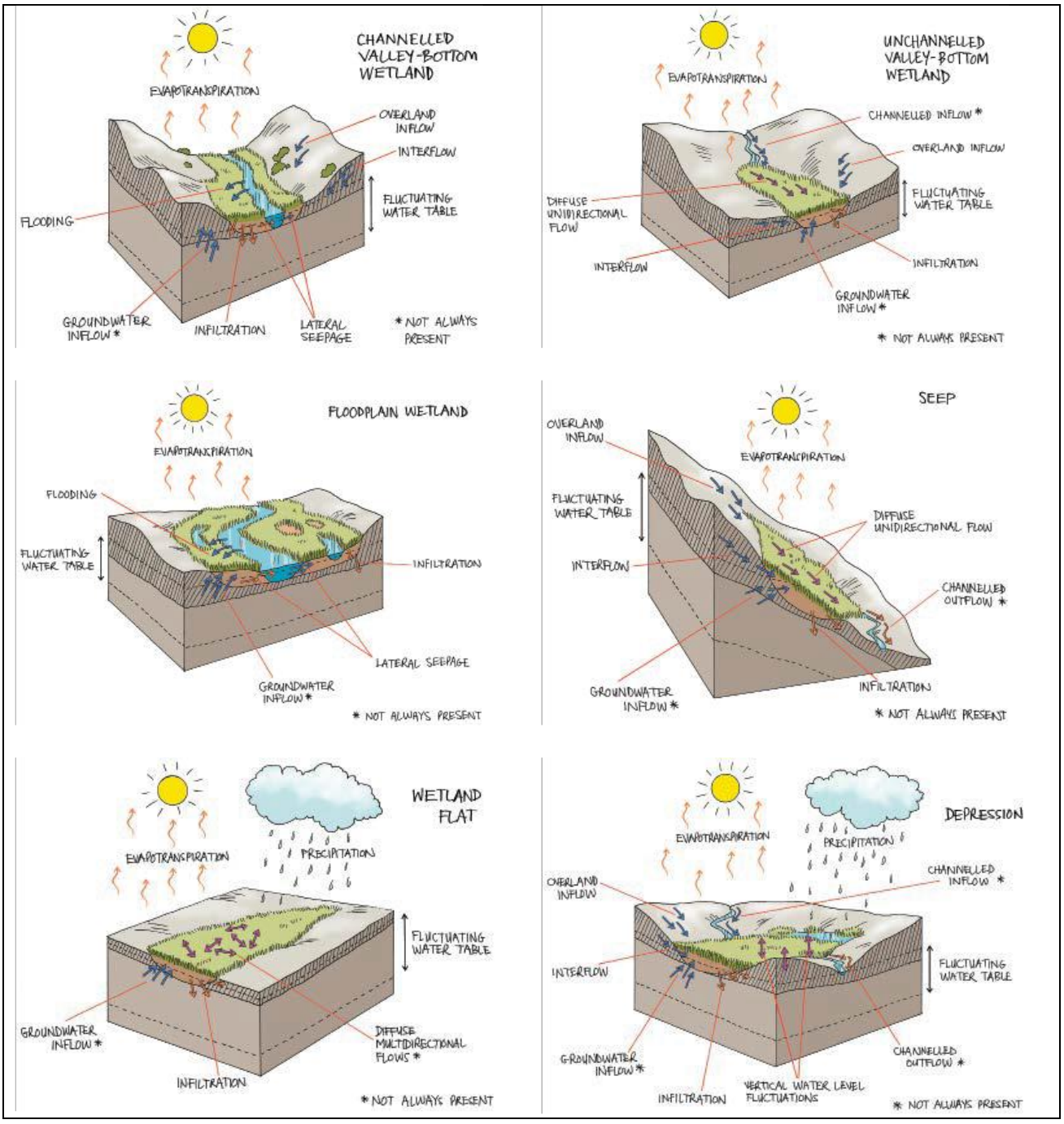

Figure 8.1: Illustrations of the different wetland HGM types.

8.1.3 Wetland Present Ecological State Assessment

The health or integrity of wetlands was assessed using WET-Health Level 1 Assessment tool. The tool attempts to assess the deviation of 3 key wetland components from their reference state prior to human induced degradation (Macfarlane *et al.* 2008). These components namely hydrological, geomorphological and vegetation are assessed separately and the results are integrated to obtain and overall score (Macfarlane *et al.* 2008). An overall wetland health score is calculated by weighting the scores obtained for each component using the following formula:

$$\textbf{Overal Health Score} = \frac{(\text{Hydrology X } 3) + (\text{Geomophology X } 2) + (\text{Vegetation X } 2)}{7}$$

The overall health score is then interpreted using a categorised system ranging from A to F with "Category A" signifying that the wetland is in a natural / unmodified state whilst the other end of the gradient "F" signifying that the wetland is critically modified. Details of the scoring system are presented in Table 8.2 below.

Table 8.2: Impact scores and categories of Present State used in WET-Health for describing the integrity of wetlands.

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

8.1.4 Wetland Functional Assessment

The functionality of the wetland in terms of providing ecosystem services was assessed using the WET-EcoServices Level 2 Assessment tool (Version 2) (Kotze *et al.*, 2020). The tool accounts wetland attributes and observed impacts to provide an estimation of the level of ecosystem service supply. Table 8.3 lists all ecosystem services assessed and also provide a description of each service.

Table 8.3: Description of each ecosystem service assessed.

Indirect Benefits	Flood Attenuation		*Refers to the effectiveness of wetlands at spreading out and slowing down storm flows and thereby reducing the severity of floods and associated impacts.*
	Regulating and Supporting Services	Stream Flow Regulation	*Refers to the effectiveness of wetlands in sustaining flows in downstream areas during low-flow periods.*
		Sediment Trapping	*Refers to the effectiveness of wetlands in trapping and retaining sediments from sources in the catchment.*
		Nutrient & Toxicant Retention and Removal	*Refers to the effectiveness of wetlands in retaining, removing or destroying nutrients and toxicants such as nitrates, phosphates, salts, biocides and bacteria from inflowing sources, essentially providing a water purification benefit.*
		Erosion Control	*Refers to the effectiveness of wetlands in controlling the loss of soil through erosion.*

	Carbon Storage		*Refers to the ability of wetlands to act as carbon sinks by actively trapping and retaining carbon as soil organic matter.*
Direct Benefits	Biodiversity Maintenance		*Refers to the contribution of wetlands to maintaining biodiversity through providing natural habitat and maintaining natural ecological processes.*
	Provisioning Benefits	Water Supply	*Refers to the ability of wetlands to provide a relatively clean supply of water for local people as well as animals.*
		Harvestable Natural Resources	*Refers to the effectiveness of wetlands in providing a range of harvestable natural resources including firewood, material for construction, medicinal plants and grazing material for livestock.*
		Cultivated Foods	*Refers to the ability of wetlands to provide suitable areas for cultivating crops and plants for use as food, fuel or building materials.*
		Food for Livestock	*Refers to the ability of wetlands to provide suitable vegetation as food for livestock.*
	Cultural Benefits	Cultural significance	*Refers to the special cultural significance of wetlands for local communities.*
		Tourism & Recreation	*Refers to the value placed on wetlands in terms of the tourism-related and recreational benefits provided.*
		Education & Research	*Refers to the value of wetlands in terms of education and research opportunities, particularly concerning their strategic location in terms of catchment hydrology.*

Table 8.4: Integrating scores for supply & demand to obtain an overall importance score.

Integrating scores for supply & demand to obtain an overall importance score						
		Supply				
		Very Low	Low	Moderate	High	Very High
Demand		0	1	2	3	4
Very Low	0	0,0	0,0	0,5	1,5	2,5
Low	1	0,0	0,0	1,0	2,0	3,0
Moderate	2	0,0	0,5	1,5	2,5	3,5
High	3	0,0	1,0	2,0	3,0	4,0
Very High	4	0,5	1,5	2,5	3,5	4,0

Table 8.5: Classes for determining importance.

Importance Category		Description
Very Low	0-0.79	The importance of services supplied is very low relative to that supplied by other wetlands.
Low	0.8 – 1.29	The importance of services supplied is low relative to that supplied by other wetlands.
Moderately-Low	1.3 – 1.69	The importance of services supplied is moderately-low relative to that supplied by other wetlands.
Moderate	1.7 – 2.29	The importance of services supplied is moderate relative to that supplied by other wetlands.
Moderately-High	2.3 – 2.69	The importance of services supplied is moderately-high relative to that supplied by other wetlands.
High	2.7 – 3.19	The importance of services supplied is high relative to that supplied by other wetlands.
Very High	3.2 - 4.0	The importance of services supplied is very high relative to that supplied by other wetlands.

8.1.5 Wetland Ecological Importance and Sensitivity Assessment

The ecological importance and sensitivity (EIS) of wetlands was assessed using an unpublished revision of the DWAF EIS tool by Rountree & Kotze, 2013. The tool assesses 3 aspects of the wetland including:

i. The Importance of the wetland in providing habitat to biodiversity,
ii. Landscape importance, and
iii. The sensitivity of the wetland to changes in flow regime and water quality.

The results of the assessment are interpreted as per the following guideline presented in Table 8.6.

Table 8.6: Ecological importance and sensitivity scores, ratings and description.

EIS Score	EIS Rating	EIS Category Description
0 - 0.5	Very Low	Wetlands that are not ecologically important and sensitive at any scale due to high degradation levels.
0.6 - 1.5	Low	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers
1.6 - 2.7	Moderate	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers
2.8 - 3.5	High	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers
<3.5	Very High	Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers

8.2 Detailed Impact Significance Assessment Results

Detailed impact significance assessment results are provided in Table 8.7 below.

Table 8.7: Detailed impact significance assessment results.

Operational Impact	Without Mitigation					With Mitigation				
	Magnitude	Duration	Extent	Probability	Significance	Magnitude	Duration	Extent	Probability	Significance
a) Transformation of watercourse habitat					N/A					N/A
b) Direct disturbance of watercourse habitat	3	1	3	27	27 Medium	0	3	1	2	8 Negligible

c)	Increased sediment input in watercourses	2	1	3	15	15 Low	1	2	1	3	12 Low
d)	Increased flood peaks in watercourses					N/A					N/A
e)	Increased pollutants input in watercourses	3	2	3	33	33 Medium	0	3	2	2	10 Low
f)	Weeds and invasive alien plant proliferation in watercourses	3	2	3	33	34 Medium	1	3	2	2	12 Low