WETLAND BIODIVERSITY MANAGEMENT PLAN FOR THE PROPOSED DE BERG PRIVATE NATURE RESERVE (DBPNR), MPUMALANGA PROVINCE

Waterfalls and headwater mountain streams that form part of the Groot-Dwars River

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LIST OF ACCRONYMS

BMU	Biodiversity Management Unit
BMUs	Biodiversity Management Units
BMU 5	Valley bottom and seep wetlands
BMU 7	Mountain streams
BMU 11	Dams
DBPNR	De Berg Private Nature Reserve
DWS	Department of Water and Sanitation
EIS	Ecological Importance and Sensitivity
EN	Endangered
GA	General Authorisation
HGM	Hydrogeomorphic
LCPE	Lydenburg Centre of Plant Endemism
masl	metres above sea level
MTPA	Mpumalanga Tourism and Parks Agency
MBSP	Mpumalanga Biodiversity Sector Plan 2014
NEMBA	National Environmental Management: Biodiversity Act
NT	Near Threatened
NWA	National Water Act
PES	Present Ecological State
POSA	Plants of Southern Africa database (http://newposa.sanbi.org)
PTV	Pollution Tolerant Values
SCC	Species of conservation concern
SCPE	Sekhukhuneland Centre of Plant Endemism
SOC	Soil organic carbon
SOM	Soil organic matter
SRSW	Sheetrock seep wetland
SRSWs	Sheetrock seep wetlands
SWSA	Strategic Water Source Area
SWSAs	Strategic Water Source Areas
VU	Vulnerable
WMA	Water Management Area
WUL	Water Use Licence

1. INTRODUCTION

1.1 Background

In November 2020, Clean Stream Biological Services approached De Castro & Brits Ecological Consultants, who appointed Imperata Consulting, to conduct a wetland study, for the purpose of providing biodiversity management recommendations for wetlands and other watercourses for the proposed establishment of the De Berg Private Nature Reserve (DBPNR). The 2127 ha study area (henceforth also referred to as the site or DBPNR study area), comprises portions of the farms De Berg 71-JT, Triangle 72-JT, Sterkfontein 52-JT Portion 3, and Goedehoop 79-JT (**Table 1; Figure 1**). Different farm portions are henceforth only referred to by their name, e.g., Triangle or De Berg, where deemed necessary for referencing specific sections of the study area (**Table 1; Figure 1**).

This study forms part of a larger biodiversity management study for the proposed DBPNR with separate specialist reports. Biodiversity concerns are the specific focus of these reports, which requires that integration and consistency between these reports are of high importance. This is needed in order to describe similar units in terms of biodiversity and to implement recommended management actions collectively to the same target areas. Efforts are made to achieve this by working with Biodiversity Management Units (BMUs), identified by the team's botanical specialist, which represent broad-scale structural-functional vegetation/habit types. A recent biodiversity assessment of a larger area that overlaps with the study area, apart from Goedehoop, identified and described three Biodiversity Management Units (BMUs) that include all identified wetlands and other watercourses (De Castro, 2021). These include the following and are used as the basis for this study to ensure an integrated approach:

- BMU 5 (Valley bottom and seep wetlands)
- BMU 7 (Mountain streams)
- BMU 11(Dams)

The study area of 2127 ha is situated in the Mpumalanga Province, within Thaba Chweu Local Municipality (**Table 1; Figure 1**). It is located approximately 17 km east of Roossenekal, 21 km north of Dullstroom, and 25.5 km west-southwest of Lydenburg Airport. This report presents the findings of the requested study conducted in accordance with the proposal submitted in November 2020 and subsequent requests by the client (Northam Booysendal).

Table 1: Farm names (and surface areas) that form part of the proposed De Berg Private Nature Reserve (DBPNR) study area.

Farm names and portion	**De Berg Remainder 71-JT**	**De Berg Portion 2 71-JT**	**Triangle 72-JT**	**Sterkfontein Portion 3 52-JT**	**Goedehoop Portion 6 79-JT**
Reference used henceforth	De Berg		Triangle	Sterkfontein	Goedehoop
Surface area per farm name	1045.77 ha		223.27 ha	684.95 ha	172.75 ha
DBPNR surface area	2126.74 ha				

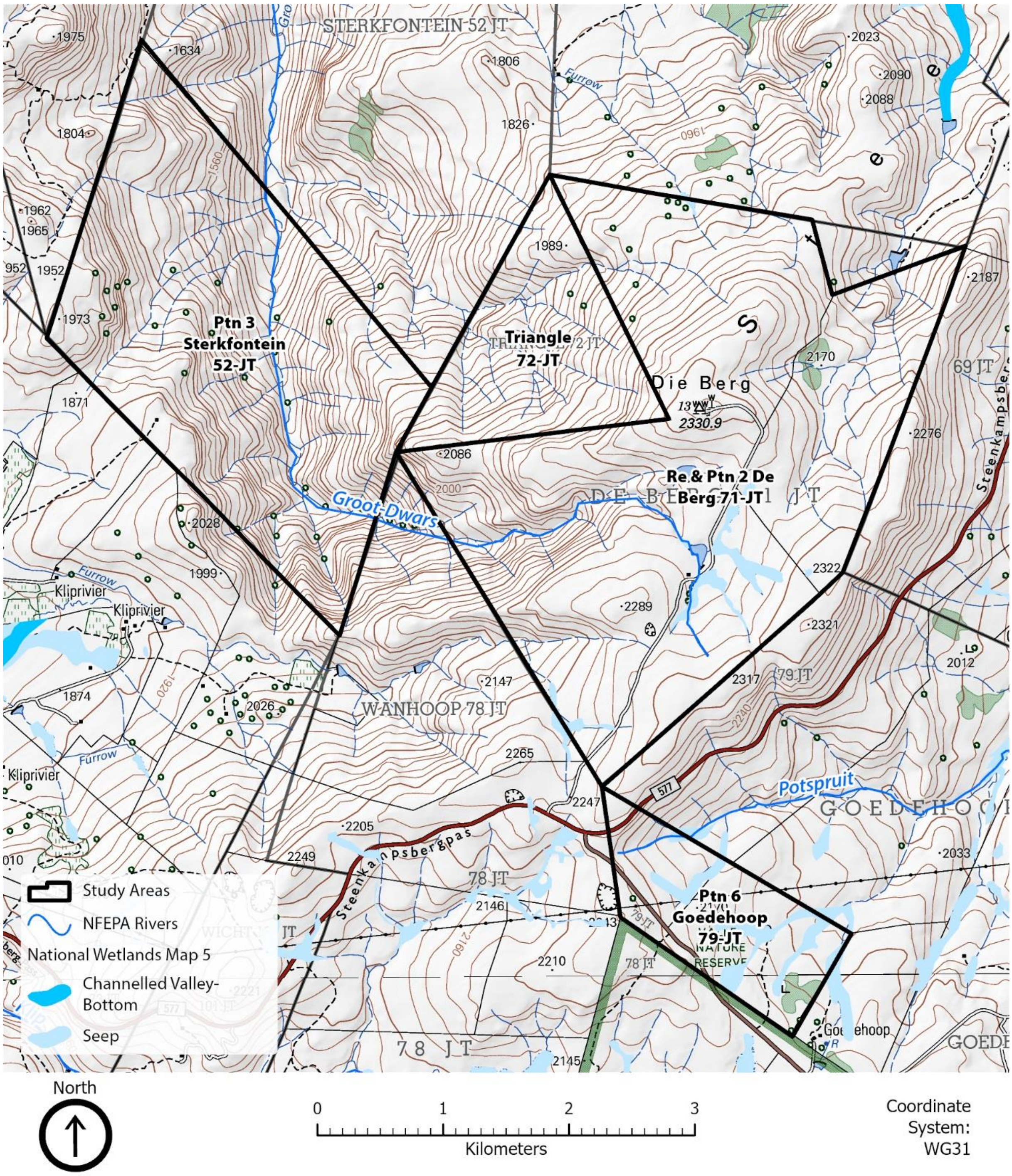


Figure 1: The DBPNR study area with wetlands from the National Wetlands Map 5 (Van Deventer *et al*., 2018) and the NFEPA river dataset (Nel *et a*l., 2011).

1.2 Objectives and Terms of Reference

The terms of references associated with the specialist wetland study pertaining to the study area as illustrated in **Figure 1**, is described below.

The proposed wetland study will delineate wetlands and other watercourses, as defined in the National Water Act, Act Nr. 36 of 1998 (NWA), at a level of detail that suffices for biodiversity management purposes, which is not as detailed (exact) as would be the case for a development application where new infrastructure footprints are proposed. Watercourses delineated and assessed in this study are consistent with those that form part of BMU units 5, 7 and 11, as described by De Castro (2021), and watercourse definitions stipulated in the NWA, namely:

- A river or spring.
- A natural channel in which water flows regularly or intermittently.
- A wetland, lake or dam into which, or from which, water flows.

The current study provides a description of recorded wetland and riparian habitat indicators that include indicators published in South African literature (DWAF, 2005; DWAF, 2008). Delineated wetlands will be classified to the hydrogeomorphic (HGM) level based on the classification system for aquatic ecosystems developed by Ollis *et al*., (2013). The HGM classification is at a lower order of hierarchy than the exiting Biodiversity Management Unit (BMU) system, described by De Castro (2021 and in prep.), for watercourse associated BMUs.

The assessment of the ecological condition of selected individual wetland systems as typical examples within the study area will be undertaken as Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessments, while ecosystem services performed by these same wetlands will also be assessed. The determination of the soil carbon of selected wetlands will be undertaken to expand the verification of confirmed peat containing wetlands (peatlands) in the study area. Lastly, existing impacts and threats to all identified watercourse associated BMUs (BMU 5, 7 and 11) will be discussed along with biodiversity orientated management recommendations for each of the three BMUs.

1.3 Details of the Author

Retief Grobler has undergrad majors in Botany (UP) and Soil Science (UP), an honours degree in Botany from the University of Pretoria (cum laude), and an MSc (cum laude) in Botany from the Department of Plant Sciences (UP) with a focus on peatland wetland systems. He is a registered Pr. Sci. Nat professional natural scientist in the fields of Botanical Science and Ecological Science (Reg. no. 400097/09) and has been working as a watercourse specialist consultant based in Gauteng over the last 16 years. He has wetland and related watercourse specialist consulting work experience in Gauteng, Mpumalanga, North-West, Limpopo, Northern Cape, Free State, Eastern Cape and KwaZulu-Natal Provinces, as well as outside of South Africa in Mozambique and Tanzania. Areas of specialisation include the delineation, description and assessment of watercourses, including wetlands, riparian habitats, peatlands and headwater drainage lines.

2. APPROACH, METHODS AND LIMITATIONS

2.1. Approach and Limitations

De Castro (2021) provides the following description of areas that were identified as part of a larger botanical baseline study, which include the current study area, in order to help identify, protect and conserve 'core biodiversity management areas':

> *The most appropriate method of conserving and managing the biodiversity of large mining areas such as the study area is to select relatively large areas that contain as wide a variety of interconnected untransformed habitats or BMUs as possible on the basis of scientific and practical criteria. The identification of such 'core biodiversity management areas' enable the mine to focus its management effort and ensure that the biodiversity of the study area is sustainably conserved within ecologically viable areas. Subsequent to the literature review and the initial field work, the part of the study area comprising the farms De Berg, Triangle and Sterkfontein Portion 3 (the proposed De Berg Private Nature Reserve) was identified as a core biodiversity management area and some emphasis was placed on surveying this area as requested by the client.*

These identified 'core biodiversity areas' consequently form part of the proposed establishment of the DBPNR (**Table 1; Figure 1**), which is the subject of this study along with other specialist studies on the biophysical environment (De Castro, in prep; Deacon, in prep.; Kotze in prep.; and Niemand, in prep.).

Watercourses presented in this report are mapped at sufficient level of detail for biodiversity management purposes and their accuracy have been refined compared to the original BMUs that were delineated in 2021 (De Castro, 2021), with an extra nine days of site wetland surveys added.

An EIA-level wetland study would also have assessed the ecological condition of every delineated wetland/watercourse. In this study, only selected individual wetlands are assessed in terms of their ecological condition (PES and EIS), in order to provide an overview of the typical state of different types of wetlands within the study area.

Portion 6 of the farm Goedehoop 79-JT was only added to the study area in March 2022 and was not surveyed at the same level of detail compared to the rest of the study area (**Figure 1**).

2.2. Methods

The following methods and approach were applied as part of this study:

- Existing spatial datasets that indicate potential watercourses and ecologically important areas were used as part of an initial desktop approach. These include the following:
    - The 1:50 000 river line dataset of the study area and its surroundings was used, as illustrated on the relevant topographic maps (2530AA Draaikraal and 2530AC Dullstroom).
    - The 2013-14 South African National Land Cover (SANLC) dataset, which indicates wetlands based on the globally available Landsat 8 imagery (GTI, 2015).

  - Wetland areas indicated on the 2020 South African National Land Cover (SANLC) dataset (GTI, 2021)
  - Creation of a Topographic Wetness Index (TWI) for the study area created from a digital elevation model (DEM) that was made from 10 m contour line data obtained from the Surveyor General and SAGA GIS software. The TWI illustrates areas with expected higher than average soil moisture conditions based on topography (landscape position).
  - The National Biodiversity Assessment (NBA) spatial wetland layer version 5, referred to as National Wetlands Map 5 (Van Deventer *et al.*, 2018).
  - Interpretations from a georeferenced old aerial photograph from 1964 and recent aerial imagery available in Google Earth Pro.

- A total of nine days of site surveys were undertaken in October 2021, February 2022 and March 2022. Wetlands, riparian habitats and natural channels were identified within the study area through the procedure described by the Department of Water and Sanitation (DWS; previously also known as DWAF and DWA), (DWAF 2005; DWAF, 2008).
- Available wetland indicators that were investigated included the presence of hydromorphic (wetland soil) features, the presence of wetland plant species (hygrophytes and hydrophytes) and terrain unit indicators, while natural channels were identified based on channel features and riparian habitat.
- Priority was given to plant species changes to inform the delineation process due to the size of the study area, its remoteness and inaccessibility in areas, and the nature of the proposed project (establishment of a private nature reserve). Less emphasis was therefore placed on recording hydromorphic (wetland soil) indicators, but the latter was still used in various locations across the study area.
- Identified wetland areas and other watercourses were delineated and classified into predetermine Biodiversity Management Units, specifically watercourse associated BMUs 5, 7 and 11 (De Castro, 2021; De Castro in prep.), were delineated into GIS polygon shapefiles, which were used to create maps.
- All natural wetlands delineated as part of BMU 5 within the study area were classified according to the recently completed 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' up to the hydrogeomorphic (HGM) level (Ollis *et al*. 2013).
- The HGM classification system is based on three key parameters pertaining to the wetland: the geomorphic setting of the wetland, the source of water inputs into the wetland, and its hydrodynamics (how does water move through the wetland), (Brinson 1993; Kotze *et al*. 2008).
- Soil organic carbon (SOC) were determined for samples from selected wetlands with expected high organic carbon content through the Walkley-Black method (eight samples analysed in 2022) and through the loss of ignition method (two samples in 2021). Wetlands with high organic content were identified based on observed site conditions, such as feeling vibrations while walking, which is typical of peatlands. Soil organic carbon was also converted to soil organic matter (SOM) through the conventional Van Bemmelen factor of 1.724 and a more recent conversion factor of 2.0 as described by Pribyl (2010).

- Present Ecological State (PES) assessments were undertaken for an example of each type of wetland within the study areas. A PES assessment compares the current condition of a wetland to its perceived reference condition (pristine/pre-disturbance), in order to determine the extent to which a particular wetland has been modified from its reference condition (Macfarlane *et al*., 2008; Rountree et al., 2007). A Level 1 PES assessment was undertaken of assessed wetlands based on the WET-Health method developed by Macfarlane *et al*. (2008).
- The A→F scale represents a continuum, and that the boundaries between categories are notional, artificially defined points along the continuum. This situation can be described by the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes (**Table 2**). For practical purposes, these situations are referred to as boundary categories and are denoted as B/C, D/E, etc. A similar approach can be applied to the determination of EIS categories.
- An Ecological Importance and Sensitivity (EIS) assessment of identified natural wetland areas were undertaken to provide an indication of the conservation value and sensitivity of delineated wetlands. The applied EIS wetland assessment was based on the classes indicated in **Table 3** and the following criteria (Rountree *et al.,* 2013):
    - Habitat uniqueness
    - Species of conservation concern
    - Habitat fragmentation with regards to ecological corridors
    - Prominent ecosystem services
- Ecosystem services performed by selected wetlands were assessed using the new WET-EcoServices (Version 2) method developed by Kotze *et al.,* (2020).

Table 2: Description of A – F Present Ecological State (PES) categories for wetlands, ranging from "Natural" (Category A) to "Critically Modified" (Category F), MacFarlane *et al.*, 2008).

Category		**Description**	**Combined impact score (Macfarlane *et al.*, 2008)**
A	Natural	Unmodified, Natural.	0-0.9
B	Largely Natural	Few modifications, small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	1-1.9
C	Moderately Modified	A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	2-3.9
D	Largely Modified	Large loss of natural habitat, biota and basic ecosystem functions has occurred.	4-5.9
E	Seriously Modified	The losses of natural habitat, biota and basic ecosystem functions are extensive.	6-7.9
F	Critically Modified	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	8-10

Table 3: Indicates Ecological Importance and Sensnsitivity (EIS) categrories for wetlands, as well as categories for direct human benefits and hydro functional importance (Rountree *et al*, 2013).

Ecological Importance and Sensitivity Category (EIS)	Range of Median	EIS Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these watercourses 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.	4	**A**
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these watercourses may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>3 and <4	**B**
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these watercourses 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.	>2 and </=3	**C**
Low/Marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these watercourses 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.	>1 and </=2	**D**
None: Wetlands that are rarely sensitive to changes in water quality/hydrological regime.	0 and </=1	**E**

3. RESULTS

3.1. Catchment setting, vegetation and land use

The study area is situated in a mountainous area that incorporates the Steenkampsberg, located primarily on the De Berg, Triangle, and Goedehoop, as well as the north-south orientated Dwarsberg, which are primarily located on Sterkfontein (**Figure 1**). These two mountain ranges have different geological origins, with the metamorphic quartzites of the Steenkampsberg being associated with the Transvaal Supergroup, while the igneous ultramafic rocks (e.g., norites) of the Dwarsberg are associated with the younger Bushveld Igneous Complex, which contains some of the richest ore deposits on Earth (Eales, 2001). This mountainous area study area overlaps with the headwaters of three different quaternary catchments and prominent rivers, namely B41F (Klip River), B41G (Dwars River), and B42F (Waterval River). The Present Ecological State (PES) of the quaternary catchments range from class B (largely natural) to Class C (Moderately modified), while their Ecological Importance and Sensitivity (EIS) range from Very high to Moderate. All three quaternary catchments form part of the Olifants Water Management Area (WMA), while the catchment divide between the Olifants and Inkomati WMAs is located approximately 1.25 km southeast of the study area.

The southern-eastern half of Goedehoop overlaps with the Mpumalanga Drakensberg Strategic Water Source Area (SWSA), as indicated on the SWSAs of South Africa, Lesotho and Swaziland spatial layer (Nel *el al*., 2013). The study area overlaps with a category 3 SWSA, which represents areas that supply ≥50 % of South Africa's water supply and are therefore regarded as national Strategic Water Sources Areas (Nel *et al*., 2013).

The difference in elevation within the study area is close to a remarkable 960 m, ranging from approximately 1370 masl at the lowest point where the Dwars River exists Sterkfontein (based on 10 m contour lines for topographic map 2530AA), to 2330.9 masl at the highest point in De Berg (as indicated on topographical map 2530AA), (**Figures 1 and 2**). This peak on De Berg is also the highest point in Mpumalanga Province. The large difference in elevation range is one of the main reasons for the high diversity in plant communities, and the presence of both savanna and grassland biomes within the study area (De Castro in prep). The regional vegetation classification by Mucina and Rutherford (2006) does not include the savanna biome within the study area as it was done at a much coarse scale. Mucina and Rutherford (2006) classify the vegetation of the study area into two montane grassland associated vegetation units, namely Sekhukhune Montane Grassland in the western half of the study area, and Steenkampsberg Montane Grassland in the eastern half. De Castro (in prep) identifies and describe a total of 10 Biodiversity Management Units (BMUs) within the study area based on floristic characteristics, of which three are watercourse associated, namely BMUs 5, 7 and 11 (**Figure 3; Table 4**).

The study area overlaps with not one, but two, listed Threatened Ecosystems according to the 2011 Schedule (Government Gazette of December 2011) of the National Environmental Biodiversity Act (Act 10 of 2004), namely Sekhukhune Mountainlands (MP 9) in the western portion of the study area, and Dullstroom Plateau Grasslands (MP 4) in the eastern half. Both of these Threatened Ecosystems are regarded as Endangered, while the Sekhukhune Mountainlands and the Sekhukhune Montane Grassland vegetation unit also form part of the Sekhukhune Centre of Plant Endemism (SCPE). The Steenkampsberg Montane Grassland forms part of the Steenkampsberg Sub-centre of Endemism that is part of the Lydenburg Centre of Plant Endemism. It follows that all parts of the study area fall within one of two Centres of Plant Endemism, namely the Sekhukhuneland Centre of Plant Endemism (SCPE) (Siebert, 1998 and Van Wyk & Smith, 2001) and the Lydenburg Centre of Plant Endemism (LCPE) (Lötter, 2019).).

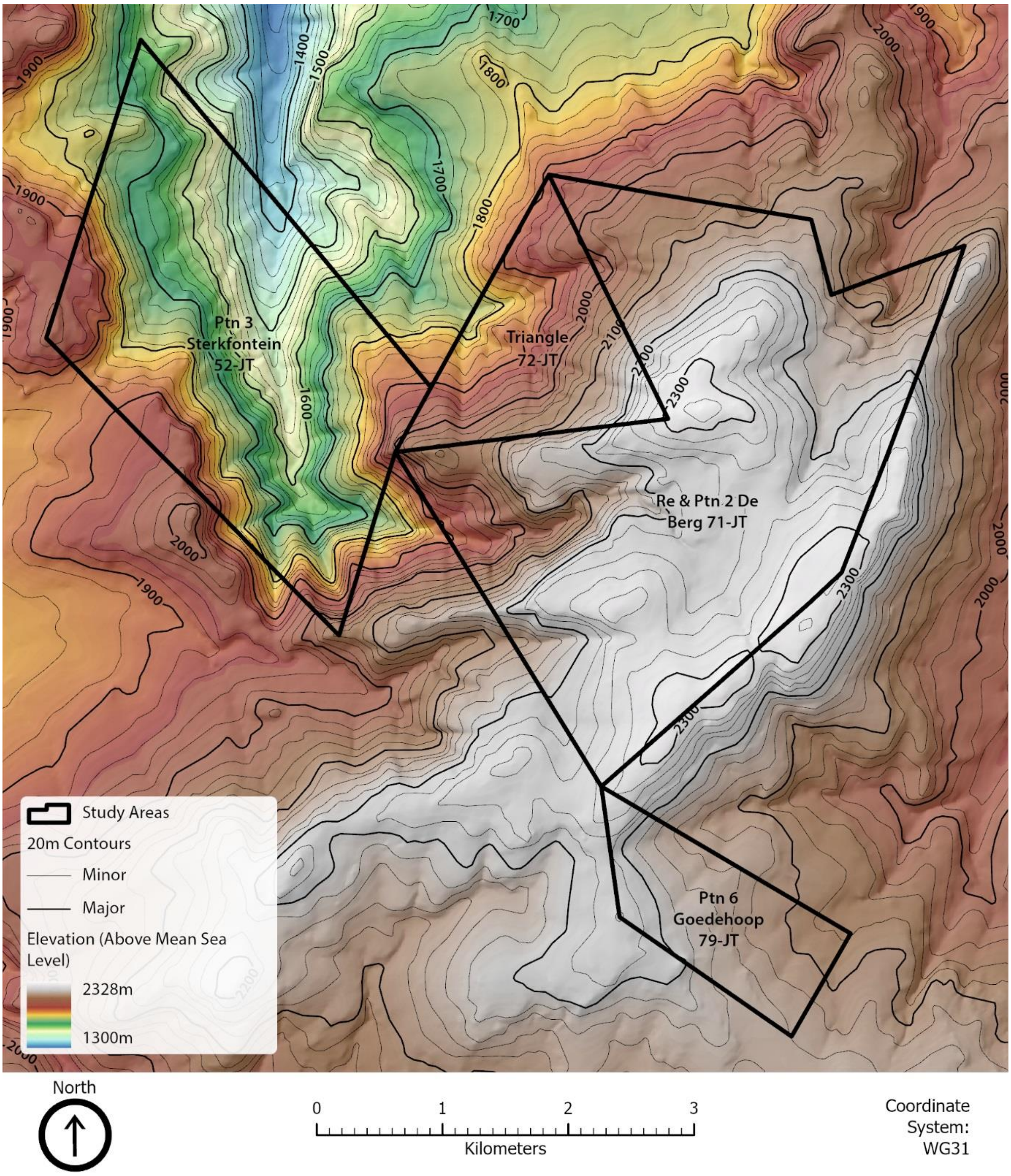


Figure 2: Changes in elevation within the study area as determine from a digital elevation model (DEM).

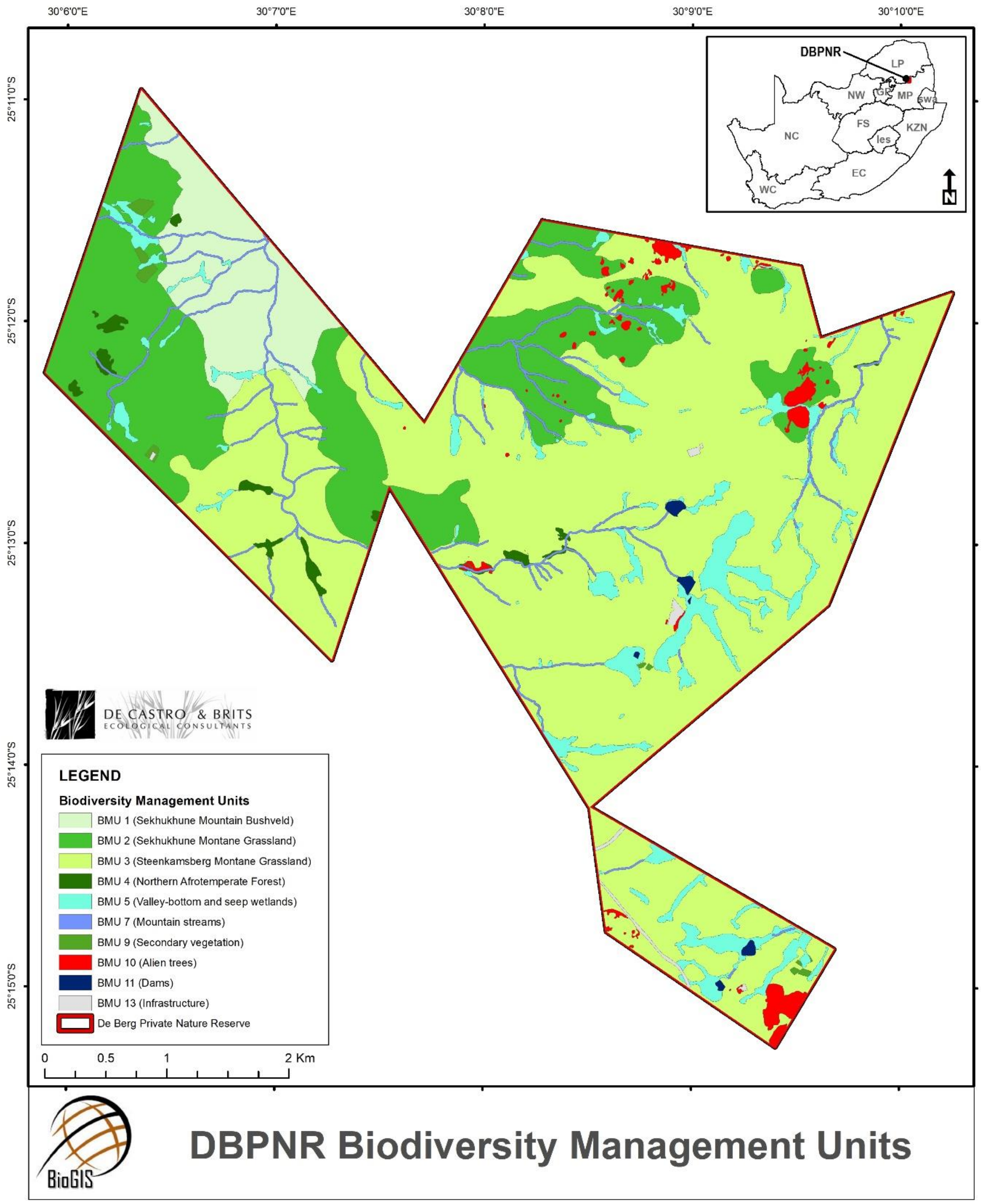


Figure 3: BMUs delineated and described for the DBPNR study area.

Table 4: List of BMUs delineated and described by De Castro (in prep.) for the DBPNR study area and whether they are assocaited with terrestrial habitat (highighted in green), or wetlands and other watercourses (highlighted in blue).

BMUs in the DBPNR study area	**Terrestrial or watercourse associated**
BMU 1: Sekhukhune Mountain Bushveld	Terrestrial habitat
BMU 2: Sekhukhune Montane Grassland	Terrestrial habitat
BMU 3: Steenkampsberg Montane Grassland	Terrestrial habitat
BMU 4: Northern Afrotemperate Forest	Terrestrial habitat
BMU 5: Valley-bottom and seep wetlands	Watercourse associated
BMU 7: Mountain streams	Watercourse associated
BMU 9: Secondary vegetation (historical cultivation)	Terrestrial habitat
BMU 10: Alien trees	Terrestrial habitat
BMU 11: Dams	Watercourse associated
BMU 13: Infrastructure	Terrestrial habitat

It has furthermore been confirmed that various endemic plant species from the two different hotspots of endemism are common across the study area, which includes wetland associated endemic plants and plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al*., 2009), (De Castro, in prep.; **Appendixes A and B**). Vegetation within the study area is largely untransformed with few signs of disturbance. The mountainous setting of the site results in steep slopes and rocky soils have excluded cultivation from the area, apart from small, localised patches, such as in Sterkfontein. The main signs of transformation in the study area include infrastructure, such as the access road to a communications tower facility in De Berg, six dams, and stands of alien trees, which includes a large remaining *Eucalyptus* spp. plantation on Goedehoop (De Castro, in prep.; **Figure 3**).

The recent addition of Goedehoop to the DBPNR study area provides it with direct connection to the existing Verloren Vallei Nature Reserve, located south of the study area. The establishment of the proposed DBPNR will therefore expand and create a larger and continuous protected area (**Figure 4**).

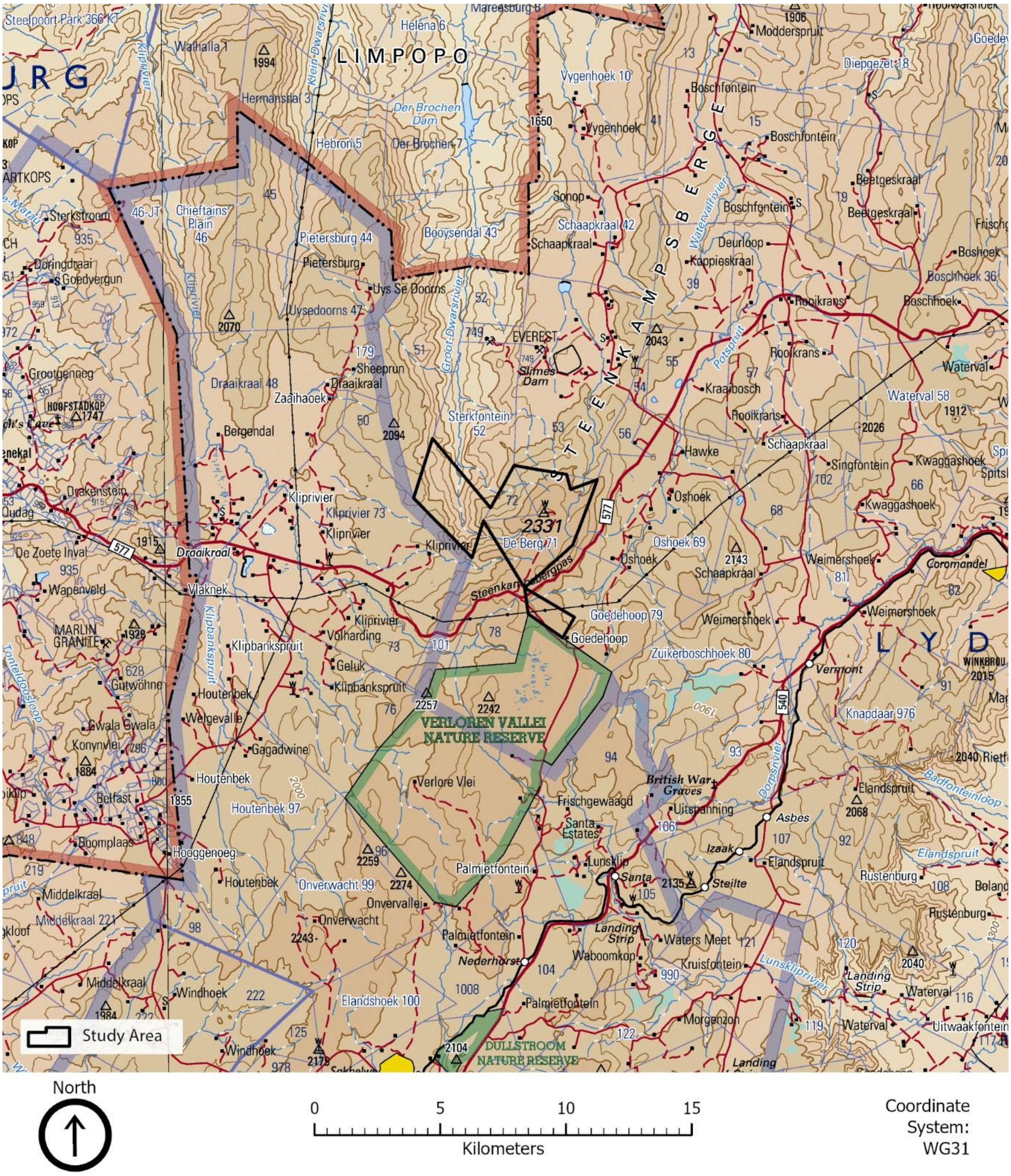


Figure 4: Illustrates the direct connection of the DBPNR study area to Verloren Vallei Nature Reserve.

3.2. Identified indicators and watercourses associated BMUs

Topographical map 2530AA does not indicate the presence of any wetland within the study area, while the National wetland Map 5 (Van Deventer *et al*., 2018) indicates the presence of wetlands in the form of seeps in De Berg and Goedehoop (**Figure 1**). The 2013-2014 South African National Land Cover (SANLC) and 2020 SANLC datasets indicate the presence of wetlands only within Sterkfontein and De Berg, with the former specifically containing wetland habitat along the drainage line that becomes the Groot-Dwars River. **Figure 5** illustrates areas in blue that have a higher probability to have increased soil moisture conditions in the study area as created by a GIS model and DEM. Areas of expected increased wetness correlate well with drainage lines present on the 1:50000 topographical map (2530AA).

Headwater drainage lines are common within the study area in areas with convergent contour lines, which is numerous for mountainous areas with steep slopes, as is indicated on topographical map 2530AA (**Figure 1**). Mountain streams delineated and described as BMU 7 by De Castro (2021) and De Castro (in prep.) are indeed present along these headwater drainage lines indicated on the topographical map, especially on steep slopes, and contain azonal vegetation habitat that differs from surrounding terrestrial areas (De Castro, 2021).

All identified and delineated wetland areas, mountain streams and dams in the study area form part of BMUs 5, 7 and 11 and have a combined surface area of 191.35 ha, which forms 9 % of the study area (**Table 5**). These three BMUs are collectively referred to as watercourse associated BMUs, as the features they contain (wetlands, mountain streams, and dams), are consistent with the definitions of a watercourse, as described in the National Water Act (NWA). All delineated watercourse associated BMUs in the study area are illustrated in **Figure 6.** This map is one of the primary outcomes of this study, as it identifies all known and expected wetlands and other watercourses that need to be managed collectively for biodiversity.

3.2.1. BMU 5 (Valley bottom and seep wetlands)

Wetlands delineated and classified previously during the 2021 Booysendal botanical baseline study, included channelled valley bottom, unchannelled valley bottom and seep wetlands, which were all grouped into BMU 5 (De Castro, 2021). These same wetlands were found to be present within the DBPNR study area, meaning that BMU 5 could be used in the same manner as in the 2021 study to incorporate wetland habitats in the current study. BMU 5 has the largest surface area of all three watercourses associated BMUs, with a size of 132.29 ha (**Table 5; Figure 6**). This is much larger than wetland habitat indicated in the study area through existing spatial datasets only, such as the National Wetlands Map 5 and the 2020 South African national land cover (SANLC) dataset.

All wetland habitat within BMU 5 can be classified into hydrogeomorphic (HGM) types, based on the classification system developed by Ollis *et al*., (2013), entitled ‘Classification System for Wetlands and other Aquatic Ecosystems in South Africa’. The HGM classification system is based on three key parameters pertaining to a wetland, namely the geomorphic setting of the wetland, the source of water inputs into the wetland, and its hydrodynamics (how water moves through the wetland). The three different HGM types applicable to BMU 5, namely channelled valley bottom, unchannelled valley bottom and seep wetlands described by De Castro (2021) and confirmed in the current study, are further described and illustrated in **Appendix C**. Seep wetlands are the most common type of wetland across the entire study area, while channelled and unchannelled valley bottom wetlands are restricted to areas with lower longitudinal slopes in De Berg and Goedehoop (**Appendix C**).

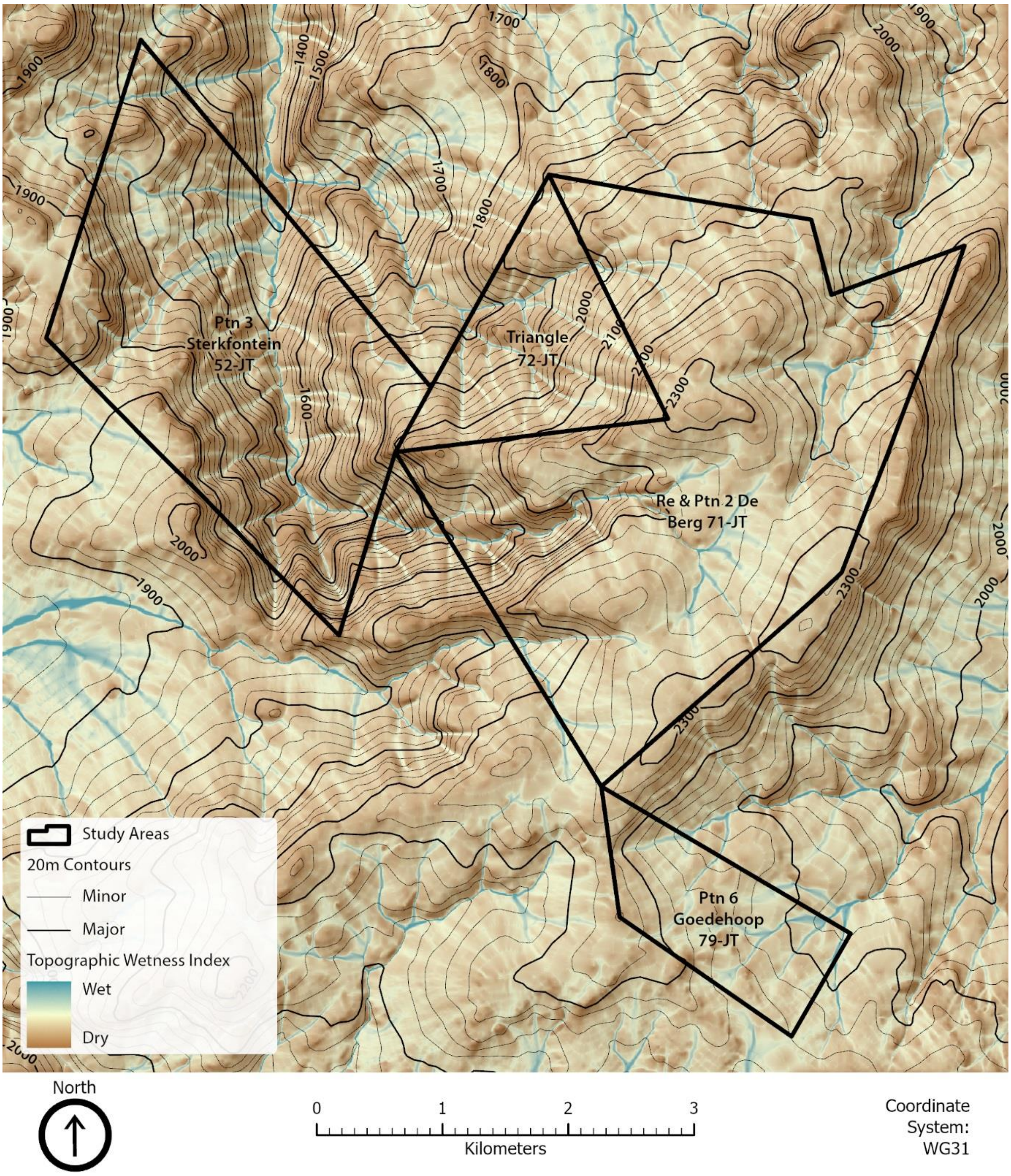


Figure 5: Topographic Wetness Index (TWI) of the study area created from a DEM and SAGA GIS software.

Table 5: Surface area of all watercourse-associated BMUs (5, 7 and 11) in the study area.

BMU name	Surface area
BMU 5 (Valley-bottom and seep wetlands)	132.29 ha
BMU 7 (Mountain streams)	54.29 ha
BMU 11 (Dams)	4.76 ha

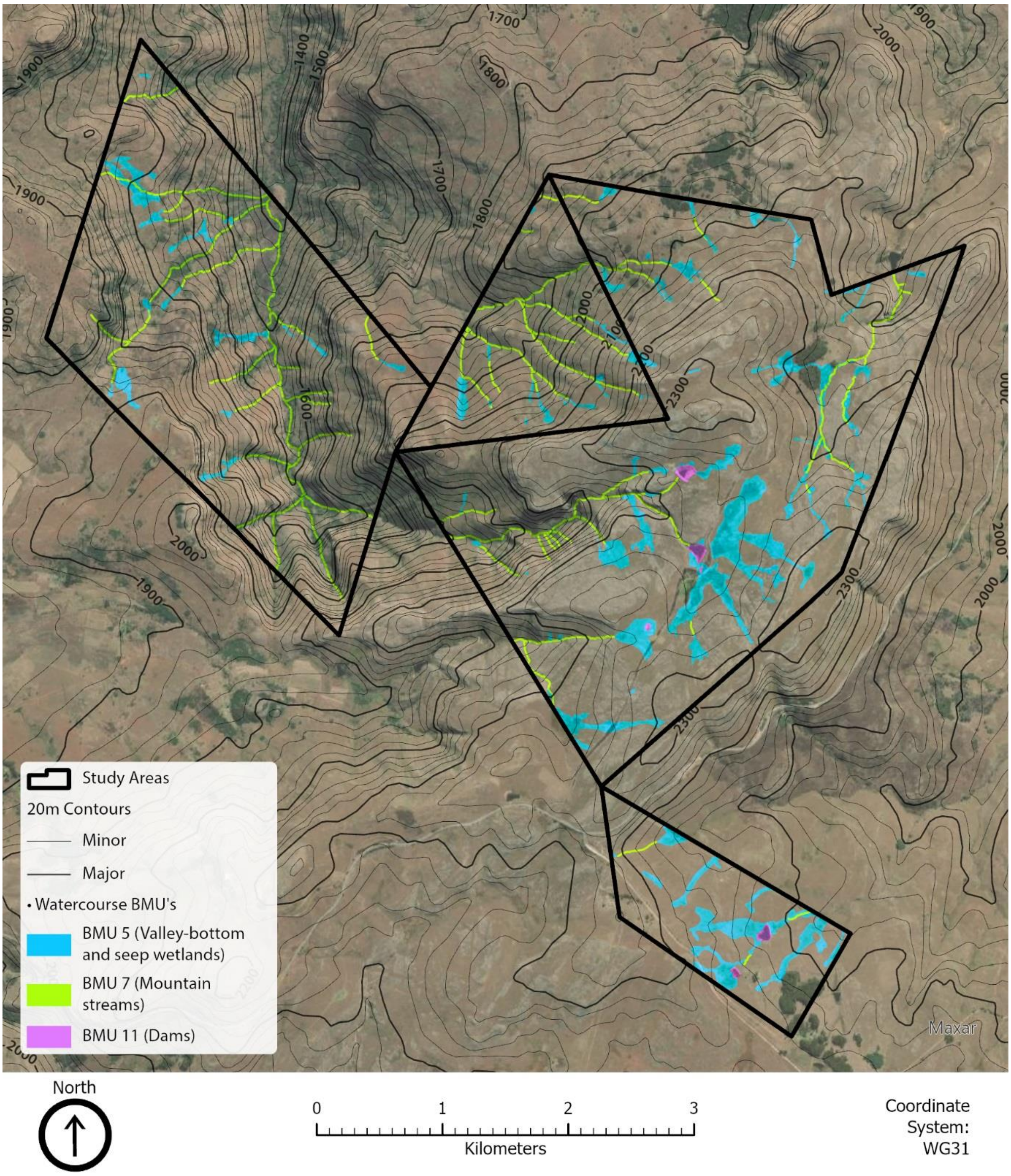


Figure 6: Aquatic BMUs (5, 7 and 11), delineated within the study area.

De Castro (2021) describes BMU 5 and the range of wetland diversity therein below, while examples of wetlands identified and classified as part of BMU 5 are illustrated in **Figure 7**:

> *Includes the hygrophytic and hydrophytic grass and sedge-dominated wetland plant communities on hydromorphic soils of channelled and unchanneled valley-bottom wetlands and seeps. This unit also includes the following spatially restricted habitats each of which contains plant communities that are distinct in terms of vegetation structure and are of elevated biodiversity conservation importance: 1, channelled valley-bottom wetlands with subterranean channels exposed in intermittent sinkholes, restricted to high plateau grassland in BMU 2 at ca. 2 000 masl on deep soils overlying igneous geology (norite); 2, actively forming peat wetlands (mires) situated within valley-bottom wetlands and seeps on the farm De Berg; 3, sheetrock wetlands which comprise areas of exposed bedrock (both norite and quartzite), with patches of shallow to skeletal soils, located on mountain slopes or terraces and which have experience temporary or seasonal surface flow and soil saturation. This unit contains an exceptionally high concentration of plant SCC and as yet undescribed taxa, and provides habitat for numerous spatially restricted habitat specialists (lithophytes and hygrophytes).*

Wetlands are associated with prolonged periods of soil saturation, which can also include temporary to permanent inundation. This results in the creation of anaerobic conditions, which can result in specific soil signatures such as low chroma matrix colours, spots of iron depletion, or mottling, depending on the duration and frequency of anaerobic conditions. Mottling occurs near the soil surface (top 0.5 m) when there is a flux between wetting and drying cycles (anaerobic to aerobic conditions), with anaerobic condition lasting for a least a few weeks per year to produce these signatures over time (DWAF, 2005 and 2008). Organic matter also accumulates under anaerobic conditions where plants with unique adaptations can still actively grow. Wetlands are also associated with low energy environments, where water moves slowly through the landscape, often with in a dispersed flow pattern and a strong reliance on interflow in the soil profile.

Figure 8 illustrates a range of hydromorphic indicators and other signs of wetness recorded in BMU 5, which include features such as organic enrichment in the A horizon, low chroma matrix colours with mottles, soils with a high organic carbon content that can include peat in instances (Section 3.3.1.), iron precipitation where groundwater (moving in the soil profile) discharges, and pug marks caused by game in areas that are, or were, previously saturated.

Bleached and light soil matrix colours were common in shallow soils that developed on weathered quartzite, which was not uniformly regarded as hydromorphic features caused by iron removal during anaerobic conditions. Light soil matrix colours can also be contributed to an expected low iron content in quartzite derived soils. In addition, these soils develop into a sandy texture with a comparatively lower clay content than most other soils, making leaching and water movement easier due to a higher hydrological conductivity. Pedogenesis on quartzite can therefore result in soils with a light/bleached colour that developed without the presence of wetland conditions. Areas identified as wetland habitat that contained dominant bleached/light colours in the topsoil profile, also had to contain other wetland indicators, such as mottling, hygrophytes and/or hydrophytes to be considered as wetland habitat.

Figure 7: Examples of different wetlands within BMU 5, such as a wide seep wetland on shallow soils in die De Berg (1st row panel); a channelled valley bottom wetland in De Berg (2nd row panel); a seep wetland feeding into a mountain stream in De Berg (3rd row panel); and a seep transitioning into a channelled valley bottom wetland at Goedehoop (4th row panel).

Figure 8: Recorded hydromorphic and non-typical wetland indicators recorded, such as mottles and low chroma matrix colour (1st row left panel), organically enriched A horizons ((1st row right panel), organic topsoil horizons (2nd row left panel), peat (2nd row right panel), visible seepage with an oily layer and orange rust-like colour caused by iron precipitation (3rd row left and bottom row panels); and pug marks in grey soils (3rd row right panel).

Wetlands previously assessed as part of BMU 5 in the large Booysendal study area of 12 950 ha, which overlaps with the DBPNR study area apart from Goedehoop, was found to contain 220 plant species (De Castro, 2021). These include hydrophyte and hydrophyte species that also occur within wetlands in the DBPNR study area. For the purposes of this study two broad terms defined by Retief and Herman (1997) are used. These terms, with some additional clarification provided by the author, can be defined as follow:

- Hygrophyte: Defined by Retief and Herman (1997) as '*marsh plants or plants that need a large supply of moisture for their growth*'. In the current report this term encompasses not only marsh plants, but all plants that occur in areas that have elevated soil moisture content in comparison with those of the surrounding landscape. These areas have soils that are usually seasonally saturated but not permanently saturated, and which may or may not be periodically (at intervals of a few years) or even seasonally inundated, but only for short periods (a few days or weeks).
- Hydrophyte: Defined by Retief and Herman (1997) as *'plants living in water or in very moist habitat; an aquatic plant*'. In the current report this term encompasses all submerged, floating leaved and emergent species that occur in areas that are usually seasonally or permanently inundated, and which usually have permanently saturated soils.

Hydrophytes and hygrophytes occur across a wetness gradient and two additional terms have been developed that can be used to provide additional information regarding their habitat preferences, namely 'facultative' and 'obligate', as defined Bailey (1999). These two terms can be defined as:

- Facultative: '*possessing the ability to utilise certain circumstances or environmental conditions but not dependent upon them'* (Bailey, 1999). For example, a facultative hygrophyte may occur, even as a dominant, on moist soils but may also occur in mesophytic habitats, such as moist grasslands that are not sufficiently wet to be regarded as wetland habitat. A facultative hydrophyte is a species that occurs predominantly in seasonally inundated and/or saturated areas but may also occur in areas that are never inundated and do not have permanently saturated soils.
- Obligate: '*having a specific requirement for a particular environmental factor or mechanism (e.g., seasonal inundation of soils) and being unable to function or survive if it is not available*' (Bailey, 1999).

It is important to note that all species regarded as 'obligate hydrophytes', 'facultative hydrophytes' or 'obligate hygrophytes' in this report, are either 'facultative wetland species' or 'obligate wetland species', as defined in the DWAF wetland delineation document (DWAF, 2005 and 2008). **Table 6** provides a list of examples of recorded hydrophyte species that occur in wetland habitat in the study area, and surroundings, as part of BMU 5 (De Castro, 2021 and De Castro in prep.). This list is by no means exhaustive, but merely present examples and focus specifically on confirmed plant SCC that occur in BMU 5 in the study area. The separation of species into hygrophytes and hydrophytes is based on the experience of the author and literature sources, such as Retief and Herman (1997), (**Table 6**). Please note that obligate hygrophytes and facultative hydrophytes occupy similar habitat niches, and the differentiation can be subjective.

Table 6: Examples of recorded and expected hygrophyte and hydrophyte species in BMU 5, as described by De Casto (2021) and selected excerpts from the DBPNR botanical study (De Castro in prep).

Examples of recorded hygrophyte species in BMU 5 (facultative and obligate)	**Examples of recorded hydrophyte species in BMU 5 (facultative and obligate)**
Sedges and rushes	
	Carex cognata
	Cyperus denudatus
	Eleocharis dregeana
	Isolepis fluitans
	Juncus lomatophyllus
	Kyllinga erecta
	Pycreus nitidus
	Schoenoplectus corymbosus
	Scleria spp.
	Typha capensis
Grasses	
Andropogon appendiculatus	*Andropogon manii*
Aristida junciformis subsp. *junciformis*	*Leersia hexandra*
Cynodon dactylon	*Phragmites australis*
Eragrostis gummiflua	
Eragrostis plana	
Koeleria capensis	
Setaria incrassata	
Setaria sphacelata	
Themeda triandra	
Forbs and ferns	
**Alepidea* cf. *longeciliata*	**Alepidea attenuata*
**Amauropelta oppositiformis*	**Alepidea cordifolia*
Berkheya setifera	**Bulbine* sp. nov. aff. *capitata*
Chamaecrista mimosoides	*Dissotis canescens*
Chironia palustris subsp. *transvaalensis*	**Disa maculomarronina*
Crocossmia paniculata	**Gunnera perpensa*
**Disa alticola*	**Ledebouria* sp. nov. '*altipaludosus*' ined.
**Eucomis autumnalis* subsp. *clavata*	*Limosella maior*

Examples of recorded hygrophyte species in BMU 5 (facultative and obligate)	**Examples of recorded hydrophyte species in BMU 5 (facultative and obligate)**
**Gladiolus calcaratus*	*Monopsis decipiens*
Helichrysum aureonitens	*Pycnostachys reticulata*
Helichrysum kraussii	*Ranunculus multifidus*
Helichrysum nudifolium var. *pilosellum*	**Watsonia bella*
Helichrysum rugulosum	**Wurmbea viridiflora*
Haplocarpha lyrata	
Haplocarpha scaposa	
**Ledebouria* sp. nov. '*noritica*' ined.	
**Ledebouria* sp. nov. '*purpurea*' ined.	
Lobelia angolensis	
Pelargonium luridum	
Senecio erubescens	

*Indicate preliminary records of **15** plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al*., 2009), confirmed in BMU 5 within the DBPNR study area. See Appendixes A and B for a more detailed information that is yet to be finalised for SCC associated with wetland habitat in BMU 5 (De Castro, in prep).

3.2.2. BMU 7 (Mountain streams)

The mountain streams of BMU 7 are higher energy systems compared to wetlands in BMU 5, with faster flowing water that are most often contained within a channel. Rapids, cascades and waterfalls occur in mountain streams, but are not typical of wetlands. Seepage may also occur in mountain streams for periods of the year, but the main pattern of water movement is through surface flow within a channel, even if the flow is only ephemeral. Mountain streams in BMU 7 has a surface area of 54.29 ha within the study area (**Table 5; Figure 6**), which form part of headwater systems.

Headwater systems consists of a continuum of four topographical components, from terrestrial hillslopes to the development of first-and second-order channels (streams), as summarised by Gomi *et* al., (2002) and illustrated in **Figures 9 and 10**:

- Hillslopes, which have divergent or straight contour lines with no channelized flow.
- Zero-order basins, which have divergent contour lines and form unchannelised hollows.
- Transitional channels (ephemeral and intermitted channels) that have defined banks, as well as discontinuous segments along their length, and emerge out of zero-order basin.
- Well defined first and second-order streams that are continuous with either intermitted or perennial flow.

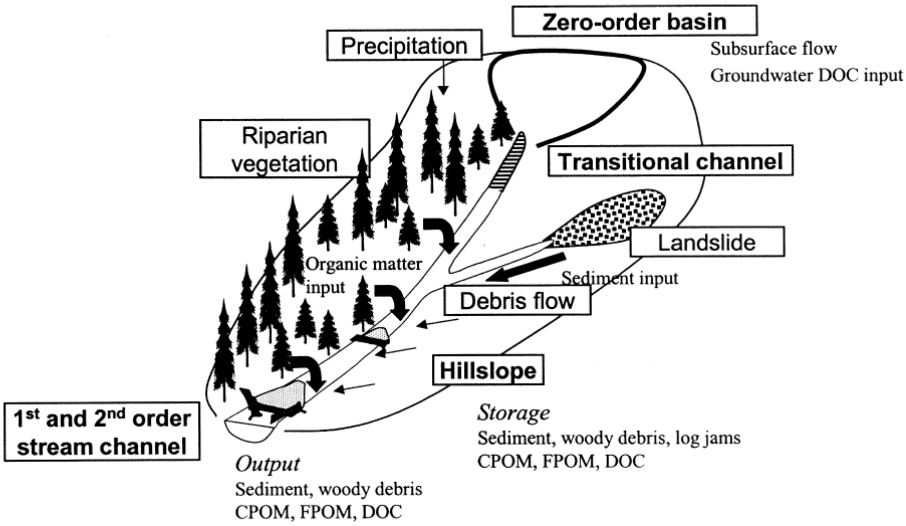


Figure 9: Structures in headwater systems consist of four topographical units namely zero-order basins, transitional channels and first and second-order channels (Gomi *et al*., 2002).

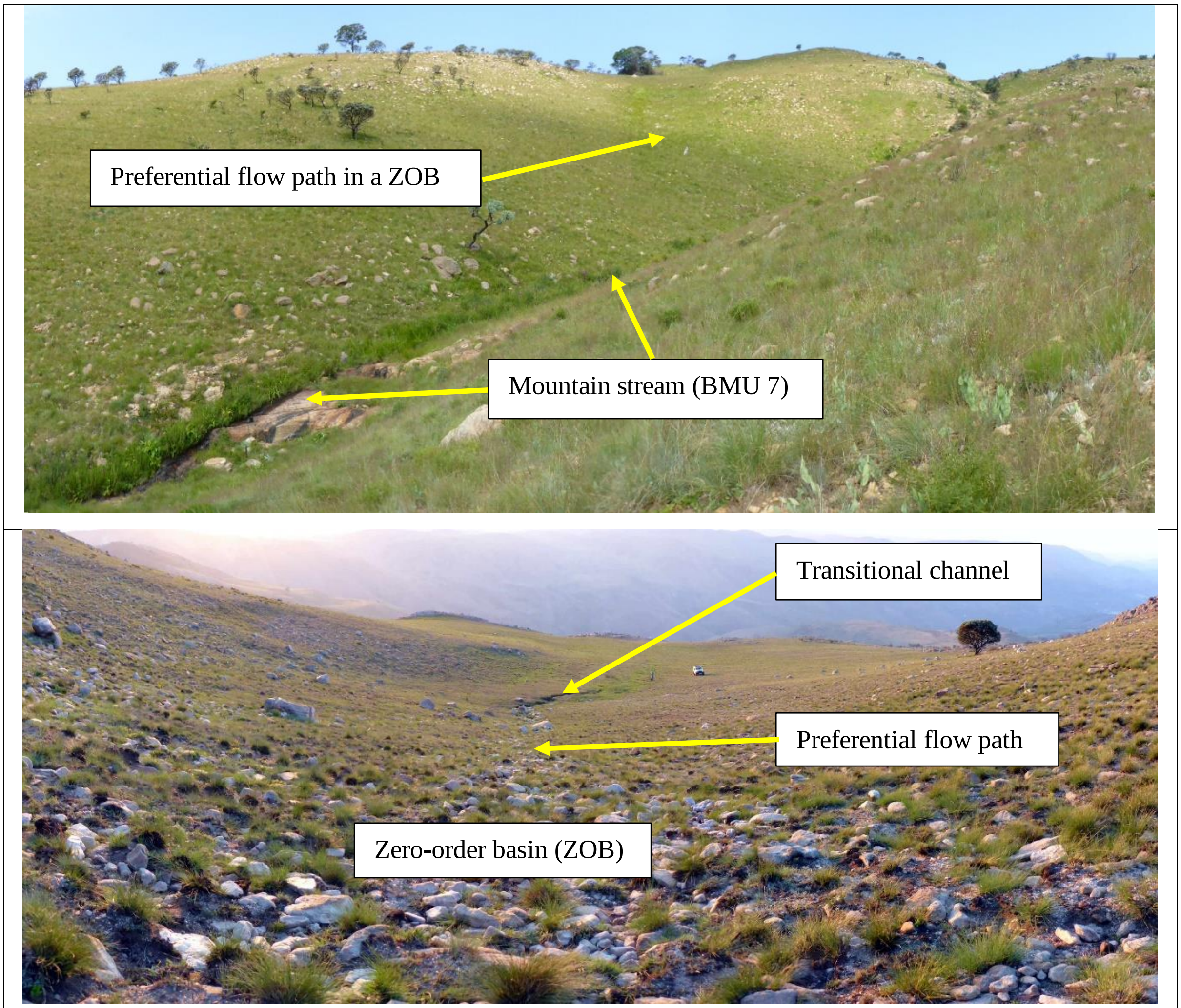


Figure 10: Illustrates examples of hollows with convergent contour lines regarded as zero-order basins (ZOBs), preferential flow paths in ZOBs, a transitional channel, and a mountain stream (included as part of BMU 5) in the study area.

Preferential flow paths form transitional channels in hollows with convergent contour lines, i.e., zero-order basins, but transitional channels lack a continuous natural channel (**Figures 9 and 10**). Runoff concentrated in preferential flow paths and transitional channels only occurs after rainfall events and for a short duration thereafter. Preferential flow paths and transitional channels were excluded from BMU 7. This is due to the absence of continuous channel features, their narrow width, and the purpose of the report, which is to map practical units associated with watercourses for biodiversity management. In addition, transitional channels are too inconspicuous and too similar to surrounding terrestrial habitat to justify inclusion into BMU 7. Only distinct headwater channels with continuous and well-defined channel bed and banks were included as part of BMU 7, irrespective of whether they were dry (ephemeral) or perennial, or whether trees or shrubs were present. Numerous mountain streams in BMU 7 contain no woody plant species, but still had species that differ from surrounding terrestrial areas (De Castro, 2021; **Table 7**). Some seepage is also possible in mountain streams of BMU 7, but the main hydrological process is associated with flow within a channel, which results in the development of woody and non-woody riparian habitat.

Figure 11 illustrates examples of mountain streams included as part of BMU 7 in the study area. All of the mountain streams comprising this BMU form part of the catchments of the Groot Dwars River, the Klip River, and the Potspruit, which becomes the Waterval River further downstream (**Figure 1**). De Castro (2021) provides the following description of BMU 7 (adjusted for the DBPNR study area):

> *Includes the azonal riparian plant communities of perennial and non-perennial mountain streams (mostly 1st, 2nd and 3rd order streams) which flow over both igneous, ultramafic rocks (mostly norite) and quartzites and arenite through all three major BMUs found within the study area, namely Sekhukhune Mountain Bushveld (BMU 1), Sekhukhune Montane Grassland (BMU 2) and Steenkampsberg Montane Grassland (BMU 3). The riparian vegetation of the steep, high altitude, upper reaches of these streams comprises herbaceous vegetation dominated by hygrophytic grasses and sedges, shrubland characterised by shrubs such as Cliffortia spp. or patches of Afrotemperate Forest (see BMU 4). The vegetation of the lower reaches of these streams usually comprises riparian woodland, often dominated by Lydenburgia cassinoides, or riparian thicket.*

Table 7: Examples of recorded and expected woody and non-woody species in BMU 7, as described by De Casto (2021) and selected excerpts from the DBPNR botanical study (De Castro in prep.), (Appendices A and B).

Woody species (shrubs and trees)	***Non-woody species (ferns, forbs, grasses and sedges)***
Cliffortia linearifolia	**Alepidea cordifolia*
Cliffortia nitidula	*Alsophila dregei* [=Cyathea dregei]
Cliffortia repens	*Andropogon appendiculatus*
Leucosidea sericea	*Andropogon eucomis*
Combretum erythrophyllum	
Ficus sur	*Arundinella nepalensis*
Halleria lucida	*Berkheya setifera*
**Ilex mitis*	*Berula repanda*
**Morella microbracteata*	*Botriochloa bladhii*
Morella pilulifera	*Botriochloa insculpta*
Morella serrata	*Cynodon dactylon*
Pittosporum viridiflorum	*Iashaemum fasciculatum*
Searsia pyroides var. *pyroides*	*Isolepis fluitans*
	**Merwillea plumbea*
	Miscanthus junceus
	Osmunda regalis
	**Pterygodium cooperi*
	Tulbaghia leucantha

*Indicate preliminary records of **7** plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al*., 2009), confirmed in BMU 7 (Mountain streams) within the DBPNR study area. See Appendixes A and B for a more detailed information that is yet to be finalised for SCC associated with BMU 7 (De Castro, in prep).

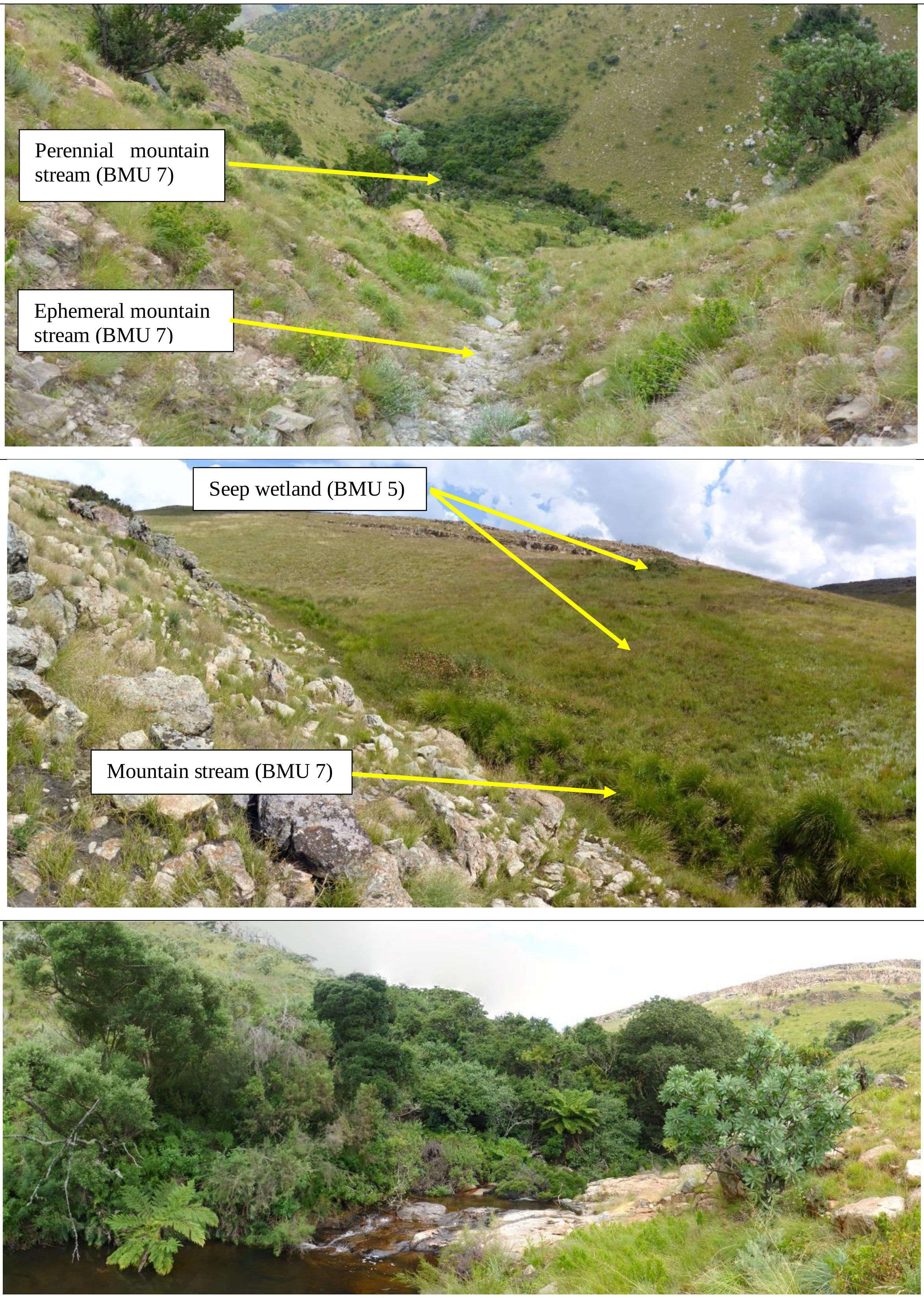


Figure 11: Illustrates examples of perennial and ephemeral mountain streams, with and without woody riparian habitat, which form part of BMU 7, as well as examples of connectivity between BMUs 5 and 7.

3.2.3. BMU 11 (Dams)

BMU 11 exists as six man-made dams that include five earth-walled farm dams and one old quarry excavation that contains water. The dams of BMU 11 have a combined surface area of 4.76 ha, with four of the six dams located in De Berg and the remaining two in Goedehoop (**Table 5; Figure 6)**. BMU 11 can be described as secondary wetland plant communities of the littoral and eulittoral zones of artificial wetlands (De Castro, 2021) that range in size from approximately 0.10 ha to 1.54 ha. Vegetation is dominated by hygrophytic and hydrophytic grasses and sedges. Artificial wetland habitat provided by dams are unlikely to provide significant habitat for unique plant communities or plant SCC (De Castro, 2021). They are furthermore regarded as impacts that affect the ecological condition of natural watercourses (BMUs 5 and 7) by submerging indigenous wetland and riparian vegetation, permanently modifying hydrological processes, and causing erosion downstream of spillways.

Dams built with spillways on rocky channels associated with BMU 7 are regarded as having a lower risk for causing downstream erosion, compared to dams with narrow spillways in wetland habitat. **Figure 12** illustrates an intact mountain steam (BMU 7) located on a bedrock channel, directly downstream of a dam spill way at coordinates 25°13’8.89’’S 30°8’56.18’’E. The spillway is, however, damaged by erosion and requires engineering intervention to help prevent the erosion of earth material from the dam embankment and possibly even trapped sediments behind the embankment, into the downstream watercourse (**Figure 12**).

Figure 12: Illustrates an intact mountain stream (BMU 7) with a bedrock channel bed located directly downstream of an eroded dam spillway.

3.3. Unique types of wetland habitat within BMU 5

It is important in a biodiversity management study to include descriptions of unique and spatially restricted wetland habitats, rather than only focussing on a wetland classification system based on HGM type. The HGM classification system is well suited to help assess the functionality of wetlands that have similar hydrological and geomorphological drivers (DWAF, 2007; Kotze *et al*., 2020; MacFarlane *et al*., 2008), but it underemphasises the importance of unique wetland habitats for biodiversity. Two important wetland habitats that form part of BMU 5 is highlighted as being of particular importance for biodiversity management, namely peat wetlands (mires) and sheetrock seep wetlands.

3.3.1. Peat wetlands (mires)

Organic matter can accumulate and undergo chemical changes if consistently favourably conditions last for long enough (decades to centuries rather than years) to form peat, which is the remains of plant litter that accumulated under very consistent water-saturated conditions through incomplete decomposition and chemical changes over time (Rydin and Jeglum, 2006). Peat is quantified by the amount of dead soil organic matter (SOM) that is present and is calculated from soil organic carbon (SOC) that is determine through total through procedures, such as the Walkley-Black method or loss of ignition method. Once the SOC of a sample has been determined it is converted to SOM by multiplying it with the conventional Van Bemmelen factor of 1.724 or the more recently revised factor of 2.0 as recommended by Pribyl (2010). Values of more than 30 % (dry mass) of dead SOM are regarded as peat internationally (Joosten and Clark, 2002). At a national level, the recently updated soil classification system for South Africa defines a peat topsoil horizon as follows (Soil Classification Working Group, 2018):

- *Contains more than 20 % organic carbon in environments associated with water inundation or at least water saturation for extended periods;*
- *Inundation, and/or water saturation must be recognised by the physical presence of water or inferred through lowland terrain positions capable of accumulating and storing water, or via wetland vegetation*

South African SOC criteria for the presence of peat make it stricter (more difficult) for a soil to classify as peat. Both the conventional Van Bemmelen conversion factor of 1.724 and the more recent Pribyl (2010) factor of 2.0, result in SOM % cut off values for peat that are higher than the 30 % SOM international specification of Joosten and Clark (2002), with resultant values of 34.48 % and 40 % SOM respectively. This is unexpected, as South Africa is largely a semi-arid country with lower peat reserves compared to countries in the northern hemisphere with far larger peat reserves, such as Canada, Scandinavia and Russia. **Table 8** provides a comparison of SOC and SOM values calculated for 10 different soils samples from different wetlands that appeared to have a high soil organic carbon content. Seven of the 10 analysed samples contained peat, while one of the remaining samples is a borderline case (**Table 8; Figure 13**).

Table 8: Summary of soil organic carbon (SOC) analysis and soil orrganic matter (SOM) using both the Van Bemmelen factor of 1.724 and the Pribyl conversion factor of 2.0 to identify the presnce of peat using international and local standardsSamples regarded as peat based on two or more indices are highlighted in green. The suspected presence of peat at four locations with nosamples collected, based purely on site observations, are also presented.

Sample number	Farm name in the study area	Sampled/ surveyed date	Latitude	Longitude	Soil Organic Carbon (SOC)	Soil Organic Matter (SOM) % Converting factor of 1.724	Soil Organic Matter (SOM) % Converting factor of 2	Status
P3a	De Berg	Apr-21	25°13'0.66"S	30°9'7.53"E	21.50 %	37.06 %	42.99 %	Peat confirmed
P4a	De Berg	Apr-21	25°13'16.81"S	30°9'1.81"E	40.88 %	23.71 %	47.42 %	Peat confirmed
BD 13	De Berg	14-Mar-22	25°13'18.78"S	30°9'15.89"E	13.80 %	23.79 %	27.60 %	Organic topsoil horizon
BD 27	De Berg	14-Mar-22	25°11'59.33"S	30°10'3.09"E	41.0 %	70.68 %	82.00 %	Peat confirmed
BD 34	De Berg	15-Mar-22	25°12'47.89"S	30°8'56.71"E	15.40 %	26.55 %	30.80 %	Organic topsoil horizon
BD 35	De Berg	15-Mar-22	25°12'54.66"S	30°9'13.29"E	41.50 %	71.55 %	83.00 %	Peat confirmed
BD 39	De Berg	15-Mar-22	25°13'18.79"S	30°8'58.58"E	21.10 %	36.38 %	42.20 %	Peat confirmed
BD40	De Berg	15-Mar-22	25°13'54.25"S	30°8'24.07"E	33.00 %	56.89 %	66.00 %	Peat confirmed
SF 17	Sterkfontein	15-Feb-22	25°11'28.38"S	30°6'10.12"E	25.40 %	43.79 %	50.80 %	Peat confirmed
GH 02	Goedehoop	15-Mar-22	25°14'57.53"S	30°9'34.38"E	6.20 %	10.69 %	12.40 %	Organic topsoil horizon
N/A	Triangle	17-Feb-22	25°12'32.88"S	30°8'27.02"E	-	-	-	Peat suspected
N/A	De Berg	Apr-22	25°13'16.19"S	30°9'29.70"E	-	-	-	Peat suspected
N/A	De Berg	Oct-21	25°13'51.07"S	30°8'17.58"E	-	-	-	Peat suspected
N/A	De Berg	Oct-21	25°12'24.90"S	30°9'34.79"E	-	-	-	Peat suspected

South African criteria specify > 20 % SOC for a topsoil horizon to be regarded as peat, values of >10 % and <20 % SOC are classified an organic topsoil horizon (Soil Classification Working Group, 2018).

International specifications require >30 % (dry mass) of dead SOM according to Joosten and Clark (2002), which can be calculated from SOC values in one of two ways, by either using the traditional Van Bemmelen conversion factor of 1.724 or using a more recent and more inclusive conversion factor of 2.0 recommended by Pribyl (2010).

Another 4 sites were identified in De Berg and Triangle with expected peat based on site conditions, such a raised domes and vibration while walking, but were not analysed (**Table 8; Figure 13**). Photos of some of the confirmed and expected peatlands identified in the study area are illustrated in **Figure 14**.

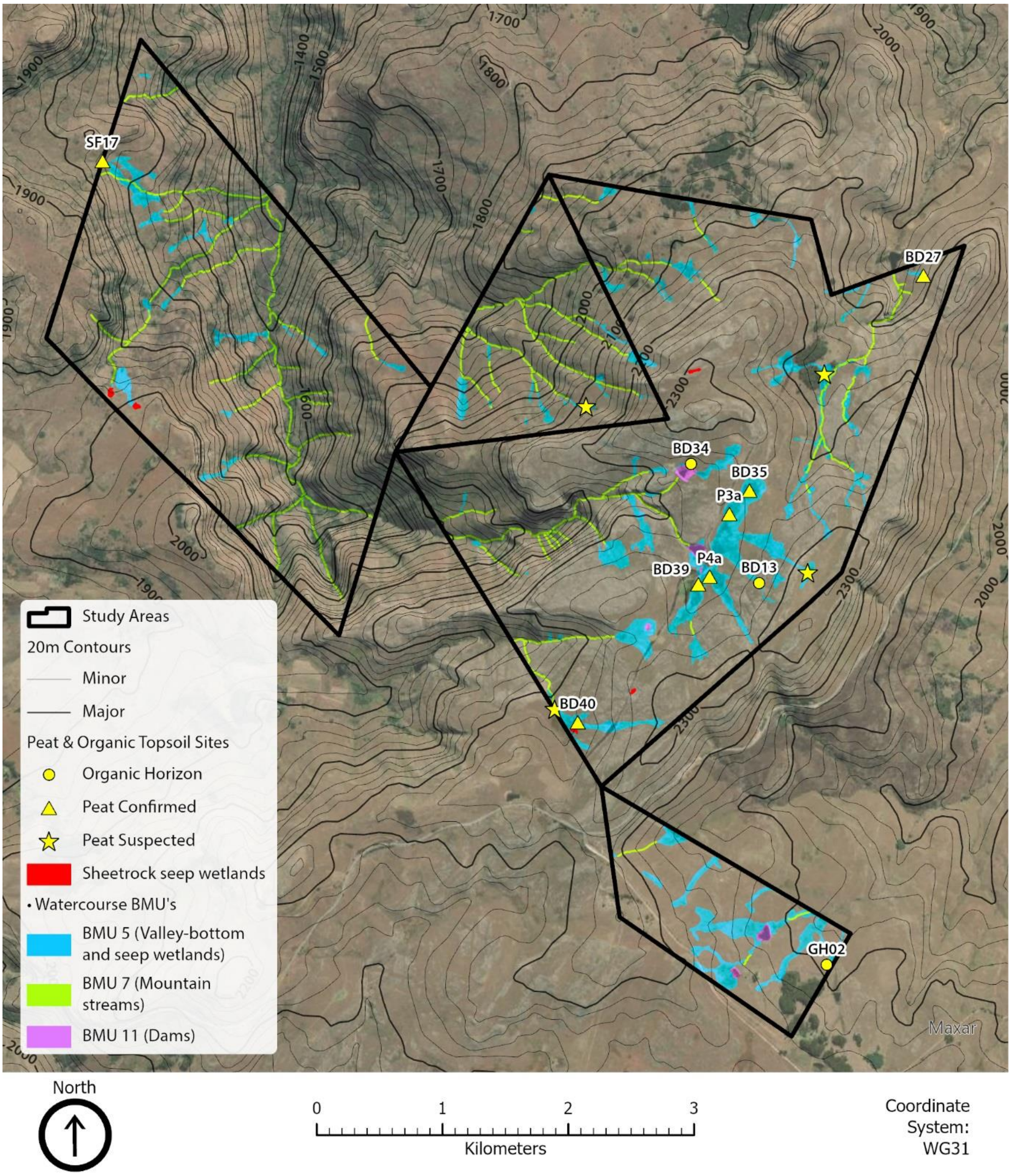


Figure 13: Illustrates confirmed and suspected peat topsoil horizons in wetlands, as well as organic topsoil horizons (Joosten and Clark, 2002; Soil Classification Working Group, 2018). Confirmed sheetrock seep wetlands are also illustrated, with many more unmapped ones present in the study area.

Figure 14: Examples of wetlands with confirmed peat include a domed peatland located on a perch, or a terrace, with a dense stand of the SCC *Watsonia bella*, at sample BD40 (1st row left panel), and a domed peatland located on a steep slope at sample BD27 (1st row right panel and 2nd row panel). Examples of suspected peatlands include a seep with permanent wetness conditions and high organic soils located on a terrace in Triangle (3rd row panel), and a seep wetland that was until recently bordered by a large plantation of *Eucalyptus* spp. (4th row panel).

The three samples analysed that do not qualify as peat, do meet the criteria for an organic topsoil horizon, which is defined as follows (Soil Classification Working Group, 2018; **Table 8; Figure 12**):

- *Is a surface horizon that contains an average of between 10 and 20 % organic carbon.*
- *Is subjected to extended periods of water saturation expressed variously as soil water in the surface horizon or upper surface horizon, or as rusty root channels; and has a terrain morphology position capable of receiving regular supplies of groundwater, river water or hillslope water.*

Recorded peat wetlands in the study area occur in the Central Highlands Peatland Ecoregion (Grundling *et al*., 2017) and form part of a group of peatlands associated with the Steenkampsberg Plateau. The majority of peatlands in the Central Highlands Peatland Ecoregion are concentrated within the Steenkampsberg Plateau, with artesian springs being common in some of these peatlands (Grundling and Grobler, 2005). Distinct signs of artesian springs were not observed within the study area, but recorded dome shaped peatlands may be associated with springs, which require further investigation in order to understand the hydrological drivers and process of these peatlands better. P

Grundling and Grobler (2005) refer to Lakenvlei Wetland Complex, located approximately 36 km south of the study area, as the largest and oldest known peatland in the Central Highlands Peatland Ecoregion, which was dated at 5 080 ± 50 years before present (BP) at a peat depth of 1.95 m. The peatland has subsequently been sampled to a depth of 4.2 m and this thickness can be used to infer a peat age of approximately 11 600 years, with an average peat accumulation of 0.36 mm/year (Grundling and Grobler, 2005). Using the same principle, it can be estimated that the mire at sample point P3a at De Berg, which has a peat thickness of close to 1 m, has an inferred peat age of approximately 2 500 years (**Table 8; Figure 13**).

All seven confirmed peat sites contain a thickness that qualify as peatlands based on site observations. A peatland is defined internationally as a peat covered terrain with a thickness of 0.40–0.30 m (Rydin and Jeglum, 2006). Recorded peat wetlands also qualify as ‘mires’ which are defined as wetlands that contain at least some peat and are dominated by living peat forming plants, such as sedges and mosses (e.g., *Sphagnum* spp.), (Rydin and Jeglum, 2006).

Six of the seven wetlands with confirmed peat substrate are located above 2000 masl, with only the wetland in Sterkfontein being the exception (sample SF17), occurring at an elevation of approximately 1740 masl based on the 10 m interval contour data (**Table 8; Figure 13**). All seven peatlands are new records of peat wetlands within the Steenkampsberg Plateau, which incorporate the four new records described by De Castro (2021). The nearest known wetland in the National Peatland Database is recorded less than 450 m southwest of the study area in Verloren Vallei Nature Reserve, located on the Farm Wanhoop 78-JT (Grundling, *et al*., 2017).

The confirmed peatland at Sterkfontein is however, of high significance as it represents the first known peatland within the Sekhukhuneland Centre of Plant Endemism based on available records in the National Peatland Database (Grundling *et al*., 2017). Grundling and Grobler (2005) mention that only 3 records of peatlands are known to be present in Verloren Vallei Nature Reserve, while 7 peat samples have been confirmed within the proposed De Berg Private Nature Reserve. However, more recent information indicate that 15 peat records have been listed in the National Peatland Dataset for Verloren Vallei Nature Reserve (Grundling *et al*., 2017), of which some are in the same wetland system.

De Castro (2021) mentioned that identified mires in the study area form highly spatially restricted habitats that contribute disproportionately to the levels of plant endemism and the number of plant SCC occurring within the study area. Examples of SCC associated with peatlands include the Endangered *Bulbine* sp. nov. aff. *capitata*, the Vulnerable (provisional) *Ledebouria* sp. nov. '*altipaludosus*' ined. and the Near Threatened *Watsonia bella* (**Appendix A**). Mires also contain interesting obligate hydrophytes, such as a carnivorous *Drosera* sp. and *Urticularia* spp. that are adapted to grow and thrive in nutrient poor (oligotrophic) environments, which is common in undisturbed mires and peatlands (Rydin and Jeglum, 2006). A change in plant species composition in peatlands can therefore be expected should an influx of nutrients occurs, such as nitrogen and phosphate associated compounds transported by runoff from point and non-point pollution sources. It must be emphasised that these pollution sources are presently absent from the study area, but they remain risks that should be considered in the future for infrastructure planning that may be required, such as recreational ablution facilities. Mires and peat wetlands are also dependent on regular saturation in order to achieve a positive netto rate of peat accumulation, or at least peat perseverance in a dry cycle. Mires and peat wetlands are consequently not only sensitive to water quality changes, but also to changes that may affect groundwater and soil water flow patterns and processes, which can include excavation and water abstraction activities.

3.3.2. Sheetrock seep wetlands

Sheetrock seeps wetlands (SRSWs) are inconspicuous and marginal wetland systems located on both noritic and quartzitic rock sheets that range from bare areas to pockets of deeper soil, often with signs of organic enrichment. Soils remain shallow (skeletal), and drainage is impeded by hard rock layers. Seepage is an important component that is present during the wet season, to create a mosaic of habitats with wetness, soil and micro relief differences. This creates habitats that are suitable for both terrestrial and wetland plant species to co-occur. The uniqueness of the habitat is further reflected by the occurrence of several plant SCC in these areas, such as the Endangered *Disa alticola* and *Ledebouria* sp. nov. '*noritica*' ined., the Vulnerable *Ledebouria* sp. nov. '*purpurea*' ined. and *Wurmbea viridiflora*, and the Rare *Amauropelta oppositiformis* (De Castro in prep; Appendix A).

The similarity in appearance of sheetrock seep wetlands to terrestrial habitat, especially during the dry season, creates a challenge to map these habitats accurately. The five identified and delineated sheetrock seep wetlands illustrated in **Figure 13** and referenced with coordinates in **Table 9** consequently do not represent all SRSWs within the study area, but only examples of them. Not all wetland specialists are expected to include SRSWs as wetlands in their investigations as they may lack typical hydromorphic indicators, such as mottling, and have a very limited soil depth. SRSWs do, however, present unique habitats with a very high biodiversity value that is dependent on seepage. Examples of SRSW habitats within the study area are illustrated in **Figure 15**.

Table 9: Coordinates for five identified sheetrock seep wetlands (SRSWs) within the study area with corresponding farm names and altitude in meatre above seas level (masl) based on 10 m interval countour lines for grid 2530AA.

Latitude	Longitude	Farm name in study area	Altitude (based on nearest 10 m interval contour line)
25°12'28.91"S	30°6'11.95"E	Sterkfontein	1880 masl
25°12'32.45"S	30°6'19.10"E	Sterkfontein	1910 masl
25°13'56.42"S	30°8'23.29"E	De Berg	2220 masl
25°13'46.60"S	30°8'39.92"E	De Berg	2280 masl
25°12'23.88"S	30°8'57.88"E	De Berg	2300 masl

Figure 15: Examples of high-altitude sheetrock seep wetlands within the study area at De Berg (1st and 2nd row panels) and slightly lower-lying SRSWs on norites at Sterkfontein (3rd row panel).

3.4. Ecological condition and ecosystem services associated of wetlands in BMU 5

Four different types of wetlands in BMU 5 are classified according to HGM types and are assessed in terms of their PES, EIS and ecosystems services. There are several more wetlands present, but these assessments are only intended to provide an overview of the ecological condition and services associated with different types of wetlands in the study area. The study area contains few disturbances, meaning that little variation is expected in the condition of different wetlands within HGM classes and habitat types. The four assessed HGM wetland units are numbered 1 to 4 and are summarised in **Table 10** and illustrated in **Figure 15**.

Table 10: HGM wetland types, surface areas and the presence of unique wetland habitat for four different wetlands of BMU 5 that are assessed in terms of their PES, EIS and ecosystem services.

HGM wetland type and number	Surface area	Description
HGM 1 - Unchannelled valley bottom wetland	0.65 ha	Peatland, sampled at P3a (**Table 8**)
HGM 2 - Channelled valley bottom wetland	1.50 ha	Peatland, sampled at BD39 (**Table 8**)
HGM 3 - Seep wetland	0.15 ha	Sheetrock seep wetland, located at 2300 masl with coordinates: 25°12'23.88"S 30°8'57.88"E
HGM 4 - Seep wetland	0.65 ha	Seep wetland, located at 25°11'56.73"S 30°9'25.93"E

3.4.1. Present Ecological State (PES) assessments

All four of the assessed wetlands are natural, unmodified wetlands with PES categories that fall in class A (**Tables 11 to 14; Figures 16 and 17**). Impacts were so negligible in the four wetlands that they did not even register in the assessments. Negligible impacts include an access road to the communications tower that borders HGM unit 1 and a few remnant trees of a plantation of *Eucalyptus* spp. that have been cut back adjacent to HGM unit 2. The only impact that registered in the scoring system is the presence of patches of *Pennisetum clandestinum* (kikuyu grass) in HGM unit 4 (**Table 14; Figure 18**). It is estimated that these alien patches occupy less than 5 % of the seep at present and were introduced into the area by livestock grazing and transportation on hooves. Future biodiversity management actions are, however, required to keep these wetlands in a pristine condition, specifically with regards to alien plant control. De Castro (2021) mentions the risk of the invasive alien tree species, and recorded *Acacia dealbata* and *Populus* x *canescens,* to have invaded and transformed significant areas of valley bottom and seep wetland habitat at elevations above ca. 1 600 masl, outside of the study area. Alien control interventions have already been implemented, and large sections of *Eucalyptus* spp. plantations have subsequently been removed through initial control. Continued alien control will be required to keep HGM unit 2, and other wetlands in the study area, in a natural condition. The implementation and updating of the existing alien control plan must therefore be prioritised as a critical feature for successful biodiversity management in BMU 5, as well as in BMU 7.

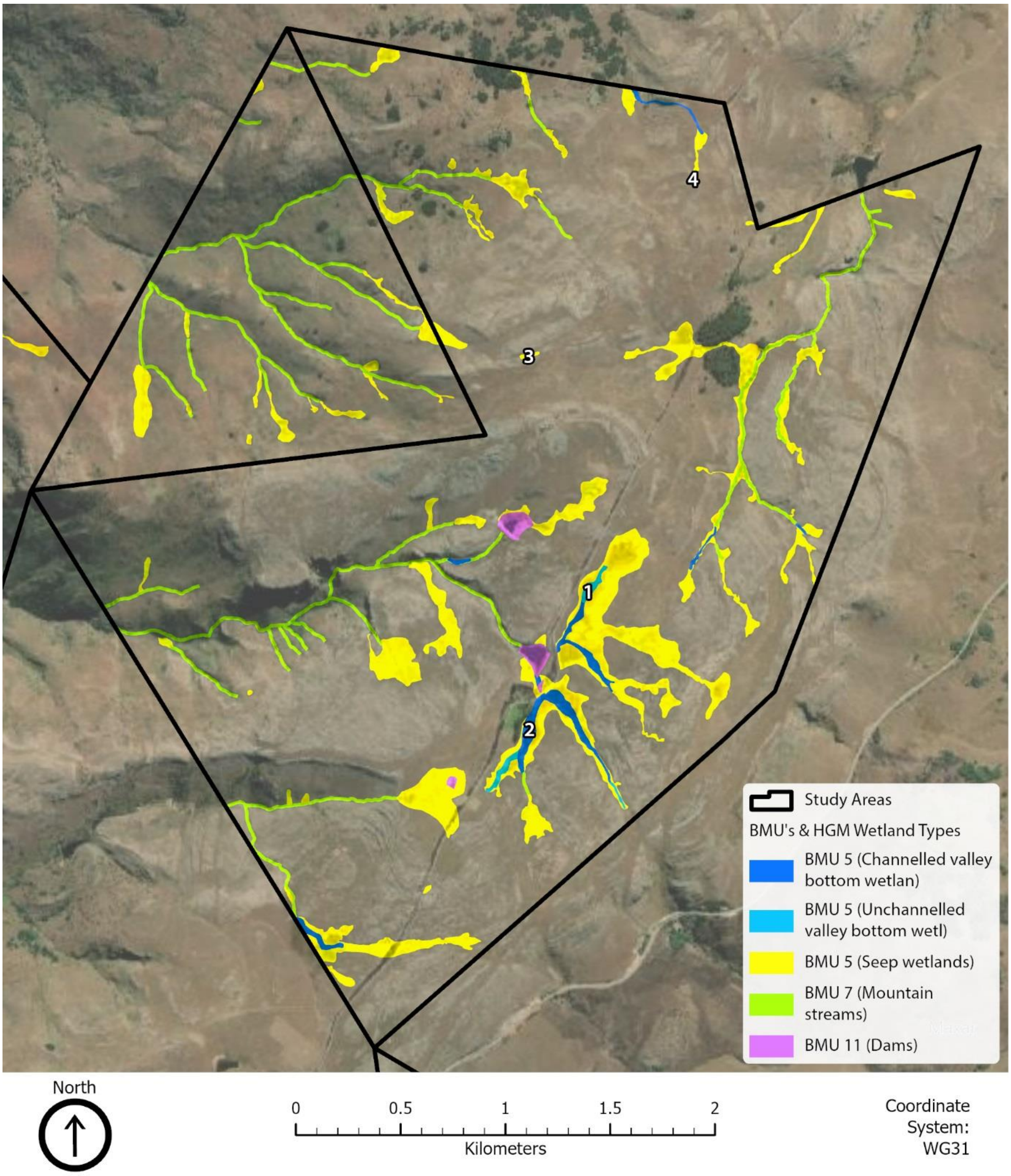


Figure 16: Four HGM units numbered 1–4 (two seeps, a channelled valley bottom and an unchannelled valley bottom wetland), present within the study area that were assessed in terms of PES, EIS, and ecosystem services.

Table 11: Summary of the current Present Ecological State of HGM unit 1 (unchannelled valley bottom peatland).

Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
12.61 ha	100 %	0.0	0	0.0	0	0.0	-1
PES category		**A**	→	**A**	→	**A**	↓
Wetland impact score		**0.0**					
Wetland PES (adjusted)		**A**					

Table 12: Summary of the current Present Ecological State of HGM unit 2 (channelled valley bottom peatland).

Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
12.61 ha	100 %	0.0	0	0.0	0	0.0	-1
PES category		**A**	→	**A**	→	**A**	↓
Wetland impact score		**0.0**					
Wetland PES (adjusted)		**A**					

Table 13: Summary of the current Present Ecological State of HGM unit 3 (sheetrock seep wetland).

Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
12.61 ha	100 %	0.0	0	0.0	0	0.0	-1
PES category		**A**	→	**A**	→	**A**	↓
Wetland impact score		**0.0**					
Wetland PES (adjusted)		**A**					

Table 14: Summary of the current Present Ecological State of HGM unit 4 (seep wetland).

Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
12.61 ha	100 %	0.0	0	0.0	0	0.6	-1
PES category		**A**	→	**A**	→	**A**	↓
Wetland impact score		**0.17**					
Wetland PES (adjusted)		**A**					

Figure 17: Illustrates the undisturbed condition of HGM units 1–3. These include the unchannelled valley bottom wetland and peatland of HGM unit 1, with a wider seep located upstream of it (1st row panel), a non-incised channel in a wide valley floor in HGM unit 2 (2nd row panel), and pristine sheetrock seep wetland habitat in HGM 3 (3rd row panel).

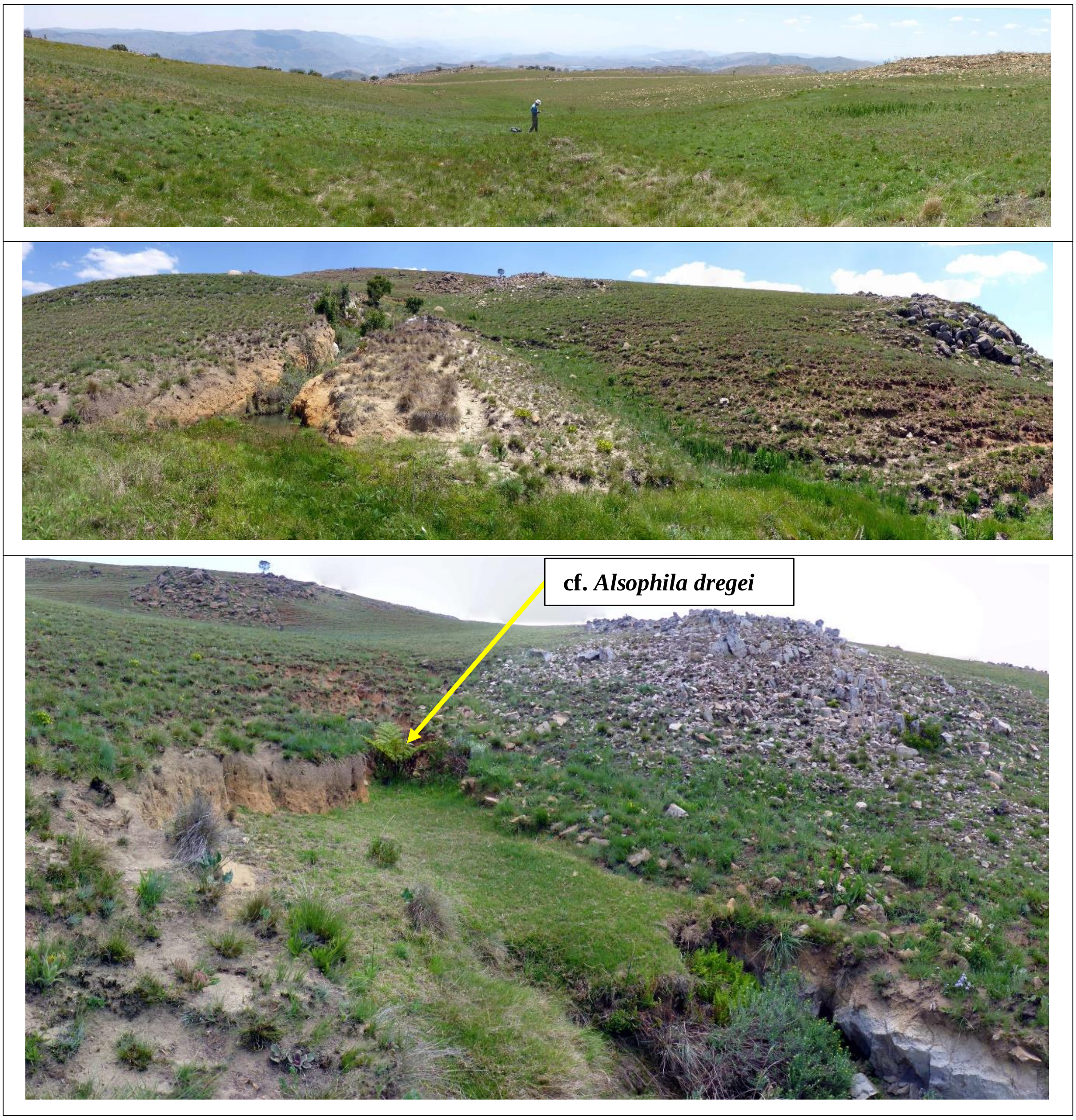


Figure 18: Illustrates variation in seep wetland 4. This includes an erosion gully that is regarded as natural due to the location of the seep on a steep slope with no signs of anthropogenic impacts (2nd and 3rd row panels). The natural headcut erosion feature has a positive impact in that it provides a niche habitat as a fire refugia for a tree fern (cf. *Alsophila dregei*), (3rd row panel). Habitat impacts include the presence of patches of the alien grass *Pennisetum clandestinum* seen below the headcut (4th row panel).

A diatom analysis was undertaken from inundated plant stems between the confluence of the HGM units 1 and 2, to obtain quantitative information about water quality characteristics in peatlands in the study area (Appendix D). The dominant diatom taxa at this site are associated with oligotrophic waters with electrolyte poor conditions. There is also evidence of very low levels of nutrients at this site and of acidic conditions, as can be expected from humic and fluvic acids associated with peat. The overall ecological water quality for this site was High with low levels of organic pollution. The ecological category (EC) is also assessed as being in class A, which is the same as the PES assessments (**Tables 11 and 12;** Appendix D).

3.4.2. Ecological Importance and Sensitivity (EIS) assessments

BMUs 5 and 7 have an uncommonly high occurrence of plant 'species of conservation concern' (SCC) (sensu Raimondo *et al*., 2009), with 21 recorded plant SCC just occurring in these two watercourse associated BMUs (Appendix A). A small sheetrock seep wetland, such as HGM unit 3, contains several specialised lithophytes and hygrophytes, including the Endangered *Disa alticola*, while peatlands habitat in HGM units 2 and 3 contain plant SCC, such as the Vulnerable (provisional) *Ledebouria* sp. nov. '*altipaludosus*' ined. and the Near Threatened *Watsonia bella*.

The irreplaceable biodiversity value of these wetlands is reflected in EIS classes that score Very high for HGM units 1 to 3 and High for HGM unit 4 (**Table 15**). These uncommonly high EIS classes are not only dependent on the presence of one plant SCC, but on more than one in most instances, while other aspects such as overlap with centres of plant endemism and intact wetland habitat were also considered

Table 15: Summary of the Ecological Importance and Sensitivity (EIS) of HGM units 1 to 4 in the study area (Rountree *et al.,* 2013).

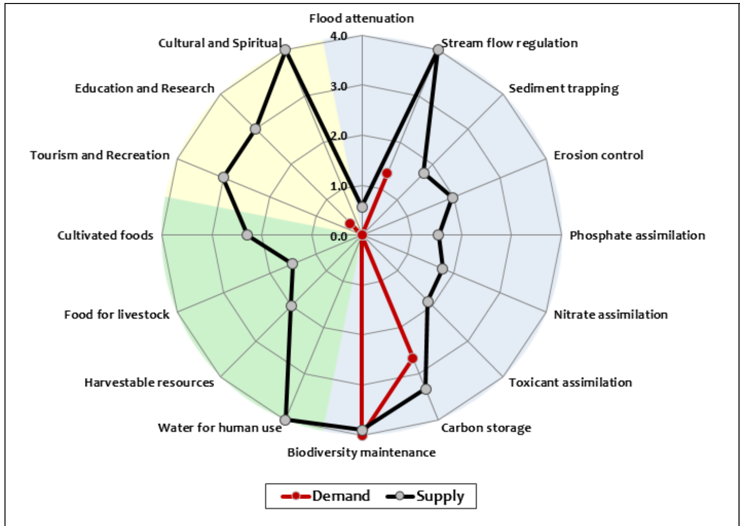
HGM type and number	Score	EIS description	EIS class
HGM 1 - Unchannelled valley bottom wetland	4.0	Very high	**A**
HGM 2 - Channelled valley bottom wetland	4.0	Very high	**A**
HGM 3 - Seep wetland	4.0	Very high	**A**
HGM 4 - Seep wetland	3.8	High	**B**

3.4.3. Ecosystem service assessments

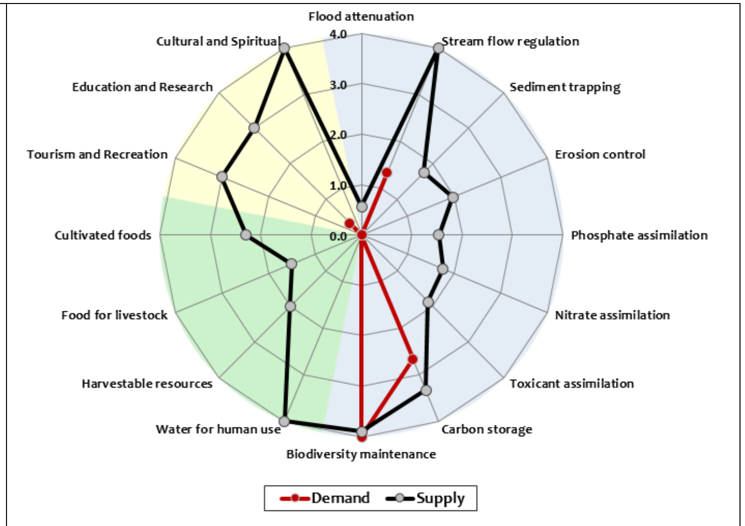
The two peatlands, HGM units 1 and 2, can perform (supply) various ecosystem services at a very high level, specifically biodiversity maintenance, stream flow regulation, carbon storage, water for human use, and cultural and spiritual services (**Figure 19**). Cultural and spiritual services have a very high supply score, but no demand score in both peatlands. This is due to the exceptional aesthetical beauty of the two HGM units (high supply score) and lack of use by the public at present (demand score). The is expected to change once the study area becomes established as a nature reserve. Biodiversity maintenance and carbon storage are the two most important ecosystem services in both HGM unit 1 and 2, as they are the only two that score high for both supply and demand (**Figure 19**).

Unsurprisingly, HGM unit 3, the sheetrock seep wetland, scores highest for biodiversity maintenance, for both supply and demand due to the presence of plant SCC and unique habitat (Section 3.3.2.; **Figure 19**). The prominent supply score for cultivated foods in HGM unit 3 is regarded as mistake due to a quirk in the algorithm used in the method developed by Kotze *et al*., (2020), as SRSWs present exceptions to assumptions that are used in the model, such as the expected presence of deep and organically enriched soils that can be used for cultivation.

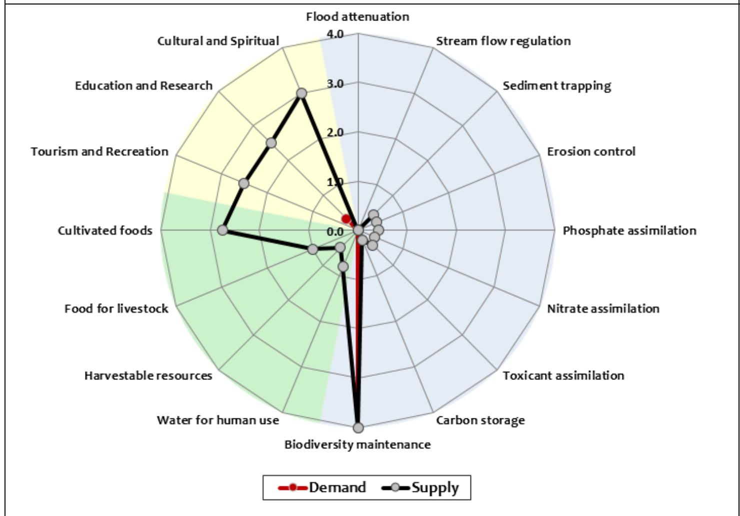
HGM unit 4 also scores very high for biodiversity maintenance, for both supply and demand, while it possesses favourable grazing habitat for livestock (high supply score), even though livestock have a restricted presence within the study area (low demand score). Biodiversity maintenance is the most important ecosystem services in HGM unit 4, as it is the only wetland function that scores high for both supply and demand (**Figure 19**).



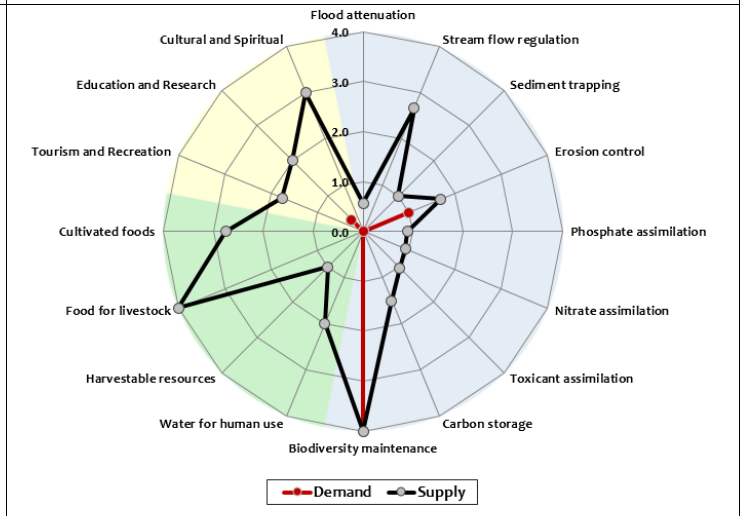
HGM unit 1



HGM unit 2



HGM unit 3



HGM unit 4

Figure 19: Graphs of ecosystem services performed by wetland HGM units 1 to 4, each service is scored in terms of supply and demand.

4. CONCLUSION AND BIODIVERSITY MANAGEMENT RECOMMENDATIONS

Valley bottom and seep wetlands in BMU 5 and mountain streams in BMU 7, represent some of the most pristine and habitat diverse watercourses in the South African grassland biome, based on the author's more than 15 years of working experience as a specialist wetland consultant. From marginal sheetrock seep wetlands with shallow soils, lithophytes and hygrophytes, to permanently saturated peat wetlands (mires) with obligate hydrophytes that include forbs, grasses, mosses and sedges. The uniqueness of these ecosystems in the study area is made abundantly clear by the presence of no fewer than 21 plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al*., 2009) that occur in BMUs 5 and 7 (Appendix A). At the time of reporting BMUs 5 and 7, which collectively form just under 9 % of the study area, provide habitat for close to 50 % of all recorded plant SCC in the study area; this value may change as the botanical study is still being finalised (De Castro in prep.).

It is not only in terms of the presence of plant SCC that BMUs 5 and 7 are remarkable, but also in terms of their ecological condition. The Present Ecological State (PES) of a selection of different wetland types were all assessed as natural/unmodified (class A PES). Hydrological and geomorphological impacts were negligible in most cases, while vegetation also remains intact and pristine for the most part. The ecological intactness of wetlands and mountain streams is the norm rather than the exception within the proposed DBPNR, which is not a common occurrence in wetland assessments. The value of valley bottom and seep wetlands in terms of their Ecological Importance and Sensitivity (EIS) was consistently assessed as Very high (class A EIS) to High (class B EIS), while ecosystem functioning related to the supply and demand for biodiversity maintenance was identified as the most important ecosystem service consistently supplied by a range of different wetland types. Peatlands also scored very high for having the potential to regulate stream flows, store carbon and provide drinking water for human consumption. Peatlands are spatial restricted wetlands with unique soils that have a high content of soil organic carbon (SOC), which is referred to as peat when it has dead soil organic matter (SOM) of more than 30 % (dry mass) or SOC of more than 20 % (Joosten and Clark, 2002; Soil Classification Working Group, 2018).

Prominent watercourse impacts are localised and include features such as six man-made dams with a combined surface area of 4.76 ha. No new dams are expected to be planned or required in the future, but the threat of other impacts will increase over time, specifically the encroachment of alien invasive plant species into BMUs 5 and 7.

In the early 2000s it was estimated that close to 25 % of peatlands in the Central Highlands Peatland Ecoregion had been altered by a range of impacts that include water abstraction, cultivation, afforestation, peat fires, agricultural drains, erosion, road infrastructure, and dams, including trout dams (Grundling and Grobler, 2005). More recently the risk of mining has increase in the surrounding area, which places wetlands and other watercourses at risk. Recorded peat wetlands in the study area, also referred to as peatlands and mires, form part of BMU 5 and are particularly sensitive to disturbances in their catchment. These wetlands are highly dependent on water infiltration and groundwater flow patterns, which are needed to create saturated conditions for peat growth and preservation.

Grundling and Grobler (2005) highlight the importance of peatlands in Verloren Vallei Nature Reserve, which borders the study area to the south, as examples of peatlands that represent the characteristics of the area due to them being well preserved with limited external (i.e., catchment) impacts. The same holds true for the 7 confirmed peat wetlands in the proposed DBPNR, as these wetlands are not only pristine, but their catchments are also ecologically intact. Peatland catchments are located entirely within the study area, except for the catchment of the peatland at Sterkfontein. The benefit of not only protecting peatlands, but also their catchments along with the catchments of the large majority of all BMUs 5 and 7 in the proposed new DBPNR, significantly increases the importance of the study area as a strategic conservation area with low risks for watercourse degradation in the future. The study area is therefore also considered as a strategic water resource area. This is confirmed by the south-eastern portion of Goedehoop overlapping with the Mpumalanga Drakensberg Strategic Water Source Area (SWSA), as indicated on the SWSAs of South Africa, Lesotho and Swaziland spatial layer (Nel *el al.*, 2013). The study area overlaps with a category 3 SWSA, which represents areas that supply ≥50 % of South Africa's water supply and are therefore regarded as national Strategic Water Sources Areas (Nel *et al.*, 2013). Over half of the Mpumalanga Drakensberg SWSA have been modified from a natural state and are particularly affected by plantation forestry, while only 9 % of this SWSA is protected (Nel *et al*., 2013). The proposed DBPNR will therefore not only conserve natural wetlands and streams (BMUs 5 and 7) and unique biodiversity, but will also protect a national Strategic Water Source Area that is currently poorly protected.

General recommendations for the management of BMUs 5, 7 and 11

- Wetlands in BMU 5 are at risk of specific alien invasive species, such as *Acacia dealbata, A. mearnsii, Populus* x *canescens* and *Eucalyptus* spp. The latter occurs as plantations that are in the process of being removed. Mountain streams in BMU 7 are more at risk of plant alien invasive species, such as *Acacia dealbata, A. mearnsii, Pinus* cf. *elliotii* and *P. patula* (De Castro, 2021). Continued alien control will be required to keep BMUs 5 and 7 in a natural condition (class A PES). The implementation and updating of the existing alien control plan developed by De Castro and Brits must therefore be prioritised as a critical feature for successful biodiversity management in BMUs 5 and 7.
- Erosion features in wetlands and mountain streams are often targeted for rehabilitation intervention in order to reduce the risk of habitat loss through erosion and/or to improve desiccated habitat along eroded gullies through the implementation of structures that can help to rewet affected areas. Care should be taken not to simply attempt to stabilise all erosion features in watercourses within the study area as natural erosion associated with the development of the drainage network is expected in this largely untransformed landscape. The study area is also located in a headwater catchment setting with steep slopes where erosion is to be expected. Erosion features that lack clear signs of anthropogenic origin/modification should ideally be left as natural erosion features unless clear motivation can be provided to intervene. Monitoring can also help to inform decisions regarding the need to stabilise erosion features, which will require expertise for the selection, design and implementation of site specific rehabilitation structures. Erosion features that may develop in peatlands should be of a higher concern and require urgent consideration, as these low energy adapted wetlands with soft peat substrates can erode rapidly in a single storm event.
- Sheetrock seep wetlands, which also form part of BMU 5, have a highly inconspicuous nature that can appear very similar to adjoining terrestrial habitat. They provide habitat for several plant SCC, but these species are minute and can be inconspicuous themselves, especially when not in flower. Sheetrock seep wetlands can therefore easily be missed, resulting in irreplaceable biodiversity loss as these areas can intuitively be regarded as non-sensitive outcrops with a low sensitivity for biodiversity. Efforts to effectively communication and raise awareness of the exceptional importance of these

wetlands for biodiversity is recommended, especially for contractors or other visitors to the area, in order to help avoid impacts.

- Future field surveys can further refine delineated watercourses that form part of BMUs 5 and 7 as delineated in this report, but any additional accuracy in terms of the presence and extent of watercourse boundaries are not regarded to be required for the purposes of managing biodiversity. It should, however, be noted that wetlands and other watercourses that form part of BMUs 5, 7 and 11 are protected water resources in South African legislation that should also be considered in their management and conservation. The National Water (Act No. 36 of 1998) specifies water use activities that can only be allowed through an approved Water Use License (WUL) or General Authorisation (GA), irrespective of the condition of the affected watercourse. Section 21 of the NWA defines different types of water use activities in a watercourse. Section 21 water uses activities listed in the NWA that pertain to watercourses (all BMUs 5, 7 and 11), which are commonly triggered in development and even certain rehabilitation activities, include the following:

    (c) impeding or diverting the flow of water in a watercourse

    (i) altering the bed, banks, course or characteristics of a watercourse.

- Development or rehabilitation actions that involve excavation, construction or other works consistent with Section 21 (c) and (i) water use activities that are located within a 500 m radius of any wetland, requires authorisation for the Department of Water and Sanitation, as either a Water Use Licence or a General Authorisation.
- The National Environmental Management Act (Act Nr. 107 of 1998) (NEMA) specify listed activities that also require authorisation when located within 32 m of a watercourse (BMUs 5, 7 and 11).
- It is recommended that any possible development within 100 m of any BMUs 5, 7 and 11, should be avoided. It follows that the necessary authorisation from different pieces of legislation will need to be obtained before any such development can proceed.

Table 16: Priority, BMU-specific management measures for BMUs 5, 7 and 11 in the 2127 ha DBPNR study area.

BMU 5: Channelled valley bottom and seep wetlands	• Development within 100 m of any area of BMU 5 should be avoided and environmental authorisation should be sought for such a development where required by the NWA or NEMA legislation. • Take into consideration requirements for authorisation from the DWS for all Section 21 (c) and (i) water use activities proposed in a 500 m radius from any wetland. • Implement the integrated alien plant control plan for the study area developed by De Castro and Brits. Specific emphasis should be placed on controlling the following alien invasive species *Acacia dealbata*, *A. mearnsii*, *Eucalyptus* spp., and *Populus* x*canescens* • The initial removal of a plantation of *Eucalyptus* spp. of approximately 7.27 ha, with subsequent follow-up control events in Goedehoop in accordance with the existing alien control plan.

	The plantation is causing a desiccation effect on downstream wetlands due to high water usage through evapotranspiration. • Follow-up control to address coppicing of three *Eucalyptus* spp. plantations that were recently controlled adjacent to valley bottom and seep wetlands directly south of the site office at coordinates 25°13’20.82’’S 30°8’55.63’’E and further east upslope of a suspected peatland at coordinates 25°12’25.52’’S 30°9’31.22’’E. The suspected presence of peat in one of the wetlands bordering a former *Eucalyptus* spp. plantation, makes complete and successful control a very high priority as their presence can result in the drying out (desiccation) of peat, which makes it susceptible to burning. Several active peat fires occur throughout South Africa and are of increasing concern as a threat to peatland wetlands. • Monitor the migration (advancement) of an eroding headcut erosion feature by staking a painted metal peg next to the current headcut position, at coordinates 25°12'23.96"S 30° 9'47.13"E. The headcut is regarded as a natural erosion feature, but it has the potential to form a gully in a seep wetland. Based on available information (lack of anthropogenic impacts), this is regarded as natural channel development within the drainage network and is not regarded as a serious threat that needs to be stabilised through rehabilitation intervention. Only monitoring is recommended at this stage. Shallow rock layers that are common in the area are expected to form a natural barrier that will halt erosion at an unknown distance upstream of the current headcut position. • The creation of vehicle tracks through any wetland (BMU 5) should be avoided as far as possible and no track crossing of a wetland should be graded. Any new road crossing in wetlands will require authorisation from regulatory authorities and will have to demonstrate that flows will remain unaltered in terms of direction, velocity and volume with mitigation measures that will help prevent scour erosion and the development of new channels caused by flow concentration. • No hydrocarbons (e.g., petrol, diesel and oil), herbicides or pesticides should be stored within 200 m of any peat wetland (mire) for any length of time as peat substrates have elevated sensitivity to hydrocarbon spills due to their ability to absorb and adsorb hydrocarbons (Moore *et al*., 1997) which makes rehabilitation practically impossible. • Control runoff of stormwater into streams and wetlands through watercourse sensitive stormwater management measures that incorporate energy dissipators and naturally vegetated buffers. Stormwater attenuation features should mimic natural water movement patterns, meaning that infiltration should be prioritised and only disbursed flows should be allowed at outlets. Erosion control need to be put in place to ensure that erosion and sedimentation does not occur in the downstream watercourses. • Delineated BMU 5 boundaries should be used in future design planning phases to help avoid overlap and maintain a 100 m setback distance between wetlands and new developments that may be required for the proposed nature reserve, such as ablution facilities, sewage systems and accommodation infrastructure.

	Additional studies, such as hydropedology studies may also be required by the DWS and other regulatory authorities. • The use of *Pennisetum clandestinum* (Kikuyu grass) should be avoided for the establishment of lawns, for erosion control, or any other use within the study area This Alien Invasive Species easily encroaches into wetlands and streams, and becomes very difficult to eradicate once established.
BMU 7: Mountain streams	• Development within 100 m of any area of BMU 7 should be avoided and environmental authorisation should be sought for such a development where required by the NWA or NEMA legislation. • Implement the integrated alien plant control plan for the study area developed by De Castro and Brits (2021). Particular emphasis should be placed on controlling alien invasive trees that are established habitat transformer within riparian habitats of mountain streams (e.g., *Acacia dealbata, Acacia mearnsii, Acacia melanoxylon, Pinus* cf. *elliotii*, and *Pinus patula*). • The creation of vehicle tracks through any wetland (BMU 7) should be avoided as far as possible and no track crossing of a stream should be graded. Any new road crossing in mountain streams will require authorisation from regulatory authorities and will have to demonstrate that flows will remain unaltered in terms of direction, velocity and volume with mitigation measures that will help prevent scour erosion and sedimentation into downstream watercourses. • Control runoff of stormwater into streams and wetlands through watercourse sensitive stormwater management measures that incorporate energy dissipaters and naturally vegetated buffers. Stormwater attenuation features should mimic natural water movement patterns, meaning that infiltration should be prioritised and only disbursed flows should be allowed at outlets. Erosion control need to be put in place to ensure that erosion and sedimentation does not occur in the downstream watercourses. • Delineated BMU 7 boundaries should be used in future design planning phases to help avoid overlap and maintain a 100 m setback distance between mountain streams and new developments that may be required for the proposed nature reserve, such as ablution facilities, sewage systems and accommodation infrastructure. Additional studies may also be required by the DWS and other regulatory authorities. • The use of *Pennisetum clandestinum* (Kikuyu grass) should be avoided for the establishment of lawns, for erosion control, or any other use within the study area This Alien Invasive Species easily encroaches into wetlands and streams, and becomes very difficult to eradicate once established. • Implement the recommended ‘burning plan’ and prevent unplanned human induced fires (e.g., establish firebreaks).
BMU 11: Dams	• Implement the integrated alien plant control plan for the study area developed by De Castro and Brits • Repair the dam spill way at coordinates 25°13’8.89’’S 30°8’56.18’’E (**Figure 12**) to prevent the erosion of the earthen

	dam wall and adjacent areas, thereby preventing sedimentation in the downstream watercourse. Also consider lowering the spillway to reduce the size of the impoundment behind the dam wall, which will allow indigenous wetland plant species to become re-established on the margins of the dam. This will also require alien control intervention. • Control runoff of stormwater into streams and wetlands through watercourse sensitive stormwater management measures that incorporate energy dissipaters and naturally vegetated buffers. Stormwater attenuation features should mimic natural water movement patterns, meaning that infiltration should be prioritised and only disbursed flows should be allowed at outlets. Erosion control need to be put in place to ensure that erosion and sedimentation does not occur in the downstream watercourses.

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APPENDIX A: PRELIMINARY LIST AND DESCRIPTION OF 21 PLANT ‘SPECIES OF CONSERVATION CONCERN’ (SCC) RECORDED IN WETLANDS AND MOUNTAIN STREAMS (BMUs 5 AND 7) IN THE DBPNR STUDY AREA (DE CASTRO IN PREP)

Table provides a list of the 21 plant 'species of conservation concern' (SCC), (*sensu* Raimondo *et al*., 2009, http://redlist.sanbi.org) that have been recorded within the DBPNR study area (including the recently acquired Farm Goedehoop) in wetlands and mountain streams (BMUs 5 and 7). These records are based on historical records included in the MTPA database as well as species recorded during the current botanical survey of the DBPNR and the 2021 survey of the 12 950ha Northam Booysendal study area (De Castro, 2021) as well as previous surveys conducted by McCleland (2010) in the adjacent Hoogland area situated directly to the north of De Berg. Twenty-one plant SCC have thus far been recorded within BMUs 5 and 7 in the DBPNR. The 9 plant 'species of conservation concern' recorded within the study area for the first time during the current survey or the 2021 De Castro & Brits survey are highlighted in yellow.

Species	**Family**	**IUCN (version 3.1) Conservation Status Category***		**Sites where species recorded within the study area during the current and previous surveys**	**BMUs where recorded** (Listed in order of importance)	**Elevation (min., max. and average m.a.s.l. provided)**
		National	**MTPA**			
Alepidea cordifolia	Apiaceae	EN	EN	xa19, xc27, xc31, xc32, xc33, xc66, xc67, xc68a, xc69, xc70, xc71, xc72, xc73, xc75, xc89, xc111, xc112, xc113b, xc114, xc123 14, 19, 37, 63, 95, 110	BMU 5 BMU 7	1811m – 2248m Avg.: 2097m (only 5 sites situated below 2000m)
Alepidea cf. *longeciliata*	Apiaceae	EN	EN	68, 70	BMU 5	2235m – 2236m Avg.: 2236m
Bulbine sp. nov. aff. *capitata* (ADC 1766)	Asphodelaceae	EN (provisional)	EN (provisional)	xa1, xc89, xc91, xc135, xc136 6, 13, 38, 63, 70, 72	BMU 5	2225m – 2243m Avg.: 2231m
Disa alticola	Orchidaceae	VU	VU	xb16, xc 77 108 Additional MTPA sites: 2.	BMU 5 BMU 3	2244m – 2312m Avg.: 2289m
Gladiolus calcaratus	Iridaceae	LC	VU	xc91 66, 73, 74, 91, 95	BMU 5 BMU 3	2134m – 2331m Avg.: 2247m
Ledebouria sp. nov. '*altipaludosus*' ined.	Hyacinthaceae	VU (provisional)	VU	xa1, xa2, xa6, xa11, xa14, xa16, xc68a, xc72, xc89, xc91, xc123, xc133a 6, 11, 12, 13, 14, 18, 66, 68, 70, 72	BMU 5	2088m – 2258m Avg.: 2201m
Ledebouria sp. nov. '*noritica*' ined.	Hyacinthaceae	EN (provisional)	EN	xb2 25, 26b, 49	BMU 5 BMU 2	1876m – 1915m Avg.: 1901m

Species	Family	IUCN (version 3.1) Conservation Status Category*		Sites where species recorded within the study area during the current and previous surveys	BMUs where recorded (Listed in order of importance)	Elevation (min., max. and average m.a.s.l. provided)
		National	MTPA			
Ledebouria sp. nov. ‘*purpurea*’ ined.	Hyacinthaceae	VU (provisional)	VU	xb14, xb15, xc8, xc12b, xc81, xc119 9, 69, 92, 93, 94 Additional MTPA sites: 2.	BMU 5 BMU 3	2151 – 2303m Avg.: 2255m
Morella microbracteata	Myricaceae	EN	EN	xa9, xc1, xc85	BMU7	1997m – 2150m Avg.: 2054m
Wurmbea viridiflora	Colchicaceae	VU (provisional)	VU	xc11, xc82, xc92 68	BMU 5 BMU 7	2219m – 2310m Avg.: 2254m
10						
Alepidea attenuata	Apiaceae	NT	NT	xc89, xc135, xc136 6, 13, 14, 37, 70, 72	BMU 5	2227m – 2243m Avg.: 2234m
Disa maculomarronina	Orchidaceae	NT	NT	xc89 72	BMU 5	2227m – 2242m Avg.: 2235m
Lydenburgia cassinoides	Celastraceae	NT	NT	xc56, xc60	BMU 7 BMU 1	1382m – 1476m Avg.: 1429m
Merwillea plumbea	Hyacinthaceae	NT	NT	xc32, xc75, xc111, xc112, xc113b, xc114 112	BMU 2 BMU 7	1762m – 2075m Avg.: 1929m
Protea parvula	Proteaceae	NT	NT	xa12, xa15, xc17, xc26b, xc93, xc95, 95, 99	BMU 3 BMU 7	2100m – 2289m Avg.: 2195m
Watsonia bella	Iridaceae	LC	NT	xa14, xc36, xc89, xc118 6, 11, 70, 72	BMU 5	2126m – 2242m Avg.: 2210m
6						
Amauropelta oppositiformis	Thelypteridaceae	LC	Rare	Single MTPA record for De Burg (MTPA locality near Site xa5 of current survey)	BMU 5	2285m
Pterygodium cooperi	Orchidaceae	LC	Rare	xc113b	BMU 7	1811m
2						
Eucomis autumnalis subsp. *clavata*	Hyacinthaceae	LC	Declining	xc8, xc115, xc123, xc133b 65	BMU 2 BMU 5 BMU 3	1885m – 2308m Avg.: 2174m

Species	**Family**	**IUCN (version 3.1) Conservation Status Category***		**Sites where species recorded within the study area during the current and previous surveys**	**BMUs where recorded** (Listed in order of importance)	**Elevation (min., max. and average m.a.s.l. provided)**
		National	**MTPA**			
Gunnera perpensa	Gunneraceae	LC	Declining	xa6, xa14, xc27, xc38, xc66, xc114 14, 19, 37, 38, 60, 98	BMU 5 (only wetlands within BMU 3)	1786m – 2248m Avg.: 2132m
Ilex mitis	Aquifoliaceae	LC	Declining	xa10, xa19, xb9, xc56, xc59, xc83, xc86, xc113b, xc114 35, 53b, 106	BMU 4 BMU 7	1382m – 2184m Avg.: 1841m
3						

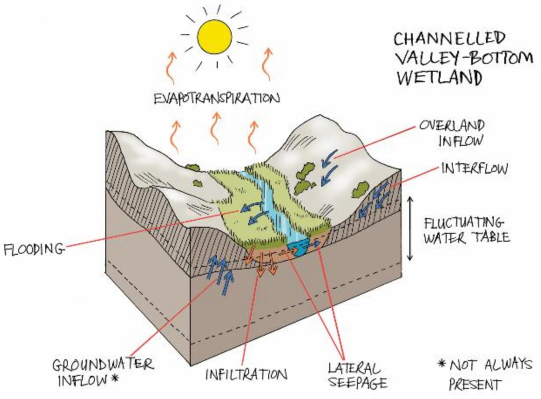
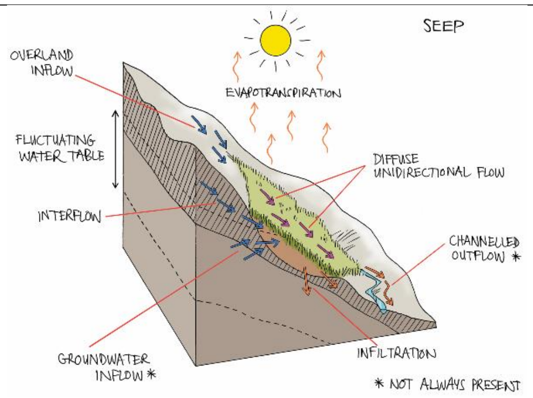
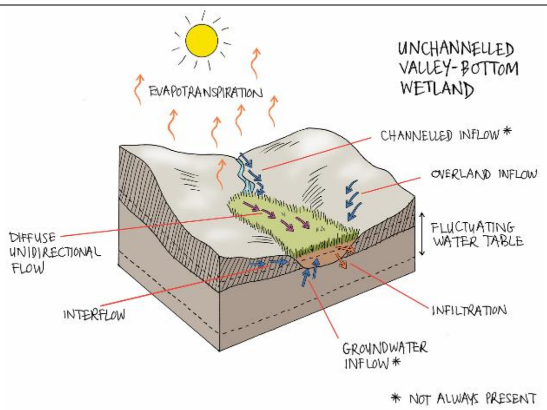
APPENDIX B: A PRELIMINARY LIST AND DESCRIPTION OF 14 PLANT ‘SPECIES OF CONSERVATION CONCERN’ (SCC) RESTRICTED TO AREAS OVERLYING QUARTZITIC LITHOLOGY IN WETLANDS AND MOUNTAIN STREAMS (BMUs 5 AND 7) IN THE DBPNR STUDY AREA, WITH DETAILED NOTES ON THE ALTITUDINAL DISTRIBUTION OF THESE SPECIES (DE CASTRO IN PREP)

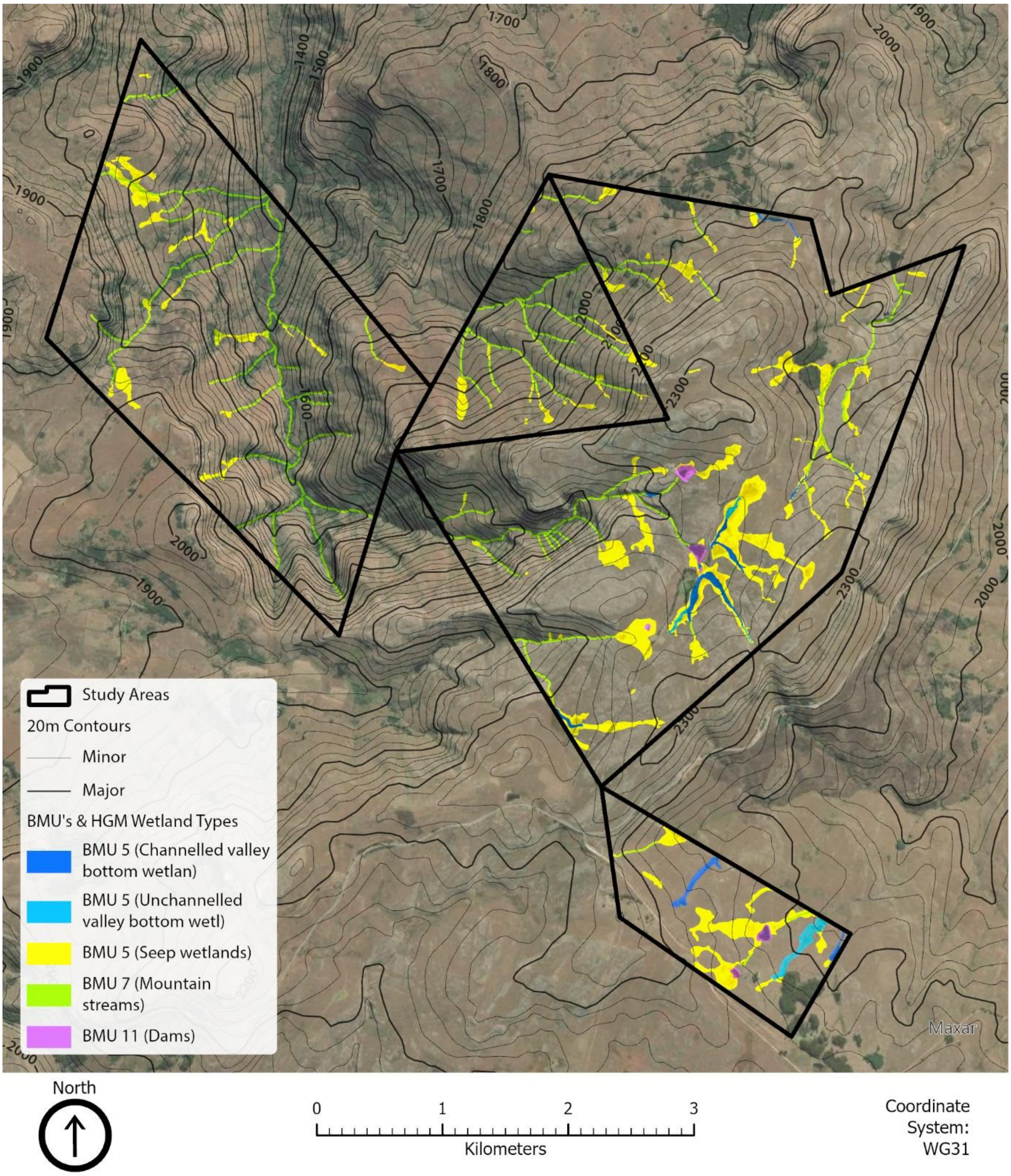
Species	Family	IUCN (version 3.1) Conservation Status Category*		Sites where species recorded within the study area during the current and previous surveys	BMUs where recorded (Listed in order of importance)	Elevation (min., max. and average m.a.s.l. provided)
		National	**MTPA**			
Alepidea cordifolia	Apiaceae	EN	EN	xa19, xc27, xc31, xc32, xc33, xc66, xc67, xc68a, xc69, xc70, xc71, xc72, xc73, xc75, xc89, xc111, xc112, xc113b, xc114, xc123 14, 19, 37, 63, 95, 110	BMU 5 BMU 7	1811m – 2248m Avg.: 2097m (only 5 sites situated below 2000m)
Alepidea cf. *longeciliata*	Apiaceae	EN	EN	68, 70	BMU 5	2235m – 2236m Avg.: 2236m
Bulbine sp. nov. aff. *capitata* (ADC 1766)	Asphodelaceae	EN (provisional)	EN (provisional)	xa1, xc89, xc91, xc135, xc136 6, 13, 38, 63, 70, 72	BMU 5	2225m – 2243m Avg.: 2231m
Disa alticola	Orchidaceae	VU	VU	xb16, xc 77 108 Additional MTPA sites: 2.	BMU 5 BMU 3	2244m – 2312m Avg.: 2289m
Gladiolus calcaratus	Iridaceae	LC	VU	xc91 66, 73, 74, 91, 95	BMU 5 BMU 3	2134m – 2331m Avg.: 2247m
Ledebouria sp. nov. ‘*altipaludosus*’ ined.	Hyacinthaceae	VU (provisional)	VU	xa1, xa2, xa6, xa11, xa14, xa16, xc68a, xc72, xc89, xc91, xc123, xc133a 6, 11, 12, 13, 14, 18, 66, 68, 70, 72	BMU 5	2088m – 2258m Avg.: 2201m
Ledebouria sp. nov. ‘*purpurea*’ ined.	Hyacinthaceae	VU (provisional)	VU	xb14, xb15, xc8, xc12b, xc81, xc119 9, 69, 92, 93, 94 Additional MTPA sites: 2.	BMU 5 BMU 3	2151 – 2303m Avg.: 2255m
Morella microbracteata	Myricaceae	EN	EN	xa9, xc1, xc85	BMU7	1997m – 2150m Avg.: 2054m
Wurmbea viridiflora	Colchicaceae	VU (provisional)	VU	xc11, xc82, xc92 68	BMU 5	2219m – 2310m Avg.: 2254m
9						
Alepidea attenuata	Apiaceae	NT	NT	xc89, xc135, xc136	BMU 5	2227m – 2243m

Species	**Family**	**IUCN (version 3.1) Conservation Status Category***		**Sites where species recorded within the study area during the current and previous surveys**	**BMUs where recorded** (Listed in order of importance)	**Elevation (min., max. and average m.a.s.l. provided)**
		National	**MTPA**			
				6, 13, 14, 37, 70, 72		Avg.: 2234m
Disa maculomarronina	Orchidaceae	NT	NT	xc89 72	BMU 5	2227m – 2242m Avg.: 2235m
Protea parvula	Proteaceae	NT	NT	xa12, xa15, xc17, xc26b, xc93, xc95, 95, 99	BMU 3 BMU 7	2100m – 2289m Avg.: 2195m
Watsonia bella	Iridaceae	LC	NT	xa14, xc36, xc89, xc118 6, 11, 70, 72	BMU 5	2126m – 2242m Avg.: 2210m
4						
Amauropelta oppositiformis	Thelypteridaceae	LC	Rare	Single MTPA record for De Burg (MTPA locality near Site xa5 of current survey)	BMU 5	2285m
1						

APPENDIX C: DELINEATED WETLANDS ASSOCAITED WITH BMU 5 CLASSSIFIED INTO IDENTIFIED HYDRO-GEOMORPHIC (HGM) TYPES THAT INCLUDE SEEP, CHANNELLED AND UNCHANNELLED VALLEY BOTTOM WETLANDS, AND MOUNTAIN STREAMS (BMU 7) WITHIN THE STUDY AREA

Description and illustration of hydrogeomorphic wetland types applicable to BMU 5 within the study area, based on definitions and illustrations from the South African aquatic ecosystem classification system developed by Ollis *et al*. (2013).

Wetland name and description	Illustration
Channelled valley bottom wetland: A valley bottom wetland with a river channel running through it. Channelled valley bottom wetlands are characterised by their position on valley floors and the absence of characteristic floodplain features. Dominant water inputs to these wetlands are from the river channel flowing through the wetland, as surface flow resulting from flooding, as subsurface flow and/or from adjacent valley side slopes (as overland flow or interflow).	
Seep wetland (previously described as hillslope seep wetland): Wetland area located on gently to steeply sloping land and dominated by the 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 unto a valley floor. Water inputs are primarily via subsurface flows from an up-slope direction.	
Unchannelled valley bottom wetland: A valley bottom wetland without a river channel running through it. These wetlands are characterised by the 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.	



Illustrates all wetlands in BMU 5 classified according to HGM types.

APPENDIX D: DIATOM ASSESSMENT OF A SAMPLE LOCATED DOWNSTREAM OF A CONFIRMED PEATLAND

Imperata Diatom Project

Peatland BD37

Diatom Analysis Report

Reference: Imperata_Diatoms_April_2022
Date: April_2022
No. of samples: 1
Version: Draft

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Limitations and Disclaimer

The spatial and temporal extents of Ecotone Freshwater Consultants CC (Ecotone) services are described in the proposal and are subject to restrictions and limitations. A total assessment of all probable scenarios or circumstances that may exist on the study site was not undertaken. No assumptions should be made unless opinions are specifically indicated and provided. Data presented in this document may not elucidate all possible conditions that may exist given the limited nature of the enquiry.

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Declaration of Independence

I, Marco Alexandre, as duly authorised representative of Ecotone Freshwater Consultants CC (Ecotone), hereby confirm my independence (as well as that of Ecotone) as a specialist and declare that neither I nor Ecotone have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal, other than fair remuneration for work performed, specifically in connection with the diatom assessment for the Imperata sites.

____

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List of Abbreviations

BDI	Biological Diatom Index
%PTV	Percentage Pollution Tolerant Valves
SPI	Specific Pollution Sensitivity Index

Key Terminology Outlined in Taylor *et al.* (2007a)

Trophy	Description
Dystrophic	Rich in organic matter, usually in the form of suspended plant colloids, but of a low nutrient content.
Oligotrophic	Low levels or primary productivity, containing low levels of mineral nutrients required by plants.
Mesotrophic	Intermediate levels of primary productivity, with intermediate levels of mineral nutrients required by plants.
Eutrophic	High primary productivity, rich in mineral nutrients required by plants.
Hypereutrophic	Very high primary productivity, constantly elevated supply of mineral nutrients required by plants.

Mineral Content	Value
Very electrolyte poor	< 50 µS/cm
Electrolyte-poor (low electrolyte content)	50 - 100 µS/cm
Moderate electrolyte content	100 - 500 µS/cm
Electrolyte-rich (high electrolyte content)	> 500 µS/cm
Brackish (very high electrolyte content)	> 1000 µS/cm
Saline	6000 µS/cm

Pollution (Saprobity)	Value
Unpolluted to slightly polluted (oligosaprobic)	BOD <2, O_2 deficit <15%
Moderately polluted (β-mesosaprobic)	BOD <4, O_2 deficit <30%
Critical level of pollution (β-á-mesosaprobic)	BOD <7(10), O_2 deficit <50%
Strongly polluted (á-mesosaprobic)	BOD <13, O_2 deficit <75%
Very heavily polluted (polysaprobic)	BOD <22, O_2 deficit <90%

Introduction and Scope of Work

Diatoms are the unicellular algal group most widely used as indicators of river and wetland health as they provide a rapid response to specific physico-chemical conditions in water and are often the first indication of change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinization and changes in pH. They are therefore useful for providing an overall picture of trends within an aquatic system as they show an ecological memory of water quality over a period of time.

Methodology

Laboratory Procedures

Diatom laboratory procedures were carried out according to the methodology described by Taylor *et al.* (2005). Diatom samples were prepared for microscopy by using the hot hydrochloric acid and potassium permanganate method. Approximately 300 to 400 diatom valves were identified and counted to produce semi-quantitative data for analysis. Prygiel *et al*. (2002) found that diatom counts of 300 valves and above were necessary to make correct environmental inferences. The taxonomic guide by Taylor *et al.* (2007b) and Cantonati *et al*. (2017) was consulted for identification purposes. Where necessary, Krammer & Lange-Bertalot (1986, 1988, 1991 a, b) were used for identification and confirmation of species identification. Environmental preferences were inferred from Taylor *et al.* (2007b) and Cantonati *et al*. (2017) and various other literature sources as indicated in the discussion section to describe the environmental water quality at each site.

Diatom-based Water Quality Indices

There are different diatom-based water quality indices that are used globally and are based on the specific water quality tolerances of diatoms. Most of the indices are based on a weighted average equation by Zelinka and Marvan (1961). Two values are assigned to each diatom species used in the calculations of the indices that reflects the tolerance or affinity of the diatom species to a certain water quality (good or bad); and indicates how strong (or weak) the relationship is (Taylor, 2004). These values are then weighted by the abundance of the diatom species in the sample (Lavoie et al. 2006; Taylor, 2004; Besse, 2007). The main difference between indices is in the indicator sets (number of indicators and list of taxa) used in calculations (Eloranta & Soininen, 2002). These indices underpin the software packages used to estimate biological water quality. One such software package commonly used and approved by the European Union is OMNIDIA (Lecointe et al. 1993). The program is a taxonomic and ecological database of 7500 diatom species, and it contains indicator values and degrees of sensitivity for given species. It allows rapid calculations of indices of general pollution, saprobity and trophic state, indices of species diversity, and of ecological systems (Szczepocka, 2007).

The Specific Pollution Sensitivity Index (SPI)

The SPI was used in this diatom assessment (**Table 0-1**). The SPI is an inclusive index and takes factors such as salinity, eutrophication and organic pollution into account (CEMAGREF, 1982). This index comprises 2035 taxa (Taylor, 2004) which are endemic to and commonly found in South Africa, thus increasing the accuracy of diatom-based water quality assessments (Harding & Taylor, 2011). The limit values and associated ecological water quality classes adapted from Eloranta & Soininen (2002), in conjunction with the new adjusted class limits that are provided in (Taylor & Koekemoer, in press), were used for interpretation of the SPI scores. The SPI index is based on a score between 0 – 20, where a score of 20 indicates no pollution and a score of zero indicates an increasing level of pollution or eutrophication.

Table 0-1: Adjusted class limit boundaries for the Specific Pollution Index in the evaluation of water quality applied in this study (adapted from Eloranta & Soininen, 2002; Harding & Taylor 2011)

Interpretation of Index Scores		
Ecological Category (EC)	**Class**	**Index Score (SPI Score)**
A	High quality	>17.3
A/B		16.8-17.2
B	Good quality	13.3-16.7
B/C		12.9-13.2
C	Moderate quality	9.2-12.8
C/D		8.9-9.1
D	Poor quality	5.3-8.8
D/E		4.8-5.2
E	Bad quality	< 4.8

The Percentage Pollution Tolerant Valves (%PTV)

The %PTV is part of the UK Trophic Diatom Index (TDI) (Kelly & Whitton, 1995) and was developed for monitoring organic pollution (sewage outfall- orthophosphate-phosphorus concentrations), and not general stream quality (**Table 0-2**). The %PTV has a maximum score of 100, where a score above 0 indicates no organic pollution and a score of 100 indicates definite and severe organic pollution. The presence of more than 20% PTVs shows organic impact. All calculations were computed using OMNIDIA ver. 4.2 programme (Lecointe *et al*., 1993).

Table 0-2: Interpretation of the percentage Pollution Tolerant Valves scores (adapted from Kelly, 1998)

%PTV	Interpretation
<20	Site free from organic pollution.
20 to <40	There is some evidence of organic pollution.
40 to 60	Organic pollution likely to contribute significantly to eutrophication.
>60	Site is heavily contaminated with organic pollution.

Results and Discussion

The diatom assessment focusses on two key aspects: (i) Discusses the ecological classification of water quality for the site according to the diatom assemblage during this assessment. (ii) Provides analyses and discussion of the dominant species and their ecological preference at the site. This report discussing the ecological water quality for a single site located in the peatland:

- Site BD37: 25°13'8.44"S 30° 9'2.75"E.

The ecological classification for water quality according to Van Dam *et al*. (1994) and Taylor *et al*. (2007) are provided in **Table 0-1** for the April 2022 assessment. The overall diatom assemblages comprised of species with a preference for:

- Freshwater (<100 µS/cm), acidic (pH < 6.5) waters and mesotrophic conditions;
- The nitrogen requirements for this site were N-Autotrophic sensitive, indicating a tolerance for low concentrations of organically bound nitrogen;
- The dissolved oxygen saturation requirements were very high (~100%) for this site;
- The pollution levels indicated that there were low levels of pollution present at this site.

Table 0-1: Ecological descriptors for the sites based on the diatom community (Van Dam et al., 1994 and Taylor et al., 2007)

Site	pH	Salinity	Organic Nitrogen uptake	Oxygen Levels	Pollution Levels	Trophic State
BD37	Acidic	Freshwater	N-Autotrophic sensitive	Very high	β-mesosaprobic	Meso-trophic

The dominant diatom taxa at this site pointed to oligotrophic waters with electrolyte poor conditions and these taxa are also tolerant to slightly polluted conditions. There was evidence of acidic conditions and very low levels of nutrients at this site. The overall ecological water quality for this site was *High* with low levels of organic pollution as supported by the low %PTV score.

Table 0-2: Diatom index scores for the study sites indicating the ecological water quality for the April 2022 assessment

Site	%PTV	SPI	Ecological Category (EC)	Class
BD37	0.3	18.4	A	High

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