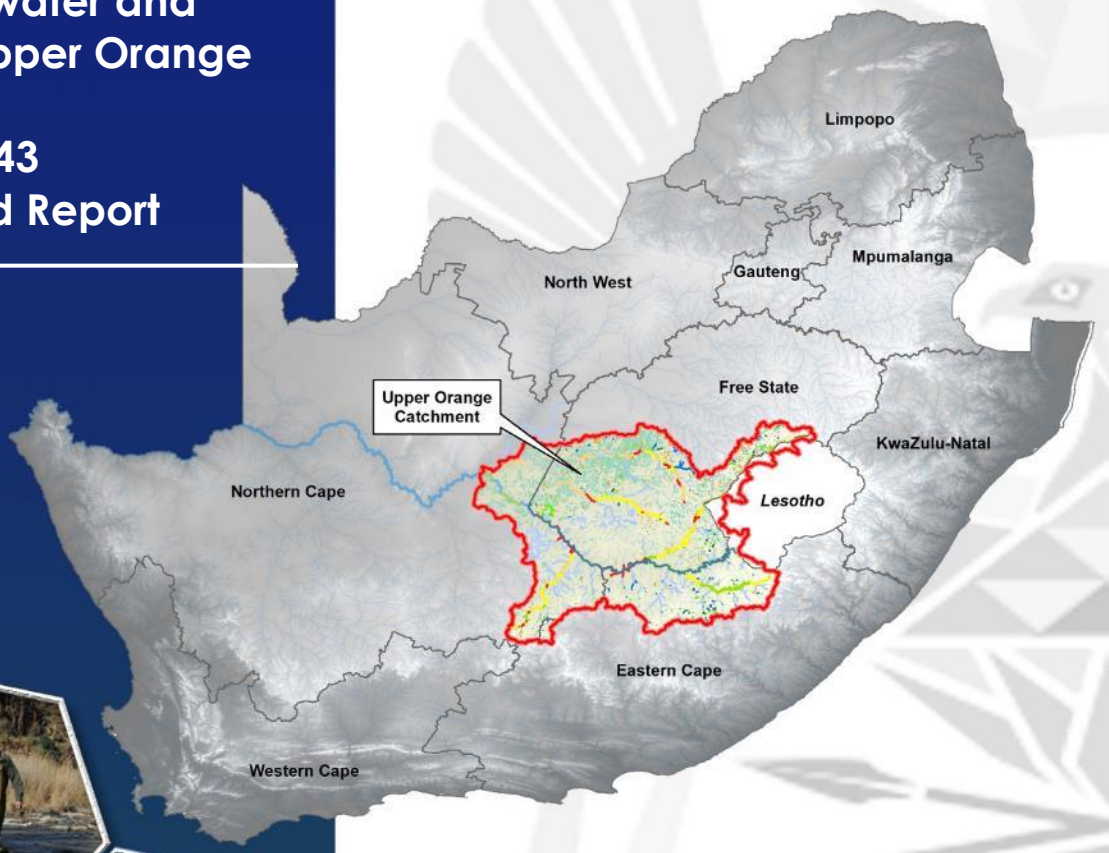
# DEPARTMENT OF WATER AND SANITATION

# A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange

## WP11343
## Final Wetland Report




REPORT NO.:
RDM/WMA13/00/CON/COMP/0922

November 2022

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Published by

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*This report is to be cited as:*

Department of Water and Sanitation, South Africa. November 2022. A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange Catchment: Wetland Report. No: RDM/WMA13/00/CON/COMP/0922.

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| **Project Name:** | *A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange Catchment: WP11343* |
| **DWS Report No.:** | *RDM/WMA13/00/CON/COMP/0922* |
| **Status of Report** | *Final* |
| **First Issue:** | *12 October 2022* |
| **Final Issue:** | *9 November 2022* |

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**Approved for the Professional Service Provided by:**

……  ……

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**Chief Directorate: Water Ecosystems Management**

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**The bold** type indicates this report

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| | | |

# LIST OF ACRONYMS

| | |
|---|---|
| BHN | Basic Human Needs |
| CVB | Channelled valley bottom |
| CD: WEM | Chief Directorate: Water Ecosystems Management |
| CR | Critically endangered |
| DCVB | Discontinuously Channelled Valley Bottom |
| DWA | Department of Water Affairs |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| EIS | Ecological Importance and Sensitivity |
| EI | Ecological Importance |
| ES | Ecological Sensitivity |
| EWR | Ecological Water Requirements |
| FEPA | Freshwater Ecosystem Priority Area |
| HGM | Hydrogeomorphic |
| IBA | Important Bird Areas |
| IEI | Integrated Ecological Index |
| IWUI | Integrated Water Use Index |
| LT | Least Threatened |
| MCA | Multi-criteria analysis |
| NFEPA | National Freshwater Ecosystem Priority Areas |
| NWM5 | National Wetlands Map 5 |
| NWA | National Water Act |
| PES | Present Ecological State |
| RDM | Resource Directed Measures |
| RU | Resource Unit |
| SWSA | Strategic Water Source Area |
| UCVB | Unchannelled valley bottom |
| VU | Vulnerable |
| WRC | Water Research Commission |
| WMA | Water Management Area |
| WRCS | Water Resources Classification System |
| WWTW | Wastewater Treatment Work |

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# 1. INTRODUCTION

## 1.1 Background

The National Water Act (No. 36 of 1998; NWA) is founded on the principle that the National Government has overall responsibility for and authority over water resource management for beneficial public use without seriously affecting the functioning and sustainability of water resources. Chapter 3 of the NWA enables the protection of water resources by the implementation of Resource Directed Measures (RDM). As part of the RDM process, an Ecological Reserve must be determined for a significant water resource to ensure a desired level of protection.

The Reserve (water quantity and quality) is defined in terms of (i) Ecological Water Requirements (EWR) based on, the quantity and quality of water needed to protect aquatic ecosystems; water quantity, quality, habitat and biota in the desired state and (ii) Basic Human Needs (BHN), ensuring that the essential needs of individuals dependant on the water resource is provided for. These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources while allowing economic development.

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) is responsible for coordinating all Reserve Determination studies in terms of the Water Resource Classification System (WRCS). These studies include the surface water (rivers, wetlands and estuaries) and groundwater components of water resources.

The Reserve has priority over other water uses in terms of the NWA and should be determined before license applications are processed, particularly in stressed and over-utilised catchments. Accordingly, the CD: WEM identified the need to determine the Reserve for the ecosystems (rivers, wetlands and groundwater) of the Upper Orange River catchment in the Orange River Water Management Area (WMA 6). This further includes the Modder-Riet system, bordering the Vaal WMA5. The aim is to provide adequate protection of aquatic systems considering (i) possible hydraulic fracturing (HF) activities, (ii) assessment of various water use license applications, and (iii) evaluation of impacts of current and proposed developments on the availability of water.

## 1.2 Purpose of this report

The purpose of this report is to document the data, information, approaches followed and results of the Rapid Reserve Determination for the selected wetland resource units (WRUs) for the Upper Orange River project area. The approach towards the Reserve determination process for the WRUs incorporated Steps 3, 5 and 7 as shown in **Figure 1-1** below. The ecological water requirements (EWR) will be determined for priority river and groundwater Resource Units only, hence Step 4 was not included in this approach. However, recommendations for the quantification of the EWRs for specific priority wetlands and where integration between groundwater and/ or rivers and wetlands are crucial will be made.

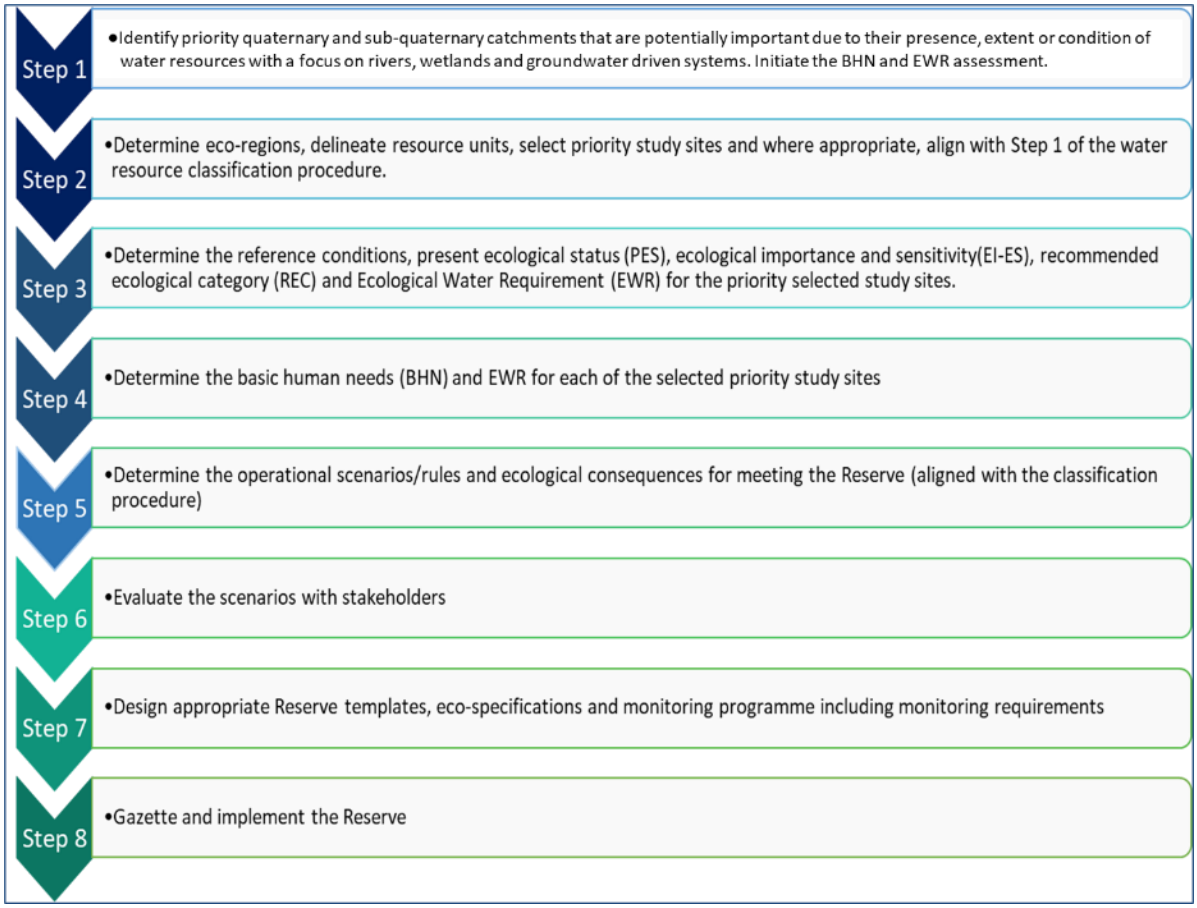


**Figure 1-1:** Integrated steps for the determination of the Reserve (DWS, 2017)

# 2. OVERVIEW OF THE STUDY AREA

The study area of the Upper Orange Catchment forms part of the Orange WMA6 (**Figure 2-1**) and includes the main stem Orange River from the Lesotho border to the confluence with the Vaal River at the town of Douglas. The major tributaries of the Orange River include the Kraai, Caledon and Seekoei Rivers. The Modder-Riet Rivers drain into the Vaal River and due to their interconnectivity (i.e., water transfers) with the Upper Orange River, are included in this study. The study area can be divided into four distinct sub-areas within secondary catchments D1, D2, D3 and C5, namely:

i. The Orange River from the Lesotho Border to the Gariep Dam, including the main tributaries: Kornetspruit, Sterkspruit, Stormbergspruit and Brandwaterspruit (catchments D12, D14 and the SA part of D15 and D18);
ii. The Caledon River from its headwaters and its tributaries to the Gariep Dam (catchments D21, D22, D23, D24);
iii. The Kraai River catchment (catchment D13); and
iv. The Orange River from the Gariep Dam to Marksdrift weir (catchments D31, D33, D34 and D35), just upstream from the confluence with the Vaal River. This includes the Seekoei River (catchment D32) in the south and the Modder-Riet River (catchments C51 and C52) in the north.

Refer to the Resource Unit Report (DWS, 2022) for details regarding the characteristics of the study area. Important to this report are the general characteristics of the wetlands within the study area.

Depression wetlands are common wetland types in the study area and their characteristics are largely associated with a combination of geology, rainfall and temperature. A total of 2,868 wetlands were identified by the National Wetlands Map (NWM5) spatial layer (Van Deventer *et al.,* 2018), covering 74,378 ha. The majority of the identified wetlands are in the Upper Karoo Bioregion, followed by the Mesic Highveld Grassland Bioregion.

Most of the identified wetlands were categorised as Least Concern followed by Vulnerable based on the vulnerability of the wetland type and vegetation with more than half of the identified wetlands in a largely natural state with limited modifications. The main modifications affecting the integrity of the wetlands within the study area are associated with multiple land use impacts e.g., irrigated commercial croplands, bare areas associated with mining operations and populated areas (hardened surfaces). Other impacts include poor land use management practises and over-grazing in all three provinces.

Large areas of the study area have highly dispersive soils that are a key consideration for the selection of wetlands of importance for protection and maintenance since many of these systems are already highly degraded and at risk of eroding beyond any rehabilitation potential.

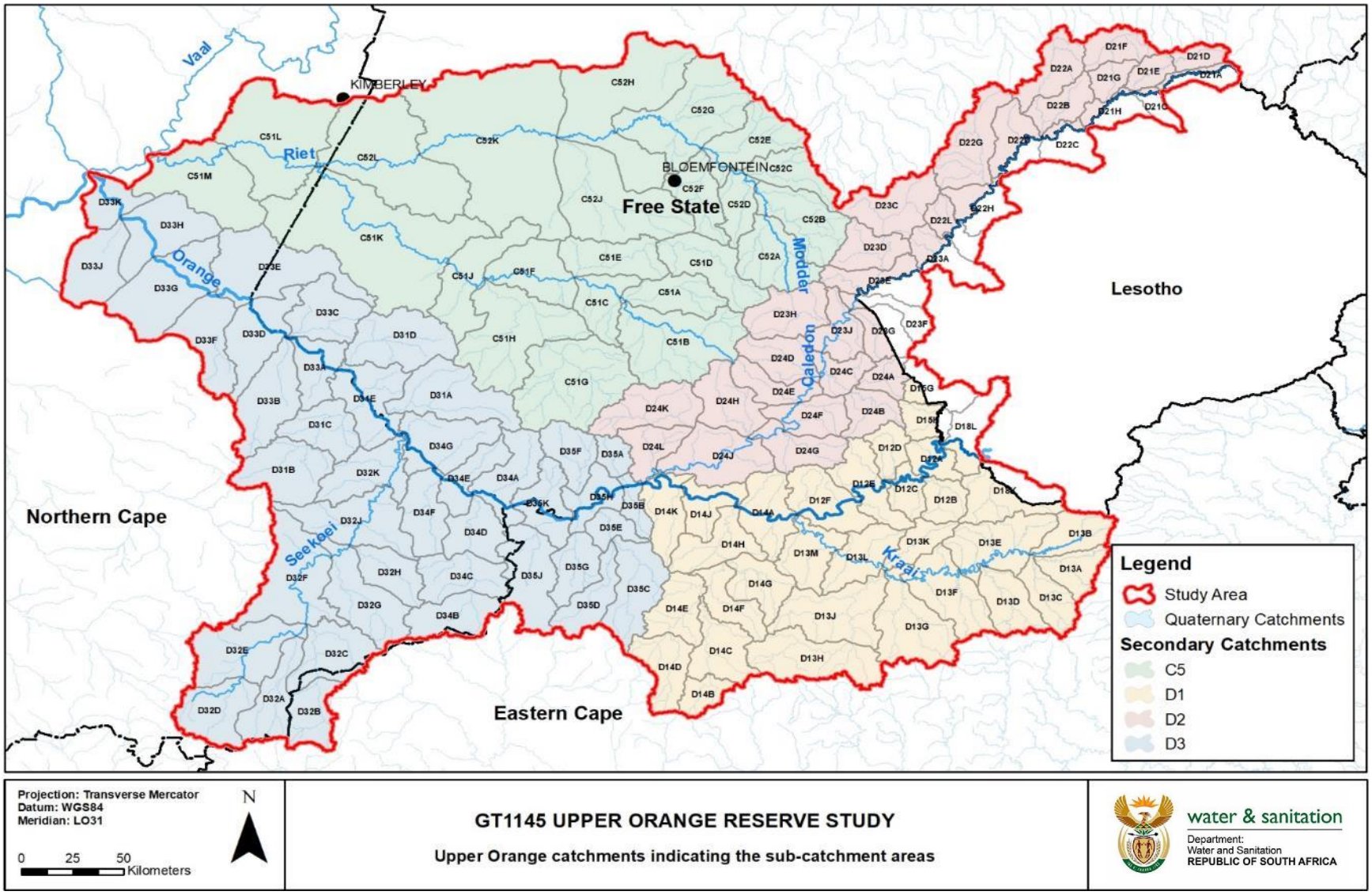


**Figure 2-1: Upper Orange River Project Area**

# 3. APPROACHES FOR WETLAND RESERVE DETERMINATION

The Department of Water and Sanitation (DWS) Rapid Ecological Reserve Determination of Inland Wetlands (Rountree *et al.,* 2013) procedure has been slightly modified and implemented in this study to determine the Reserve for the selected WRUs in the Upper Orange River catchment. This includes the implementation of some steps of the procedural framework in **Figure 1-1**. A summary of the steps that were undertaken to determine the Reserve for the WRUs in this study include:

- **Step 1: Initiate the EWR and BHN assessment and identify priority quaternary and sub-quaternary catchments:** Priority catchments and priority systems within these catchments were identified at a desktop level as the study area spans a large part of the interior of South Africa. A team of specialists with a diverse range of experience were selected to undertake the study.
- **Step 2: Delineate wetland resource units and select priority sites:** The identification of wetland RUs was focused on identifying systems at an ecosystem level and was strongly reliant on knowing where important and/or priority wetland systems were within the landscape (cf. the RU report for more information DWS, 2022a). Therefore, the methods used to identify these priority RU areas were reliant on existing wetland coverages (Nel et al., 2011 and Van Deventer *et al.,* 2019) and modification of previous approaches used to define strategically important wetland areas within the broader landscape (Van Deventer *et al.,* 2019). Additional spatial layers were considered and incorporated into a multi-criteria analysis (MCA) to broadly define those wetlands that were considered more important, based on a selected list of variables viewed as important from a wetland ecological, functioning, social and/or biodiversity perspective. The following information was sourced and used in the identification of priority wetlands for consideration in this study:
    - National Wetland Map 5 spatial dataset (Van Deventer *et al.* 2019);
    - National Freshwater Ecosystem Priority Areas (NFEPAs) wetland shapefile (Nel *et al.,* 2011);
    - Important Bird Areas (IBAs) (BirdLife South Africa, 2016);
    - Crane sightings and nest sites (Endangered Wildlife Trust, 2019);
    - Wetlands that interacted with the surface and groundwater SWSAs (Lötter & Maitre, 2021);
    - Wetlands with a Present Ecological State (PES) of A/B (Van Deventer *et al.* 2019);
    - Hydrogeomorphic (HGM) unit type, which was used to determine the level to which each system may provide services associated with (cf. Van Deventer *et al.* 2019):
        - Flood attenuation;
        - Stream flow regulation;
        - Erosion control;
        - Sediment trapping; and
        - Water quality enhancements (assimilation of nutrients).
    - Those systems classified as *Critically Endangered or Endangered* (Nel *et al.,* 2012);
    - Wetlands located upstream of important water supply dams; and
    - Identified water-stressed catchments/basins from the river RU process.

  Once the WRUs had been selected, the WRUs were prioritised in terms of their overall importance and the level of detail with which each WRU was to be assessed. Three 'tiers'

were created with Tier 1 WRUs requiring the least amount of detail and Tier 3 WRUs requiring the most amount of detail (see the Wetland Fieldwork Report for more details; DWS 2022b). A site visit to each of the WRUs was undertaken in April 2022.

- **Step 3: Determine reference conditions; PES, EIS, and REC for the priority sites:** The reference conditions of each WRU were determined using a variety of appropriate assessment tools such as the WET-Health framework. The PES for each wetland was determined using the WET-Health v2 assessment tool (MacFarlane *et al.,* 2020) and either a Level 1B or a Level 2 WET-Health assessment was undertaken for each WRU depending on the pre-determined level of assessment (determined in Step 2). The hydrological, geomorphic, water quality and vegetation components of each WRU were assessed as part of the PES assessment. The EIS and the REC of each WRU were determined using the approach defined in Rountree *et al.* (2013). It was during this step that WRU 01[1] and WRU 14[2] were excluded from this report.
- **Step 4: Determine the basic human need (BHN) and the Ecological Water Requirements (EWR):** This step was not undertaken for the wetland component of this study.
- **Step 5: Ecological consequences of operational scenarios/rules:** The potential impacts of developments in each WRU and their associated catchments were considered, specifically in terms of any potential changes to water inputs and outputs. These specify the operational scenarios/rules and ecological consequences for meeting the Reserve.
- **Step 6: Evaluate the scenarios with stakeholders:** This component of the Reserve determination process is carried out by the regulators of the Water Management Areas (WMA) assisted by the project team and includes the consideration of the RECs and the operational scenarios/rules before the initiation of the gazetting process. This allows the interested and affected parties to comment on the suggested Reserve. The gazetting of the Reserve does not form part of this study and only Reserve templates will be compiled (see step 7 below).
- **Step 7: Design appropriate Reserve templates, eco-specifications and monitoring programmes:** The wetland component of this study included the specification of monitoring requirements for each WRU (where necessary). These eco-specifications will then be

[1] After a detailed desktop assessment of WRU 01, it was decided that this unit would be excluded from further assessment due to the extremely modified nature of the system. The system has been extensively canalised and while it is providing some ecosystem services, it is considered to be too modified for inclusion as a WRU. It is anticipated that the system has crossed a threshold and entered into an alternate stable state whereby it would require large investment of resources to return it to a functional system with a moderate level of integrity.

[2] After a detailed desktop assessment of WRU 14, and feedback from the rivers survey team, it was decided that this unit would be excluded due to the artificial nature of the system. The floodplain characteristics of this system have been created due to artificially elevated rates of sediment accumulation as a result of the construction of a weir in the Caledon River as well as the Welbedaght Dam downstream. An artificial system of this nature cannot be formally assessed using the WET-Health assessment tool as there is no reference state against which it can be measured. However, it is providing extensive ecosystem services in the form of sediment trapping, water quality enhancement, streamflow regulation and flood attenuation. It should be considered for alien invasive plant removal activities to maintain the provision of those ecosystem services.

incorporated into Water Use License conditions to allow for monitoring and auditing of the condition of the resource.

- **Step 8: Gazette and implement the Reserve:** The gazetting and the implementation of the Reserve is carried out by the regulators of the WMAs and is assisted by the project team where necessary.

An important aspect of the overall Reserve study is the integration of the separate ecological components (rivers, wetlands and groundwater) to ensure that their respective requirements interact in a way that works to satisfy the various water resource components (river-groundwater, wetland-river and wetland-groundwater). However, this integration process is not included in this report as the other components (groundwater and rivers) were only able to carry out fieldwork significantly later than the wetland team was. Therefore, the integration of these three components will be documented within the rivers EWR Quantification Report.

# 4. WETLAND RESERVE DETERMINATION FOR THE UPPER ORANGE CATCHMENT - RESULTS

Twelve wetland resource units were selected for the Upper Orange Catchment and were visited as part of the field survey by the team (**Figure 4-1** and **Table 4-1**). These systems varied drastically in terms of their type, integrity, functionality and size, but were all regarded as important enough to be included in this report. The outcomes of the Reserve determination for the wetlands in the Upper Orange Catchment are presented summarily in the following sections.

**Table 4-1 Summary of information for the WRU's selected for the Upper Orange Reserve study**

| WRU Number | Latitude | Longitude | Quaternary Catchment | Associated River/Groundwater Area |
|---|---|---|---|---|
| WRU 02 | 28°43'48.03"S | 28°06'49.33"E | D21G | Brandwater River |
| WRU 03 | 28°43'48.03"S | 28°06'49.33"E | C52H | N/A |
| WRU 04 | 30°29'03.80"S | 24°37'01.38"E | D31B | Hondeblaf River |
| WRU 05 | 27°33'30.68"S | 30°31'40.58"E | D13G | Wolwespruit |
| WRU 06 | 30°49'30.78"S | 27°27'54.22"E | D13E | Klein-Wildebeesspruit |
| WRU 10 | 29°38'02.89"S | 24°39'00.21"E | D33C | Lemoenspruit |
| WRU 11 | 28°59'52.00"S | 25°50'03.80"E | C52G | Kaalspruit |
| WRU 12 | 28°42'36.67"S | 26°17'42.21"E | C52G | Rietspruit |
| WRU 13 | 28°55'59.70"S | 27°43'14.61"E | D22G | Rantsho River |
| WRU 15 | 29°49'01.45"S | 25°28'32.13"E | C51H | Prosesspruit |
| WRU 16 | 27°33'30.68"S | 30°31'40.58"E | D13D | Rytjiesvlaktespruit |
| WRU 17 | 30°40'33.81"S | 27°57'24.79"E | D13B | Kraai River |

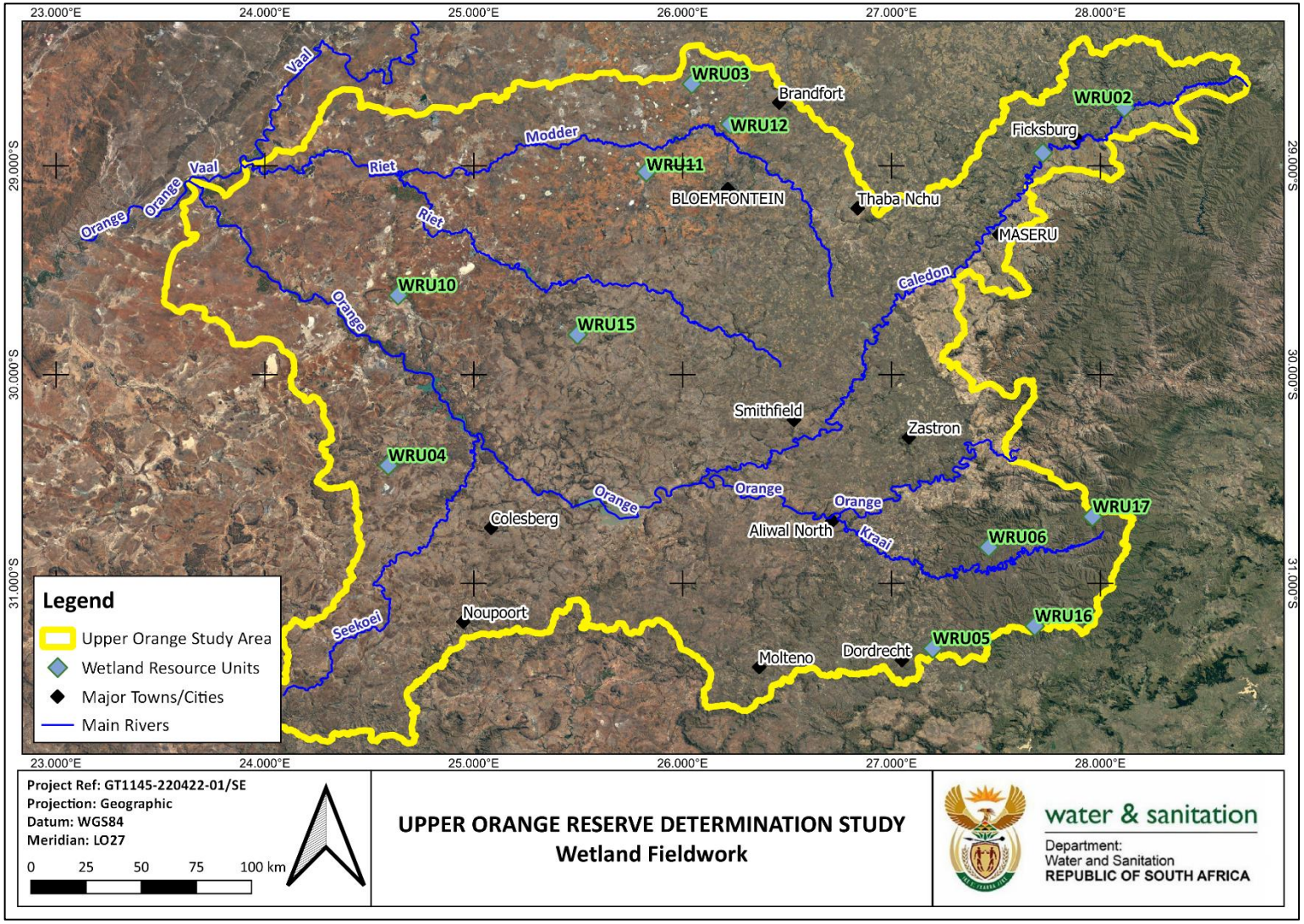


**Figure 4-1 Overview of the wetland resource units selected for the Upper Orange Catchment area.**

## 4.1 WRU 02 – Brandwater Floodplain

| Factor | Comment |
|---|---|
| WRU Number | WRU 02 |
| HGM Unit Type(s) | Floodplain Wetland |
| Description of WRU | The Brandwater floodplain is a medium-sized floodplain wetland approximately 260 ha in size with a longitudinal slope of 0.08%. The wetland is fed by an upstream catchment that is over 76 000 ha in size, a large proportion of which is cultivated (**Figure 4-2**). While no major dams are located on the two main feeder streams, many of the tributaries of these streams are extensively dammed. The Brandwater floodplain is located at the toe of the Brandwater River, approximately 1.5km upstream of its confluence with the Caledon River. A dolerite sill acts as a geological control and a local base level for the wetland. However, the channel within the Brandwater floodplain has become incised and is approximately 4-6m deep along the length of the wetland, and it is unlikely that it overtops its banks regularly (**Figure 4-3**). The lower portion of this channel has been colonised by *Salix babylonica* trees. Large seasonal lateral flood-out areas are still maintained adjacent to the channel through lateral seepage and tributary inputs and are characterised by a mix of facultative positive and obligate wetland species (**Figure 4-4**). Large portions of these lateral flood-outs have been drained to allow for cultivation, hay production and grazing within the floodplain. |
| Unique Features | While the floodplain is no longer activated via floodwaters, the maintenance of the lateral flood-out zones is critical for providing ecosystem services such as biodiversity maintenance and grazing for livestock. It is uncommon to find such extensive and hydrologically well-maintained flood-out zones in a floodplain context. |
| Vegetation types | Mesic Highveld Grassland Group 2 (NBA, 2018); Eastern Free State Clay Grassland (Mucina and Rutherford, 2006) |
| Threat Status | Critically Endangered (CR) |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 02 - Brandwater Floodplain | | | |
| Assessment Unit | Brandwater Floodplain 1 | | | |
| HGM type | Floodplain wetland | | | |
| Wetland area (ha) | 258.6 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 3.6 | 2.8 | 1.5 | 5.6 |
| PES Score (%) | 64% | 72% | 85% | 44% |
| Ecological Category | C | C | B | D |
| Combined Impact Score | 3.4 | | | |
| Combined PES Score (%) | 66% | | | |
| Combined Ecological Category | C | | | |

EI-ES

| *Brandwater Floodplain* | |
|---|---|
| | Importance |
| Ecological Importance & Sensitivity | 3.2 |
| Hydro-Functional Importance | 1.2 |
| Direct Human Benefits | 0.1 |
| Overall Importance And Sensitivity Score | 3.2 |
| Overall Importance And Sensitivity Category | B |

REC

REC is **C** category. While the EIS is high, it is not easily feasible to increase the current PES to meet the EIS category as much of the loss of integrity in the wetland has occurred as a result of the widespread channel incision and the deactivation of large portions of the floodplain wetland. The rehabilitation of this would require large-scale intervention, beyond the financial affordability of private landowners and/or the state.

| | |
|---|---|
| Operational Scenarios/Rules | With approximately 32% of the catchment area commercially cultivated, there is a moderate impact on the present water quality state (PWQS) that originates from diffuse flows from the catchment area. A very small proportion of the cultivation in the catchment is irrigated agriculture, but should this proportion increase, it is likely to be accompanied by an increase in dams within the catchment and a reduction in the water inputs to the wetland (especially in terms of flows into the important flood-out zones from the lateral inputs). Additionally, some drains were noted within the lateral flood-out zones within the wetland which drain these important portions of the wetland to allow for cultivation and the production of hay. These drains have a negative impact on water retention and distribution in the wetland, and an increase in the density of drains will lead to a further reduction in water retention and distribution within the wetland. Furthermore, the undrained flood-outs are utilised for grazing (it is assumed predominantly in the winter months), which will have a negative impact on the vegetation composition in these flood-out areas. |
| Eco Specifications | A desktop-based landcover assessment must be undertaken every 3-5 years to monitor the integrity of the flood-out zones adjacent to the channel within the floodplain. The density of drains within these flood-out zones must be monitored, and a qualitative assessment of the level of desiccation of these flood-outs should simultaneously be carried out using historical aerial/satellite imagery. No additional cultivation should be allowed to take place within the wetland, especially not within an intact portion or flood-out zone. There should be no further encroachment of AIP species within the wetland. Additional recommendations include the removal of *Salix babylonica* trees from the channel of the wetland and ensuring the control of alien invasive plants takes place within the wetland – provided that their removal can be undertaken safely and in such a way that it is beneficial both to the wetland and the landowners (i.e., their removal does not result in unnecessary and excessive ecological damage to the wetland and provided that these trees are not currently used by farmers to provide livestock with shaded areas). |

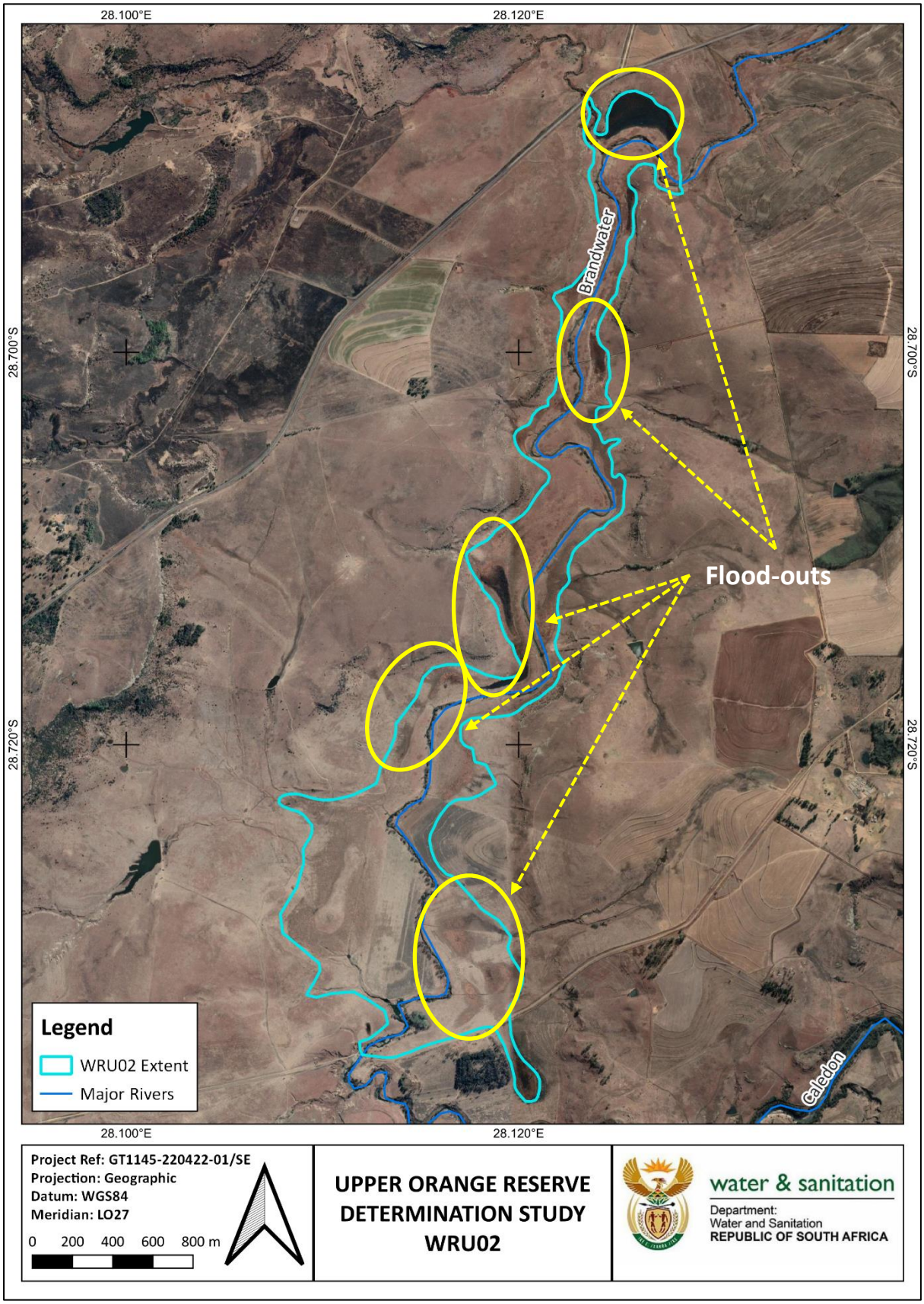


**Figure 4-2 Overview of WRU 02. Areas circled in yellow indicate large lateral flood-out zones which should be maintained where possible.**

**Figure 4-3** **Deeply incised and widened channel of the Brandwater River as it flows out of the southern portion of the WRU 02 wetland.**

**Figure 4-4** **Large flood-out features maintained by lateral processes as indicated by darker patches of vegetation in the central and right-hand side of the photograph.**

## 4.2 WRU 03 - Soutpan Depression Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 03 |
| HGM Unit Type(s) | Depression Wetlands |
| Description of WRU | WRU 03 is a large wetland complex consisting of a total of 27 depression wetlands that range in size from 6 ha to 1 800 ha (**Figure 4-5**). The largest of these wetlands is known as Soutpan and is an active salt mine as the name implies (**Figure 4-6**). The majority of these depression wetlands are endorheic and have no clear outward-flowing connection to river systems. However, most of the depression wetlands have inward flowing streams which contribute hydrologically to their functioning but will also contribute any sediments and pollutants originating from the catchment associated with the inflowing stream. Most of the other depression wetlands within the WRU are relatively intact and do not appear to have any significant in-system impacts. However, the catchments of many of these wetlands have been extensively cultivated, which likely contributes to a decline in the present water quality and geomorphic state of these wetlands. These depression wetlands are generally characterised by seasonal wetness and associated seasonal wetland vegetation that typically consists of a mosaic of grass and sedge species. These depression wetlands provide very important nesting and feeding habitats for aquatic birds in the region. |
| Unique Features | These depression wetlands, as a complex, provide important habitat diversity in an otherwise relatively homogenous landscape. According to the Mucina and Rutherford (2006) vegetation classification, these salt pans support vegetation that is distinct from the surrounding vegetation. These wetlands form unique features in the broader landscape and provide important habitats for both fauna and flora. |
| Vegetation types | Dry Highveld Grassland Group 3 (NBA, 2018); Highveld Salt Pans (Mucina and Rutherford, 2006) |
| Threat Status | Least Threatened (LT) |
| PES | The PES assessment for WRU 03 was separated into two assessments. One assessment was undertaken for Soutpan itself, as the land use within the wetland is vastly different from the surrounding depression wetlands. An additional wetland assessment was undertaken based on the landcover data for a subset of the other depression wetlands included within the WRU as their characteristics were generally very similar i.e., this assessment is considered to be representative of the wetland complex. It was not feasible to undertake individual assessments for all the identified depression wetlands. |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 03 – Soutpan Wetland Complex** | | | |
| Assessment Unit | **WRU 03a Soutpan** | | | |
| HGM type | Depression without flushing | | | |
| Wetland area (ha) | 1860.7 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 3.7 | 2.3 | 3.6 | 4.8 |
| PES Score (%) | 63% | 77% | 64% | 52% |
| **Ecological Category** | **C** | **C** | **C** | **D** |
| **Combined Impact Score** | 3.6 | | | |
| **Combined PES Score (%)** | 64% | | | |
| **Combined Ecological Category** | **C** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 03b - Soutpan Wetland Complex** | | | |
| Assessment Unit | **WRU 03b Remaining Depression Wetlands** | | | |
| HGM type | Depression without flushing | | | |
| Wetland area (ha) | 698.0 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 1.2 | 1.7 | 0.8 | 1.0 |
| PES Score (%) | 88% | 83% | 92% | 90% |
| **Ecological Category** | **B** | **B** | **A** | **B** |
| **Combined Impact Score** | 1.2 | | | |
| **Combined PES Score (%)** | 88% | | | |
| **Combined Ecological Category** | **B** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 03a - Soutpan</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.2</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.2</td></tr>
<tr><td>Direct Human Benefits</td><td>0.6</td></tr>
<tr><td>Overall Importance and Sensitivity Score</td><td>2.2</td></tr>
<tr><td>Overall Importance and Sensitivity Category</td><td>C</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 03b - Soutpan Remaining Wetlands</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.1</td></tr>
<tr><td>Direct Human Benefits</td><td>0.2</td></tr>
<tr><td>Overall Importance and Sensitivity Score</td><td>2.8</td></tr>
<tr><td>Overall Importance and Sensitivity Category</td><td>C</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>REC for WRU 03a is C while the REC for WRU 03b is a B category. The REC for Soutpan can be achieved if the salt mining operations are maintained at their current intensity, and the agricultural practices within the catchment are maintained at their current extent. An increase in these activities will result in impacts on the wetlands at greater magnitudes than currently recorded. The REC for the remaining depression wetlands can be achieved if appropriate buffer zones are maintained between agricultural areas and the wetlands and their inflowing streams. Furthermore, the agricultural activities must be maintained at or near their current intensity and extent in order to maintain the current REC (intensification and expansion would possibly result in an increase in the use of herbicides, pesticides and fertilizers). Erosion and the encroachment of alien invasive vegetation must be controlled to achieve the REC for both WRUs.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>Depression wetlands by nature are sensitive to changing land uses in their catchments, specifically land uses that result in adverse water quality and sediment mobilisation. Most of these depression wetlands are endorheic and function as a sink for pollutants and sediment. With mean annual precipitation (MAP) of 456mm and potential evaporation (PE) of 2452mm, these systems are often threatened by toxic concentrations of pollutants that accumulate over long periods. In addition, because they are not fluvial systems, they also act as sediment</td></tr>
</table>

| | |
|---|---|
| | sinks and are often threatened by extensive sediment deposition which can submerge natural vegetation and cause shifts in their geomorphic structure. With the proliferation of cultivation and livestock farming in this region of the northern Free State, these systems are increasingly threatened by land use changes and/or the degradation of natural veld in their catchments. With increasing unmitigated land degradation in the catchments of these depression wetlands, they are at risk of adverse changes in their PES. |
| Eco Specifications | A landcover-based assessment of the catchments of this RU must be undertaken every 3-5 years to monitor whether the depression wetlands are under increasing pressure from the surrounding land uses. A detailed landcover-based assessment of the depression wetlands must be undertaken to assess the extent of sediment deposition and nutrient flushes from the surrounding landscape. |

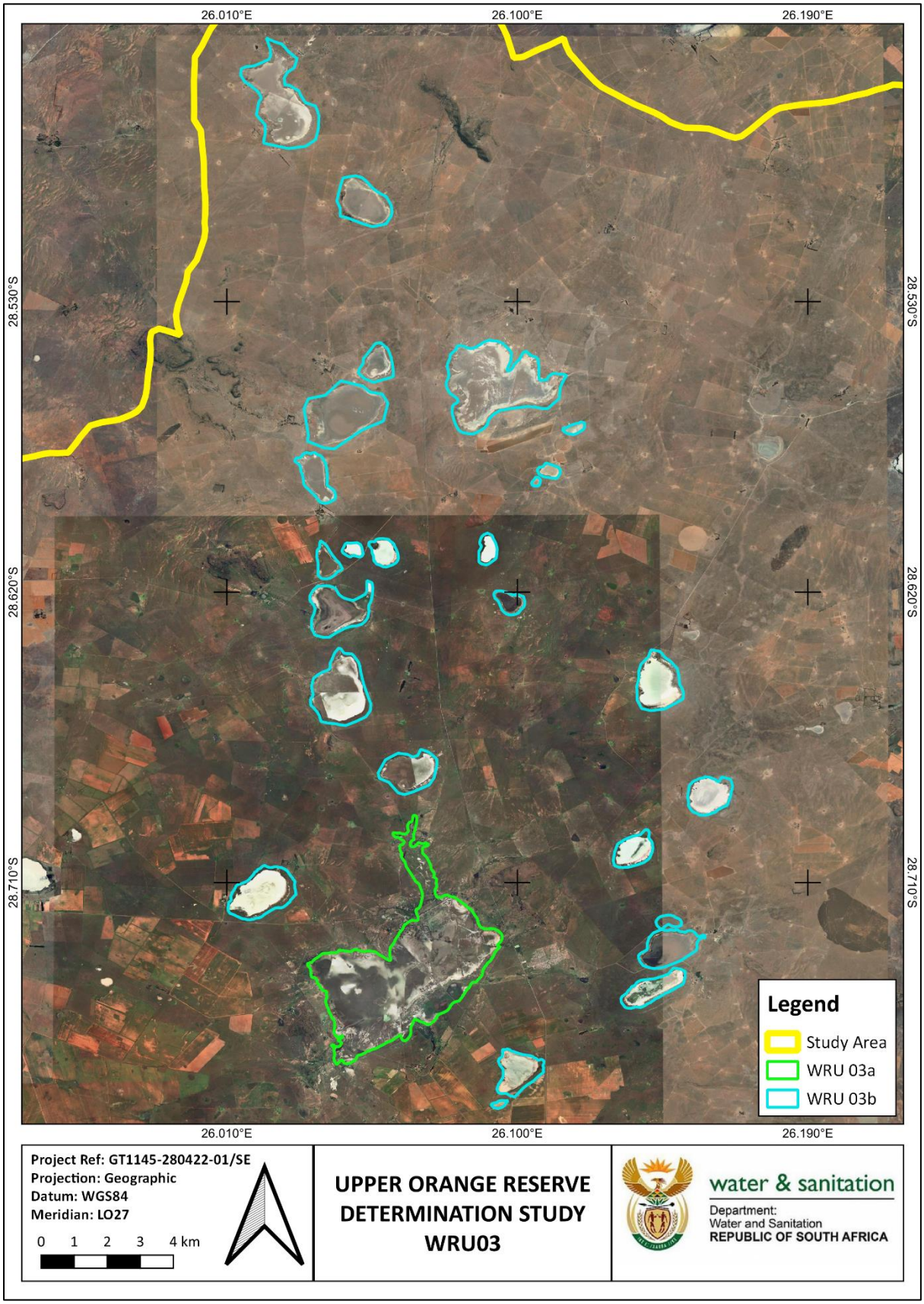


**Figure 4-5 Overview of the WRU 03 wetland complex**

**Figure 4-6** **Picture of Soutpan with evidence of vegetation clearing in the foreground in preparation to set up a salt mining operation, and an active salt mining operation located to the right of the photograph.**

## 4.3 WRU 04 – Philipstown Unchannelled Valley-Bottom Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 04 |
| HGM Unit Type(s) | Unchannelled Valley-Bottom and Depression Wetlands |
| Description of WRU | WRU 04 is a complex of two different wetland types, a depression wetland approximately 1 100 ha in size and an unchannelled valley-bottom (UCVB) wetland approximately 190 ha in size (**Figure 4-7**). The upstream catchment areas of both wetland units are in a relatively natural condition with little to no human impact. Aside from a small number of roads and scattered farmhouses, the majority of the catchments appear to be relatively unaffected by agriculture or settlement. However, a large herd of goats and a herd of sheep were observed in the catchment of the UCVB, and evidence of light grazing was observed in both wetland catchments – which is indicative of grazing pressure which exceeds the natural situation. The UCVB wetland was included as a wetland RU for its proximity and hydrological connection to the Vanderkloof Dam downstream as the UCVB wetland provides important ecosystem services in terms of water quality enhancement and sediment trapping to these downstream freshwater ecosystems (see large reedbed areas in **Figure 4-8**). The depression wetland was included in the WRU because it has a significant catchment and may have groundwater linkages to the valley-bottom wetland downstream. It is also an important wetland for unique assemblages of fauna and flora in the area. The large area to the east of the depression wetland (indicated by grey colours in aerial imagery) is a dam in which wetland conditions have been created. |
| Unique Features | Similar to WRU 03, the depression wetland provides important habitat diversity in an otherwise relatively homogenous landscape. According to the Mucina and Rutherford (2006) vegetation classification, these salt pans support vegetation that is distinct from the surrounding vegetation. These wetlands form unique features in the broader landscape and provide important habitats for both fauna and flora. Additionally, with a mean annual precipitation of 313mm and potential evaporation of 2466mm, it is rare to find fluvial wetlands such as a UCVB in this landscape. The hydromorphic indicators observed within the UCVB are unique and provide habitat diversity in an otherwise arid landscape. |
| Vegetation types | Unchannelled Valley-Bottom: Upper Nama Karoo (NBA, 2018); Northern Upper Karoo (Mucina and Rutherford, 2006); Depression: Upper Nama Karoo (NBA, 2018); Highveld Salt Pans (Mucina and Rutherford, 2006) |
| Threat Status | Unchannelled Valley Bottom: Vulnerable (VU); Depression: Least Threatened (LT) |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 04a | | | |
| Assessment Unit | Phillips Town Depression Wetland | | | |
| HGM type | Depression without flushing | | | |
| Wetland area (ha) | 1148.8 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 0.0 | 0.3 | 0.5 | 1.0 |
| PES Score (%) | 100% | 97% | 95% | 90% |
| **Ecological Category** | **A** | **A** | **A** | **B** |
| **Combined Impact Score** | 0.4 | | | |
| **Combined PES Score (%)** | 96% | | | |
| **Combined Ecological Category** | **A** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 04b | | | |
| Assessment Unit | Phillips Town UCVB Wetland | | | |
| HGM type | Unchannelled VB wetland | | | |
| Wetland area (ha) | 192.6 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 2.9 | 1.8 | 0.6 | 4.1 |
| PES Score (%) | 71% | 82% | 94% | 59% |
| **Ecological Category** | **C** | **B** | **A** | **D** |
| **Combined Impact Score** | 2.4 | | | |
| **Combined PES Score (%)** | 76% | | | |
| **Combined Ecological Category** | **C** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 04a - Phillips Town Depression Wetland</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>1.6</td></tr>
<tr><td>Direct Human Benefits</td><td>0.1</td></tr>
<tr><td>Overall Importance and Sensitivity Score</td><td>2.8</td></tr>
<tr><td>Overall Importance and Sensitivity Category</td><td>C</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 04b - Phillips Town UCVB Wetland</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>3.0</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.1</td></tr>
<tr><td>Direct Human Benefits</td><td>0.2</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.0</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The REC for WRU 04a is A while the REC for WRU 04b should be maintained at a C category. The REC for WRU 04a can be achieved by maintaining the current level of land utilisation within the catchment – which is limited primarily to grazing and very limited cultivation. The depression wetland should be protected from salt mining. The REC for WRU 04b can be achieved by maintaining the current number of dams within the catchment and by maintaining the low level of cultivation within the catchment and the wetland. Furthermore, the encroachment of AIP species should be kept at low levels to achieve the REC for both WRU 04a and WRU 04b.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>Depression wetlands by nature are sensitive to changing land uses in their catchments, specifically land uses that result in adverse water quality and sediment mobilisation. This depression wetland is endorheic and acts as a sink for pollutants and sediment. With mean annual precipitation (MAP) of 456mm and potential evaporation (PE) of 2452mm, these types of systems are often threatened by toxic concentrations of pollutants that accumulate over long periods. In addition, because they are not fluvial systems, they also act as sediment sinks and are often threatened by extensive sediment deposition which can bury natural vegetation and cause shifts in the geomorphic structure of these systems. With the proliferation of cultivation and livestock farming in this region of the northern Free State, these systems are increasingly</td></tr>
</table>

| | |
|---|---|
| | threatened by land use changes and/or the degradation of natural veld in their catchments. With increasing unmitigated land degradation in the catchments of these depression wetlands, they are at risk of adverse changes in their PES. The same applies to valley-bottom wetlands, with the proliferation of agriculture and localised developments, many valley-bottom wetlands are under increasing pressure to provide ecosystem services, and the fauna and flora associated with these wetlands are increasingly threatened. |
| Eco Specifications | A landcover-based assessment of the catchments of this RU must be undertaken every 3-5 years to monitor whether the wetlands are under increasing pressure from the surrounding land uses. A further detailed landcover-based assessment of the depression wetland must be undertaken to assess the extent of sediment deposits and or nutrient flushes from the surrounding landscape. Furthermore, there must be no expansion of agricultural activities or other land uses into the remaining intact UCVB wetland areas. |

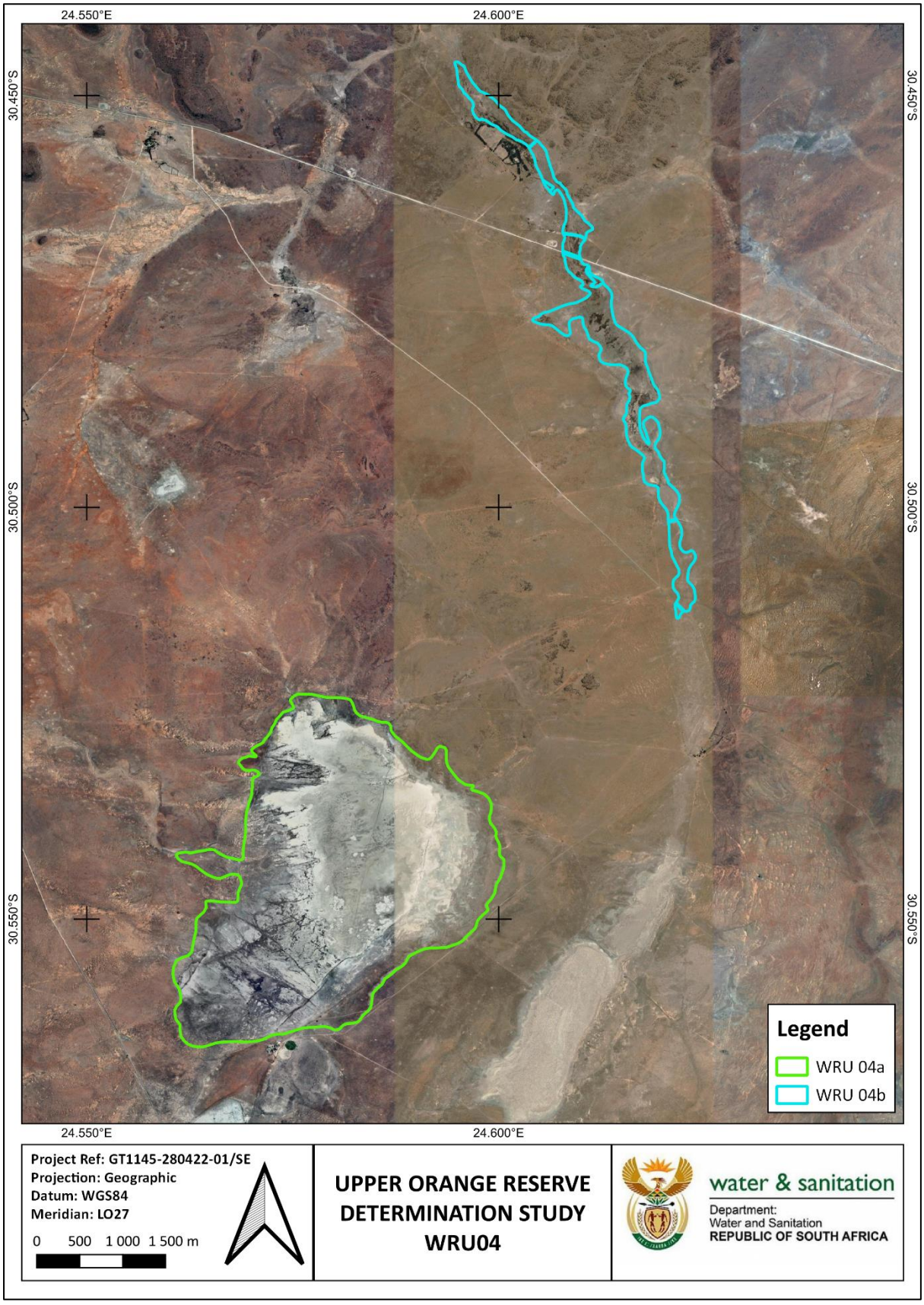


**Figure 4-7 Overview of WRU 04.**

**Figure 4-8** **Extensive *Phragmites australis* reedbed located downstream of road crossing with extensive stands of *Miscanthus capensis* along the valley-bottom wetland.**

## 4.4 WRU 05 – Wolwespruit Headwaters Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 05 |
| HGM Unit Type(s) | Unchannelled Valley-Bottom and Hillslope Seep Wetlands |
| Description of WRU | WRU 05 is a large wetland complex consisting of a series of unchannelled valley-bottom (UCVB) wetlands which are fed by multiple hillslope seep (HSS) wetlands (**Figure 4-9**). In total, the WRU covers an area of approximately 420 ha and forms the headwaters of the Wolwespruit River. The catchments of many of these systems have been extensively cultivated and/or grazed, with extensive areas of cultivation (incorporating contour banks and other runoff management measures) and many small dams located on the tributaries (**Figure 4-10** and **Figure 4-11**). The valley-bottom wetlands have been extensively dammed, with over 15 dams along the length of the mainstem valley. In addition, there are a total of nine road crossings within the WRU, the majority of which have insufficient allowance for flows to pass beneath them, resulting in damming of water upstream and the desiccation of the wetland downstream of the crossings. Several boreholes and wind pumps were observed adjacent to many of the valley-bottom wetlands, with some situated near or within the seepage wetlands. The wetlands are predominantly used directly for grazing and as a water source for cultivation in the catchment areas. A large number of Blue Cranes (*Grus paradisea*) and Crowned Cranes (*Balearica regulorum*) were noted in the wetland. |
| Unique Features | A large number of cranes were noted within this wetland complex, predominantly within the valley-bottom systems. Although it was not confirmed on site, it is assumed that these wetlands are used as a foraging site by both crane species and possibly also a breeding site for the Crowned Cranes. |
| Vegetation types | Unchannelled Valley-Bottom: Drakensberg Grassland Group 2 (NBA, 2018); Southern Drakensberg Highland Grassland (Mucina and Rutherford, 2006); Hillslope Seep: Drakensberg Grassland Group 2 (NBA, 2018); Southern Drakensberg Highland Grassland (Mucina and Rutherford, 2006) |
| Threat Status | Unchannelled Valley Bottom: CR; Hillslope Seeps: CR |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 05a** | | | |
| Assessment Unit | **Wolwespruit UCVB Wetlands** | | | |
| HGM type | Unchannelled VB wetland | | | |
| Wetland area (ha) | 340.0 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 2.4 | 2.2 | 1.7 | 4.8 |
| PES Score (%) | 76% | 78% | 83% | 52% |
| **Ecological Category** | **C** | **C** | **B** | **D** |
| **Combined Impact Score** | 2.8 | | | |
| **Combined PES Score (%)** | 72% | | | |
| **Combined Ecological Category** | **C** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 05b** | | | |
| Assessment Unit | **Wolwespruit Seep Wetlands** | | | |
| HGM type | Seep | | | |
| Wetland area (ha) | 80.5 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 2.1 | 2.1 | 1.5 | 4.2 |
| PES Score (%) | 79% | 79% | 85% | 58% |
| **Ecological Category** | **C** | **C** | **B** | **D** |
| **Combined Impact Score** | 2.4 | | | |
| **Combined PES Score (%)** | 76% | | | |
| **Combined Ecological Category** | **C** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 05a - Wolwespruit UCVB Wetlands</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>3.2</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.6</td></tr>
<tr><td>Direct Human Benefits</td><td>0.8</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.2</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>B</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 05b - Wolwespruit Seep Wetlands</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>1.8</td></tr>
<tr><td>Direct Human Benefits</td><td>0.4</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>2.8</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The RECs for WRU 05a and WRU 05b will pragmatically have to be maintained at C categories. It is unrealistic for WRU 05a to achieve a B- category REC due to the existing impacts linked to land use activities and infrastructure within the wetland. These existing impacts include multiple dams, multiple road crossings and several cultivated areas within the UCVB wetlands in the complex – most of which cannot easily be reversed or restored. However, to maintain a C category for both WRUs, it is necessary not to increase the current number of dams within the wetland complex and not exceed the level of AIPs within the complex. Furthermore, several drains have been excavated within the complex to increase the rate of flow into some of the dams. Additional drains must not be excavated within the wetland complex to maintain the current PES categories. It is also important to limit cultivation within the catchment areas, ensuring mitigation measures are incorporated into the land use planning in terms of sediment generation, fertiliser and herbicide/pesticide regimes and water supply requirements.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>There will likely be an expansion and an intensification of agriculture within the catchment of WRU 05 in future. This will place a greater demand on the wetland in terms of supplying water to these cultivated areas as well as to enhance the provision of water quality ecosystem services to the water resource which will likely become increasingly polluted with fertilizers and herbicides/pesticides as agriculture intensifies.</td></tr>
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|---|---|
| | Furthermore, the increase in agriculture may also necessitate the drilling and installation of additional boreholes and windpumps which will have a detrimental impact on the water inputs to the seepage wetlands if they are fed by the same aquifer/groundwater source. |
| Eco Specifications | Landcover-based assessment of the catchments of this RU must be undertaken every 3-5 years to monitor if the wetlands are under increasing pressure from the surrounding land uses. No further dams must be permitted within any of the wetland areas, and an appropriate groundwater study must be undertaken before any further boreholes/windpumps are constructed within the wetland and its catchment. No further cultivation must be permitted within the remaining intact portions of the wetland and there must be no further changes to the natural hydrology of the wetland – e.g., from perennial to seasonal wetness zones. No further drains must be permitted within the remaining intact portions of the wetlands and no new roads should be constructed through intact wetland areas. A WET-Health assessment of the complex must be undertaken every 2-3 years[3] with a specific focus on the Hydrology module and the 'Change in water distribution and retention' score – specifically for the UCVB wetlands. Where possible, existing roads must be upgraded to incorporate sufficient throughflow capacity in the form of culverts or permeable road bedding to encourage natural water distribution and retention across the width of the wetland up and downstream of the roads. In addition, rotational burning (2-3 years) of the wetland should be encouraged where possible to promote vegetation vigour although this should be sensitive to the requirements of the crane species utilising the system |

[3] The frequency of these assessments is high because of the threat status of the wetland and its importance as a headwater wetland.

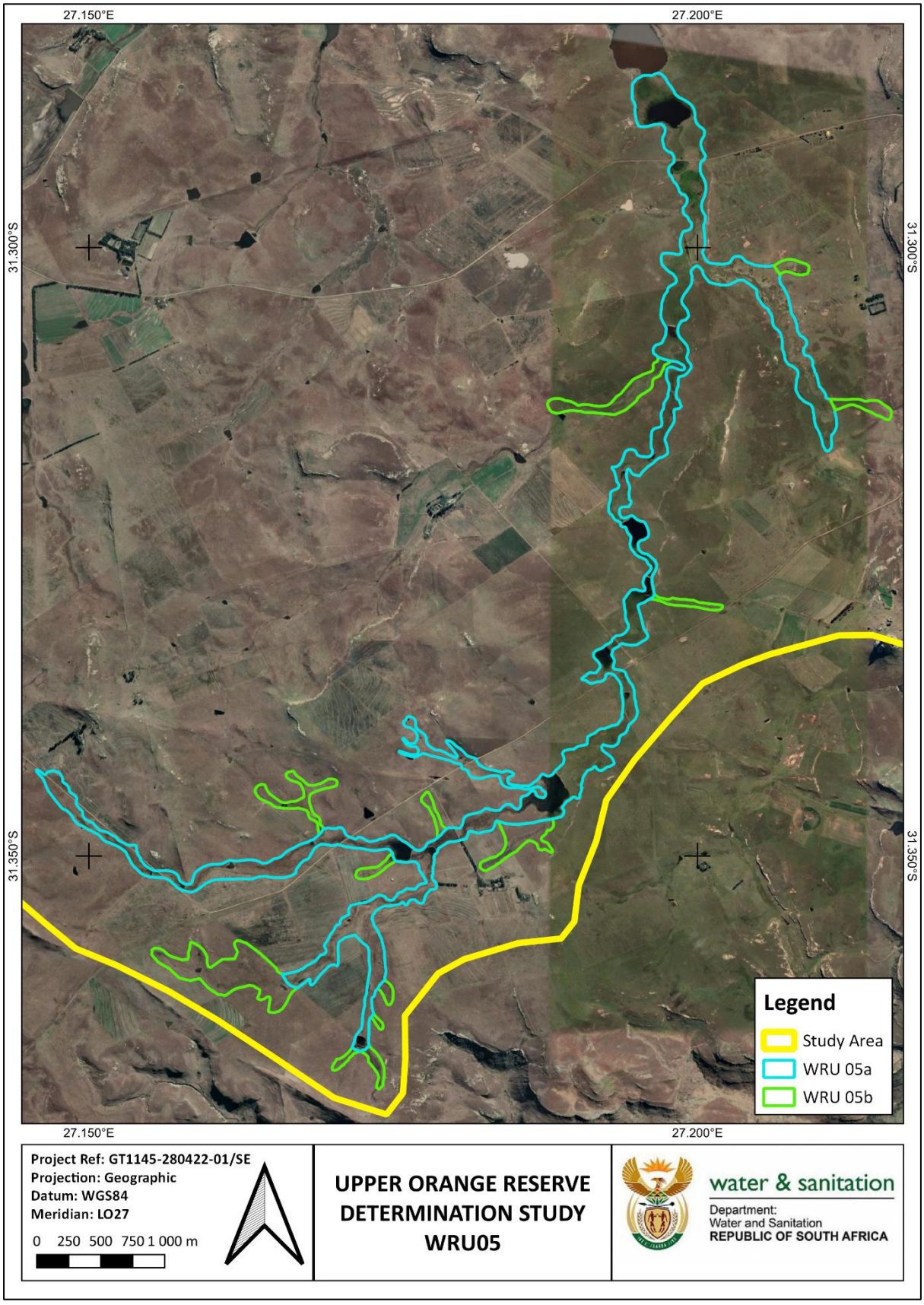


**Figure 4-9 Overview of WRU 05**

**Figure 4-10 Extensive wetland area upstream of a small farm dam visible in the centre of the photograph. A windmill can be seen on the right-hand side of the picture.**

**Figure 4-11 Broad valley-bottom wetland with several head of cattle on either side of the wetland.**

## 4.5 WRU 06 – Klein-Wildebeespruit Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 06 |
| HGM Unit Type(s) | Channelled Valley-Bottom and Hillslope Seep Wetlands |
| Description of WRU | WRU 06 is a large wetland complex located along the Klein Wildebeesspruit and the unnamed river to the east of the Klein-Wildebeesspruit. The WRU is comprised of a series of valley bottom wetlands which amount to approximately 950 ha in size. These valley-bottom wetlands are fed by many seep wetlands which total approximately 450 ha in size together. These two large wetland complexes are tributaries of the Kraai River and are therefore key in providing ecosystem services such as water quality enhancement and sediment trapping (**Figure 4-12**). The catchments of both wetland complexes are generally intact, with little to no impacts in the more distal areas of the catchments, given the remoteness and the steep topography. However, the broad and relatively flat valley-bottom areas have been utilised extensively for cultivation and there are a number of large commercial farming operations located within the valley-bottom and seep wetlands. These operations have resulted in the multiple impacts to the wetlands which include the implementation of drains, channel modification, infilling and reduction in surface roughness. High concentrations of AIP species have also promulgated along many of the channels in the valley-bottom wetlands[4]. |
| Unique Features | N/A |
| Vegetation types | Drakensberg Grassland Group 3 (NBA, 2018); Southern Drakensberg Highland Grassland (Mucina and Rutherford, 2006) |
| Threat Status | CVB: EN; SEEP: VU |

[4] This WRU was not visited as part of the field campaign as has therefore been assessed at a desktop level. As such, it is not possible to identify the species of AIP lining the channels.

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 06a | | | |
| Assessment Unit | Klein-Wildebeesspruit CVB Wetlands | | | |
| HGM type | Channelled VB wetland laterally maintained (i.e. with substantial lateral inputs) | | | |
| Wetland area (ha) | 949.8 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 4.4 | 3.0 | 3.0 | 6.8 |
| PES Score (%) | 56% | 70% | 70% | 32% |
| **Ecological Category** | **D** | **C** | **C** | **E** |
| **Combined Impact Score** | 4.3 | | | |
| **Combined PES Score (%)** | 57% | | | |
| **Combined Ecological Category** | **D** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 06b | | | |
| Assessment Unit | Klein-Wildebeesspruit Seep Wetlands | | | |
| HGM type | Seep | | | |
| Wetland area (ha) | 456.9 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 4.7 | 3.3 | 3.3 | 7.1 |
| PES Score (%) | 53% | 67% | 67% | 29% |
| **Ecological Category** | **D** | **C** | **C** | **E** |
| **Combined Impact Score** | 4.6 | | | |
| **Combined PES Score (%)** | 54% | | | |
| **Combined Ecological Category** | **D** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 06a – Wildebeesspruit CVB Wetlands</th></tr>
<tr><th></th><th>Importance</th></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.4</td></tr>
<tr><td>Direct Human Benefits</td><td>0.8</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>2.8</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 06b – Wildebeesspruit Seep Wetlands</th></tr>
<tr><th></th><th>Importance</th></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.6</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.0</td></tr>
<tr><td>Direct Human Benefits</td><td>0.7</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>2.6</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The REC for WRU 06a is a D category while the REC for WRU 06b is a C category – determined by the current PES and EIS scores respectively. The REC for WRU 06a has been determined by its PES score because the integrity of the majority of the valley-bottom wetlands cannot be pragmatically improved from a D category. Too much infrastructure and investment into farming land and associated infrastructure has been made into this portion of the WRU. However, opportunity to improve the condition of many of the seep wetlands does exist – hence the REC of C. A number of the seep wetlands in WRU 06b have been negatively impacted by erosion and drainage associated with historical agricultural practices.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>The immediate catchment of the WRU is predominantly utilised for agriculture (>30%) and grazing, while the majority of the remaining catchment area remains undeveloped for agriculture. This is partially because of the remote nature of the WRU, as well as the steep, rocky and relatively inarable nature of the remaining catchment. Most of the arable land within the catchment appears to have been utilised for agriculture and it is therefore considered that the expansion of agriculture within the catchment can practically only occur in limited areas.</td></tr>
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| | There is some opportunity to expand into a number of the wetland areas (specifically the seep wetlands) as they are not as completely cultivated as the valley-bottom wetlands. |
| Eco Specifications | A landcover-based assessment of the catchments of this RU must be undertaken every 3-5 years to monitor whether the wetlands are under increasing pressure from the surrounding land uses. No further cultivation must be permitted within the remaining intact portions of the wetland and there must be no further changes to the natural hydrology of the wetland – e.g., from perennial to seasonal wetness zones. No further drains must be permitted within the remaining intact portions of the wetlands and no new roads should be constructed through intact wetland areas. There should be no further encroachment of AIP species within the wetland. Additional recommendations include the removal of AIP trees from the channel of the wetland valley-bottom wetlands and ensuring the control of alien invasive plants takes place within the wetland – provided that their removal can be undertaken safely and in such a way that it is beneficial both to the wetland and the landowners (i.e., their removal does not result in unnecessary and excessive ecological damage to the wetland and provided that these trees are not currently used by farmers to provide livestock with shaded areas). |

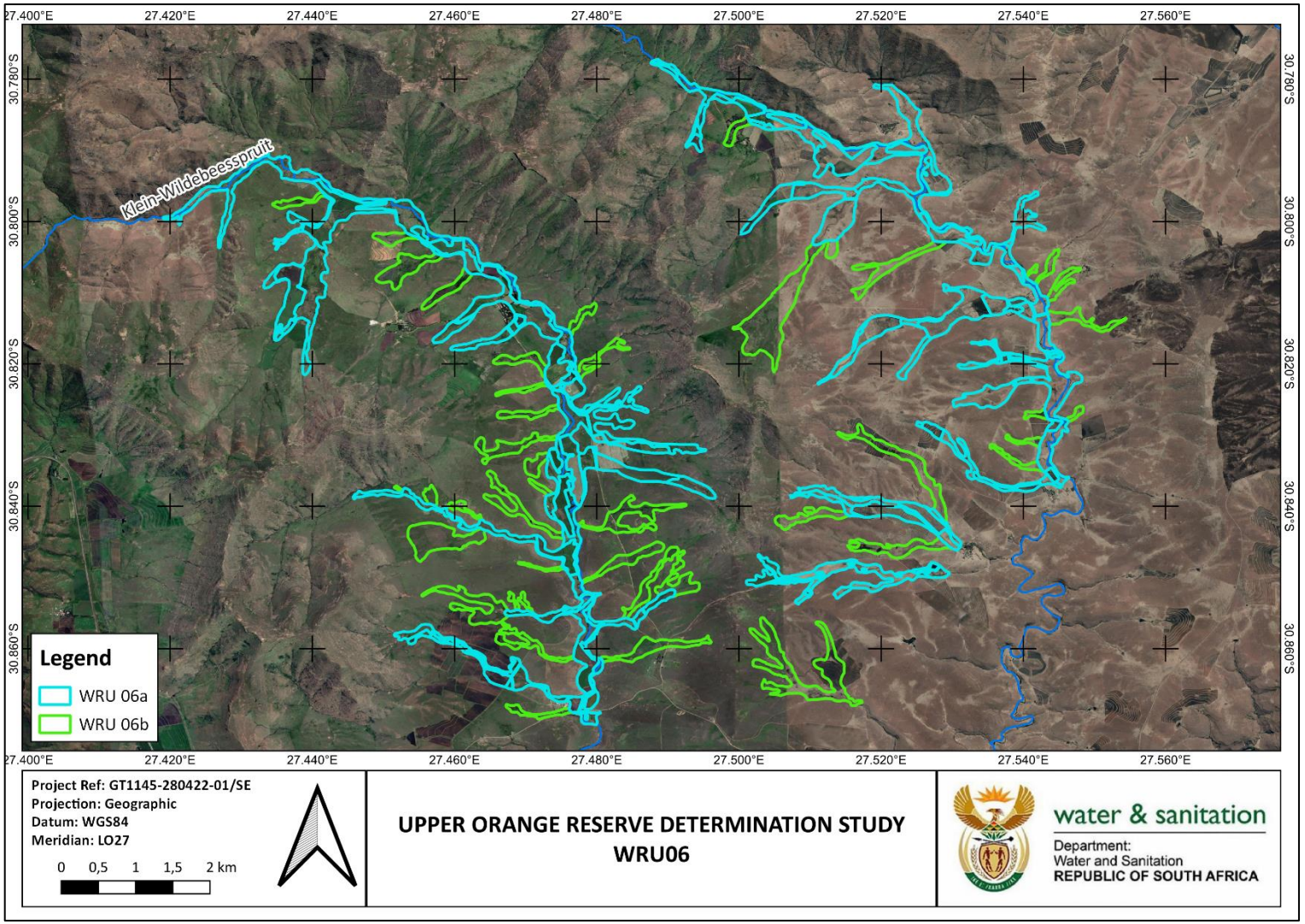


**Figure 4-12 Overview of WRU 06**

## 4.6 WRU 10 – Luckhof Depression Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 10 |
| HGM Unit Type(s) | Depression Wetlands |
| Description of WRU | WRU 10 is a large series of depression wetlands that are hydrologically connected via surface and groundwater. These depression wetlands range in size from 7 ha to 1 200 ha. These fluvially connected wetlands flow in a south-easterly direction into the Lemoenspruit River which is a tributary of the Orange River (**Figure 4-13**). A large number of centre pivot irrigated fields are located to the north of the wetland complex within the upstream catchment of the northern depression wetlands. These fields are supplied by a large irrigation canal which originates from the Vanderkloof Dam. Consequently, there is a low level of reliance on water from the depression wetlands. However, impacts associated with the farming activities in the catchments of these depressions were observed – specifically sedimentation and the possibility of chemical fertilizer/herbicide/pesticide entering the depression wetlands. Aside from the agriculture to the north of the depression wetlands, the catchments of these wetlands are generally natural and undisturbed. The depression wetlands themselves appear to be in a relatively natural condition, with little to no disturbance. The large area to the south of the depression wetlands initially appeared to have wetland characteristics from a desktop scan of the area, but upon arriving onsite it was clear that these features are indicative of an active dune field and not wetlands. |
| Unique Features | These depression wetlands, as a complex, provide important habitat diversity in an otherwise relatively homogenous landscape. According to the Mucina and Rutherford (2006) vegetation classification, these salt pans support vegetation that is distinct from the surrounding vegetation. These wetlands form unique features in the broader landscape and provide important habitats for both fauna and flora. |
| Vegetation types | Upper Nama Karoo (NBA, 2018); Highveld Salt Pans (Mucina and Rutherford, 2006) |
| Threat Status | LT |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 10 | | | |
| Assessment Unit | Luckhof Depression Wetland Complex | | | |
| HGM type | Depression with flushing | | | |
| Wetland area (ha) | 1841.8 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 0.4 | 1.1 | 4.3 | 1.1 |
| PES Score (%) | 96% | 89% | 57% | 89% |
| **Ecological Category** | **A** | **B** | **D** | **B** |
| **Combined Impact Score** | 1.6 | | | |
| **Combined PES Score (%)** | 84% | | | |
| **Combined Ecological Category** | **B** | | | |

EI-ES

| *WRU 10 - Luckhof Depression Wetland Complex* | |
|---|---|
| | **Importance** |
| **Ecological Importance & Sensitivity** | **2.7** |
| **Hydro-Functional Importance** | **1.6** |
| **Direct Human Benefits** | **0.1** |
| **Overall Importance And Sensitivity Score** | **2.7** |
| **Overall Importance And Sensitivity Category** | **C** |

REC

The REC for WRU 10 is a **B** category – determined by the current PES score. This REC can be achieved through the careful planning of land use changes in the catchment, should the need arise.

Operational Scenarios/Rules

Depression wetlands by nature are sensitive to changing land uses in their catchments, specifically land uses that result in adverse water quality and sediment mobilisation. Most of these depression wetlands are endorheic and act as a sink for pollutants and sediment. With mean annual precipitation (MAP) of 332mm and potential evaporation (PE) of 2551mm, these systems are often threatened by toxic

| | |
|---|---|
| | concentrations of pollutants that accumulate over long periods. Additionally, because they are not connected to larger-scale fluvial systems, they collectively also act as sediment sinks and are often threatened by extensive sediment deposition which can submerge natural vegetation and cause shifts in the geomorphic structure of these systems. With access to water via the Vanderkloof canal, there is potential for the expansion of cultivation and livestock farming in this region and these systems are increasingly threatened by land use changes in their catchments. With increasing unmitigated land degradation in the catchments of these depression wetlands, they are at risk of adverse changes in their PES. |
| Eco Specifications | A landcover-based assessment of the catchments of this RU must be undertaken every 3-5 years to monitor whether the depression wetlands are under increasing pressure from the surrounding land uses. A further detailed landcover-based assessment of the depression wetlands themselves must be undertaken to assess the extent of sediment deposits and or nutrient flushes from the surrounding landscape, especially as these may be concentrated by the hydraulic linkages across the irrigation canal. All discharge points which are currently routed into the WRU must be investigated every 3-5 years for adverse impacts on the wetlands. No further agricultural runoff must be discharged into the WRU without appropriate mitigation measures being implemented. No further cultivation should be permitted within the remaining intact portions of the WRU either. |

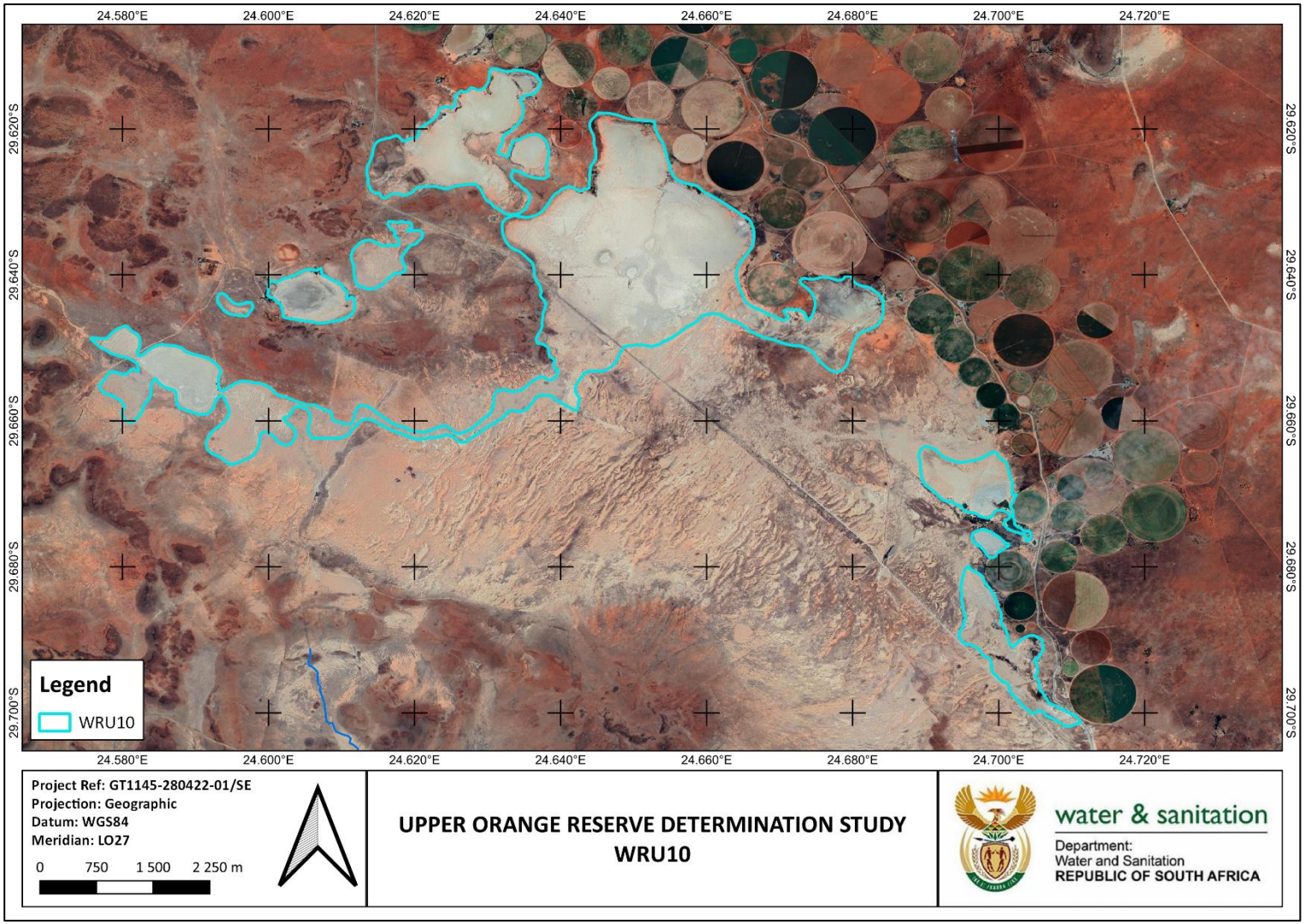


**Figure 4-13 Overview of WRU 10**

## 4.7 WRU 11 – Kaalspruit Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 11 |
| HGM Unit Type(s) | Channelled Valley-Bottom (CVB), Discontinuously Channelled Valley-Bottom (DCVB) and Depression Wetlands |
| Description of WRU | WRU11 is a large wetland complex consisting of several depression wetlands, a discontinuously channelled valley-bottom and a discontinuously channelled valley-bottom wetland (**Figure 4-14**). The mainstem valley-bottom wetland is approximately 2 800 ha in size while the depression wetlands range from 320 ha to approximately 20 ha in size. The valley-bottom wetland is located along the Kaalspruit River, which is a tributary of the Modder River. The catchments of this WRU are dominated by cultivation – predominantly maize and sunflower cultivation. The catchment land use has had a significant impact on a number of the depression wetlands in the RU through extensive sedimentation and possible nutrient loading from fertilizers used in the surrounding agricultural areas. The mainstem wetland is predominantly utilised for grazing and has impacts associated with channel incision in the lower portion of the WRU. A large dam exists in the upstream section of the mainstem wetland and is impacting the hydrological connectivity of this wetland negatively, as well as the natural sediment flux through the wetland. |
| Unique Features | A depression wetland is nested within the CVB wetland, which is a relatively unique and rare situation (**Figure 4-15**). A small channel (separate from the main Kaalspruit River) feeds into the depression wetland, and a larger outflowing channel removes water from the depression wetland when it reaches its capacity. This depression wetland is unique from the other depression wetlands in the area as it has more continuous cycling of water (flushing) and does not become a sink for pollutants or sediment to the same extent that endorheic depression wetlands do. This is indicated by the difference in the colour of the water within the two depression wetlands shown in **Figure 4-16**. This depression feature within the CVB context provides unique habitat diversity in this landscape. |
| Vegetation types | CVB: Dry Highveld Grassland Group 3 (NBA, 2018); Western Free State Clay Grassland and Highveld Alluvial Vegetation (Mucina and Rutherford, 2006); Depressions: Dry Highveld Grassland Group 3 (NBA, 2018); Highveld Salt Pans (Mucina and Rutherford, 2006); |
| Threat Status | CVB: LT; Depressions: LT |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 11a** | | | |
| Assessment Unit | **Kaalspruit Valley Bottom Wetlands** | | | |
| HGM type | Channelled VB wetland not laterally maintained | | | |
| Wetland area (ha) | 2839.3 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 1.9 | 2.2 | 1.9 | 4.1 |
| PES Score (%) | 81% | 78% | 81% | 59% |
| **Ecological Category** | **B** | **C** | **B** | **D** |
| **Combined Impact Score** | 2.5 | | | |
| **Combined PES Score (%)** | 75% | | | |
| **Combined Ecological Category** | **C** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 11b** | | | |
| Assessment Unit | **Kaalspruit Depression Wetlands** | | | |
| HGM type | Depression without flushing | | | |
| Wetland area (ha) | 1050.6 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 2.3 | 2.6 | 2.7 | 4.2 |
| PES Score (%) | 77% | 74% | 73% | 58% |
| **Ecological Category** | **C** | **C** | **C** | **D** |
| **Combined Impact Score** | 2.9 | | | |
| **Combined PES Score (%)** | 71% | | | |
| **Combined Ecological Category** | **C** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 11a - Kaalspruit Valley Bottom Wetlands</th></tr>
<tr><th></th><th>Importance</th></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>3.0</td></tr>
<tr><td>Direct Human Benefits</td><td>0.3</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.0</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>B</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 11b - Kaalspruit Depression Wetlands</th></tr>
<tr><th></th><th>Importance</th></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.4</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.1</td></tr>
<tr><td>Direct Human Benefits</td><td>0.3</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>2.4</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The REC for both WRU 11a and WRU 11b is C. It is unrealistic to restore the valley-bottom wetland to B category system without major investment and the potential removal of infrastructure already built within the HGM unit. Much of the impact on the valley-bottom wetland is associated with actively used agricultural infrastructure which cannot be removed currently. However, the REC must be maintained in both wetlands through the maintenance of appropriate buffer zones between the surrounding land uses and the wetland areas. Furthermore, the current number of dams as well as the current aerial extent of cultivation within the wetland must not be increased. It is imperative that further agricultural practices within the catchment (especially within a 2km radius of the wetlands) are implemented with care. Careful consideration of the cumulative pressure of agriculture on the wetland must be considered with any further expansion of agricultural practices within the catchment.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>The immediate catchment of the WRU is predominantly cultivated, but a large proportion of the upstream catchment to the south of the WRU is not yet cultivated or developed. Should the expansion of agricultural practices occur within the catchment, which is considered likely, the CVB wetland will come under increasing pressure to provide water quality enhancing ecosystem services, as it is a tributary of the Modder</td></tr>
</table>

| | |
|---|---|
| | River. Additionally, there are not yet many dams located on the upstream tributaries of the CVB wetland, which is likely why the hydrology of the wetland is in a relatively good condition (**B** category). However, should agricultural expansion occur in the catchment, this is likely to be accompanied by the construction of additional dams along the Kaalspruit and its tributaries that will have further adverse impacts on the hydrology and geomorphology of the wetlands. Furthermore, the continuous cultivation around the depression wetlands may lead to more adverse impacts on the water quality, geomorphic and vegetation present ecological states. Appropriate specialist studies must be initiated to inform the adoption of appropriate mitigation measures to protect the identified wetland systems. |
| Eco Specifications | No further cultivation must be permitted within any of the remaining intact wetland areas, and no additional dams must be allowed within the remaining intact portions of the wetland. Formal buffer areas between the cultivated areas and the depression wetlands must be established and maintained with the adoption of appropriate mitigation measures. AIP species must also be managed at the current levels, and further encroachment of AIP species must be avoided. No new road must be approved through any of the remaining intact wetland areas. A large sediment deposit was observed in one of the depression wetlands. The erosion source resulting in the deposition of this sediment must be rehabilitated immediately to prevent the further loss of wetland functioning and integrity in subsequent rainfall seasons. |

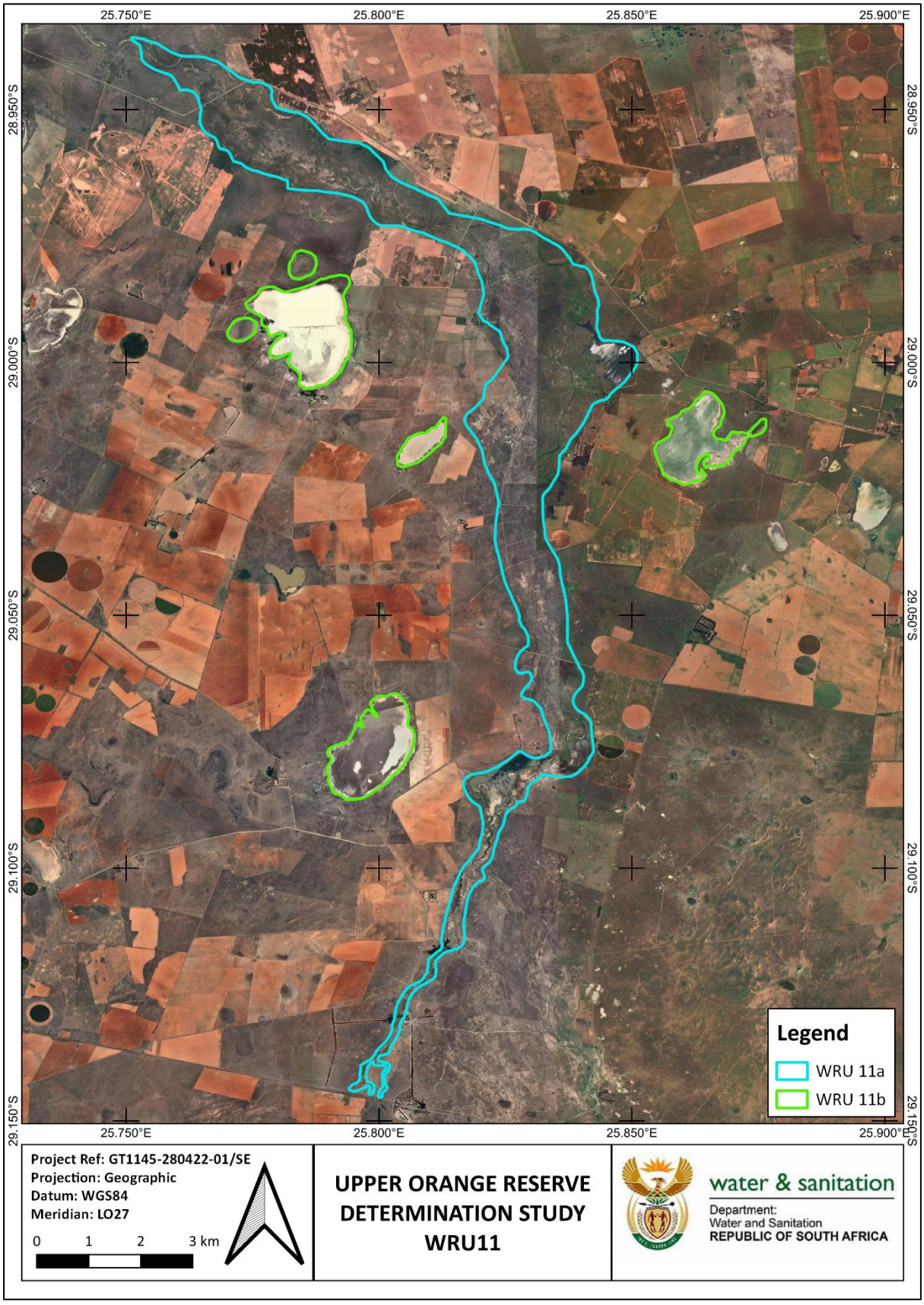


**Figure 4-14 Overview of WRU 11**

**Figure 4-15** **Large depression wetland forming a part of WRU11. This depression wetland is unique in that it receives water from the main valley-bottom wetland at its head and feeds water back into the valley-bottom wetland at its toe.**

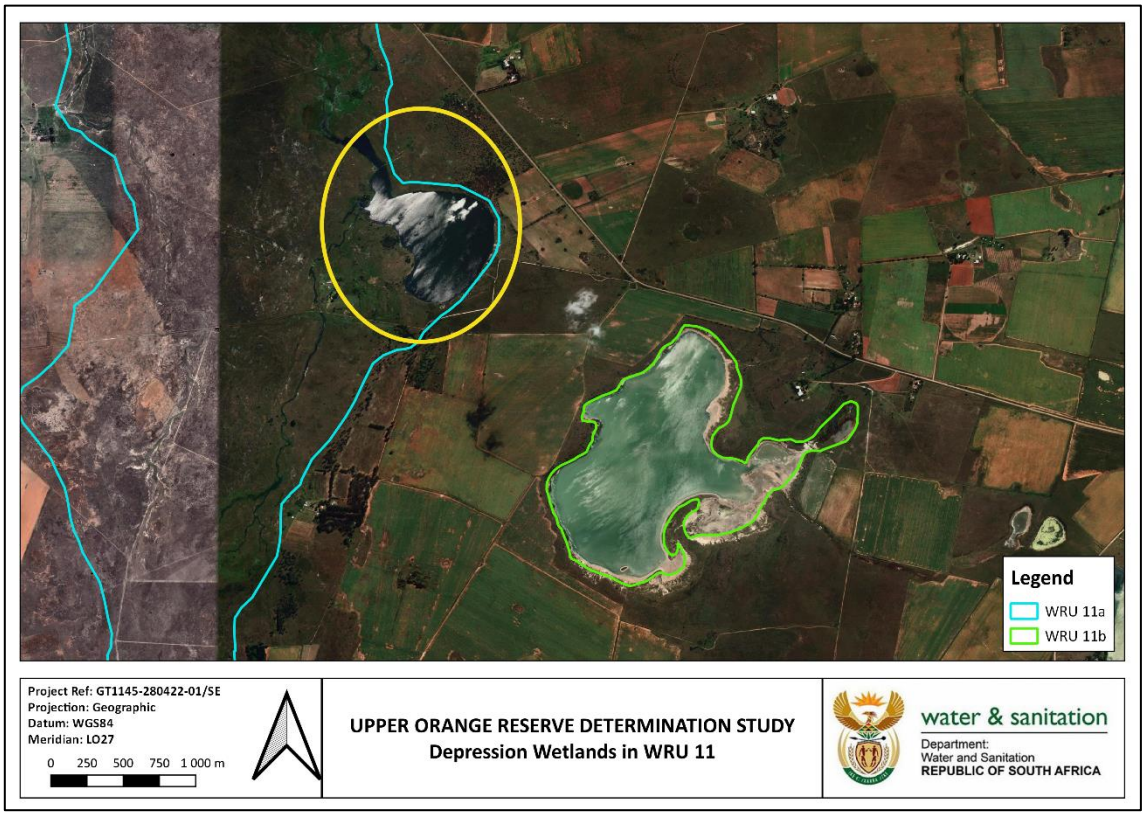


**Figure 4-16** **Difference between two depression wetlands, the yellow circle indicating the nested depression wetland in the DCVB wetland with flushing and the green outline indicating the endorheic depression wetland.**

## 4.8 WRU 12 – Aardoringspruit Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 12 |
| HGM Unit Type(s) | Discontinuously Channelled Valley-Bottom (DCVB) and Wetland Flats |
| Description of WRU | WRU 12 is a large wetland complex that includes a large wetland flat and a discontinuously channelled valley-bottom wetland which encompasses the Aardoringspruit River (**Figure 4-17**). The confluence of the Aardoringspruit and Keeromspruit Rivers occurs within the WRU, from which the Rietspruit flows. The entire complex is approximately 1700 ha in size and has a very gentle longitudinal slope of 0.2% down its length (**Figure 4-18**). The catchment of this wetland complex is comprised of large areas of cultivation as well as large semi-natural areas which are likely utilised for grazing. Due to the extremely gently sloping nature of the majority of the catchment, very few dams have been constructed in the catchment as the landscape does not lend itself well to the construction of dams. As such, impacts to the hydrological integrity of the wetland complex are predominantly derived from within wetland impacts. The northern (upstream) section of the wetland flat is characterised by a flat wetland with shallow soils and a mix of seasonal and permanent zones. Small preferential flow paths were observed within the upslope portion of the wetland flat which is generally characterised by permanent wetland.. This wetland was included as a RU because its lower portion receives flows from Brandfort via the Keeromspruit River which, according to local stakeholders, has been receiving untreated sewage from dysfunctional wastewater treatment works in Brandfort regularly. This section of the wetland is characterised by greater relief and a more well-defined valley line that is the driver for the formation of a discontinuously channelled valley-bottom wetland. The wetland is predominantly used for grazing and some water supply dams have been constructed along the Aardooringspruit River. |
| Unique Features | WRU 12 is a large wetland area which is atypically flat and broad given the mean annual precipitation received in this part of the Free State. It is unusual to find a wetland flat in this part of the country. |
| Vegetation types | DCVB: Dry Highveld Grassland Group 3 (NBA, 2018); Highveld Alluvial Vegetation (Mucina and Rutherford, 2006); Wetland Flat: Dry Highveld Grassland Group 3 (NBA, 2018); Highveld Alluvial Vegetation and Western Free State Clay Grassland (Mucina and Rutherford, 2006); |
| Threat Status | DCVB: LT; Wetland Flat: Endangered (EN) |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 12a** | | | |
| Assessment Unit | **Aardoringspruit Valley Bottom Wetland** | | | |
| HGM type | Channelled VB wetland not laterally maintained | | | |
| Wetland area (ha) | 665.9 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 3.3 | 1.4 | 1.0 | 4.2 |
| PES Score (%) | 67% | 86% | 90% | 58% |
| **Ecological Category** | **C** | **B** | **B** | **D** |
| **Combined Impact Score** | 2.6 | | | |
| **Combined PES Score (%)** | 74% | | | |
| **Combined Ecological Category** | **C** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 12b** | | | |
| Assessment Unit | **Aardoringspruit Wetland Flat** | | | |
| HGM type | Flat | | | |
| Wetland area (ha) | 1075.4 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 3.4 | 2.2 | 1.9 | 5.4 |
| PES Score (%) | 66% | 78% | 81% | 46% |
| **Ecological Category** | **C** | **C** | **B** | **D** |
| **Combined Impact Score** | 3.3 | | | |
| **Combined PES Score (%)** | 67% | | | |
| **Combined Ecological Category** | **C** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 12a - Aardoringspruit Valley Bottom Wetland</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>2.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.5</td></tr>
<tr><td>Direct Human Benefits</td><td>0.3</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>2.8</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>C</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 12b - Aardoringspruit Wetland Flat</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>3.1</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.5</td></tr>
<tr><td>Direct Human Benefits</td><td>0.2</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.1</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>B</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The REC for both WRU 12a and WRU 12b is a C category. It is not feasible to restore the wetland flat to a B category without major investment and the potential removal of infrastructure and conversion of agricultural land already established within the HGM unit. However, the REC can be maintained in both wetlands through the maintenance of appropriate buffer zones between the surrounding land uses and the wetland areas. Furthermore, the maintenance of the current number of dams as well as the current aerial extent of cultivation within the wetland must not be increased. It is essential that additional agricultural practices in the catchment (especially within a 2km radius of the wetlands) are restricted considering the cumulative pressure of agriculture on the wetland.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>The immediate catchment of the WRU is uncultivated and is used for grazing, while a substantial proportion of the upstream catchment to the north of the WRU is cultivated. However, there are still large areas of uncultivated and undeveloped land within the catchment. It is probable that there will be an expansion of cultivation and development in the catchment. If expansion of agricultural practices occur, the wetland complex will come under increasing demand to provide water quality enhancing ecosystem services, including streamflow regulation and increased grazing ecosystem services. Additionally, the sewerage works in Brandfort Town may come under increasing pressure if the town</td></tr>
</table>

| | |
|---|---|
| | population increase. If not upgraded, the sewerage works will continue to periodically release untreated sewage into the Keeromspruit River which will be transported into the WRU 12. Increasing pressure on the wetland's capacity to provide water quality control services will occur. This will have long-term adverse impacts on the biota within the DCVB wetland. |
| Eco Specifications | To maintain the REC, it is necessary to maintain the hydrological functioning of the HGM units in such a way that the patterns of water retention and distribution are not altered further than what they are currently. This requires that additional dams must not be constructed within the wetland and no additional roads must be constructed within the wetland either. While no cultivation has yet taken place in the wetland , no intensive cultivation must be permitted in the remaining intact portions of the wetland. The wetland is widely used for grazing, but the grazing pressure must be kept at an appropriate level to prevent further erosion in the discontinuously channelled portion of the HGM unit. |

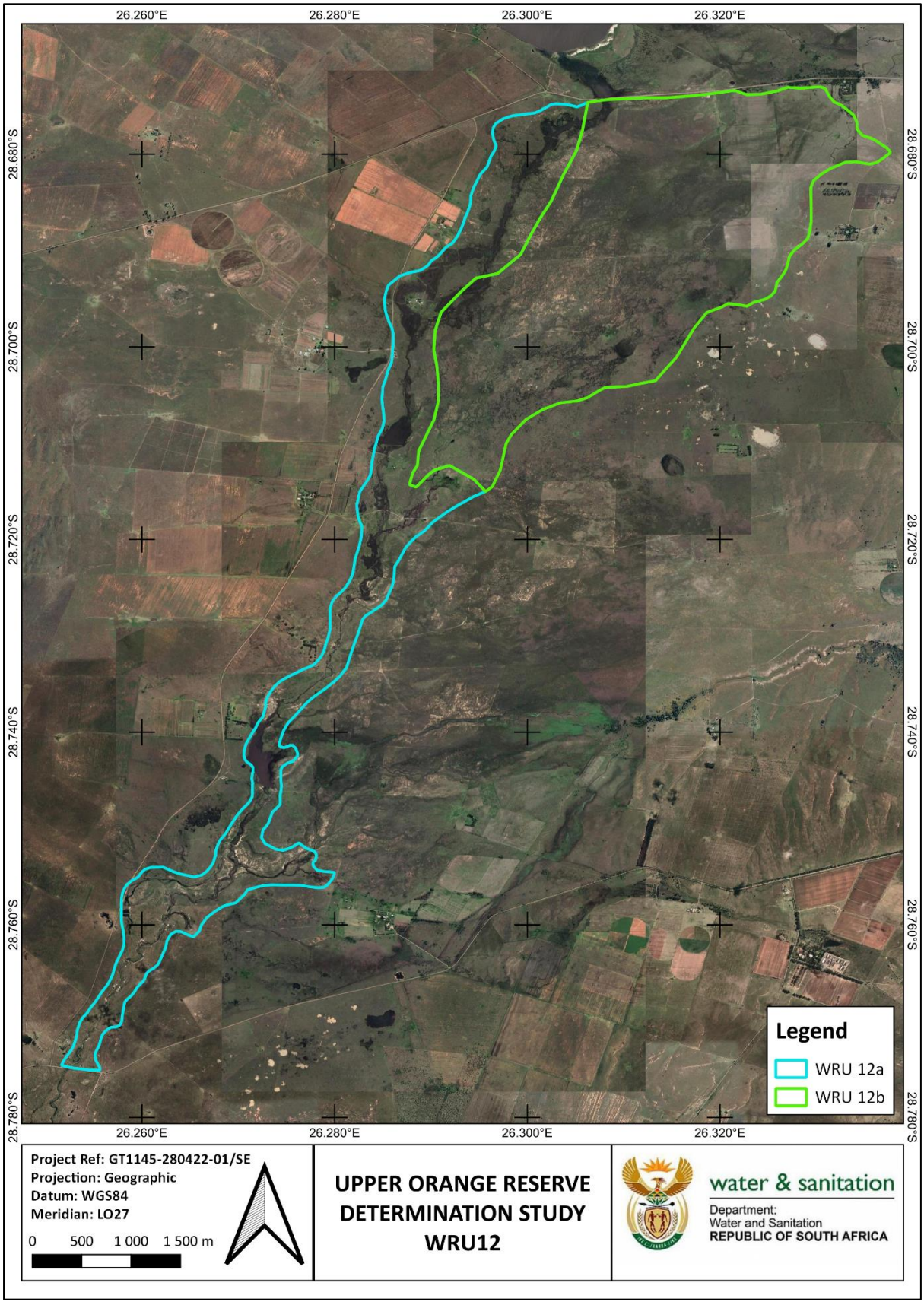


**Figure 4-17 Overview of WRU 12**

**Figure 4-18** **Middle section of the large wetland flat looking upstream. Extremely flat topography with extensive areas of standing water due to recent heavy rains in the region**

## 4.9 WRU 13 – Rantsho Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 13 |
| HGM Unit Type(s) | Floodplain (FP), CVB and UCVB |
| Description of WRU | WRU 13 is a wetland complex approximately 275 ha in size and is located between the R26 road and the Mohokare (Caledon) River on the Rantsho River (**Figure 4-19**). The wetland is located to the west of Ficksburg and is directly adjacent to the Peka Bridge Border Post between South Africa and Lesotho. A large proportion (<35%) of the catchment is cultivated, but only a small proportion (5% of the total catchment area) of this cultivated area is irrigated and therefore the abstraction of water from the catchment is assumed to be relatively low. There are no dams on the Rantsho River but most of the tributaries of the Rantsho River are extensively dammed. It is expected that the flows from these tributaries have been reduced The floodplain wetland has three distinct sections that are separated by a very confined section of valley. The northern lobe of the wetland is bisected by the R26 road. The section of wetland upstream of the R26 is used for hay production and grazing while the section downstream of the R26 appears only to be utilised for grazing. The channel in the northern section is moderately sinuous and does not appear to be excessively incised hence the retention of floodplain features in the valley-bottom (**Figure 4-20**). The northern lobe becomes confined and loses its floodplain characteristics as the valley narrows. The valley then becomes less confined again and floodplain features appear. Approximately 2 km downstream of this flood out, the channel loses confinement as well and the wetland becomes an unchannelled valley-bottom wetland. A small, stable channel has formed between the unchannelled valley-bottom wetland and the Mohokare River (**Figure 4-21**). Land uses in this southern section of the wetland include grazing, hay production, water supply (a small off-channel dam) and cultivation. Runoff from a chicken run was noted entering the unchannelled valley-bottom wetland. |
| Unique Features | The wetland complex is unique in that it consists of three valley-bottom HGM unit types which have formed because of a very unique geomorphic setting and a unique set of geomorphic processes (see Grenfell *et al.,* 2008 for a description of the conceptual model for the formation of WRU 13). Valley-bottom wetlands, specifically FP and UCVB wetlands are typically able to provide ecosystem services to a greater degree than the other HGM units. A series of valley-bottom wetlands such as the WRU 13 is unique and can provide significant streamflow regulating services. |
| Vegetation types | Mesic Highveld Grassland Group 2 (NBA, 2018); Eastern Free State Clay Grassland (Mucina and Rutherford, 2006) |
| Threat Status | FP: CR; CVB: CR; UCVB: EN |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 13a** | | | |
| Assessment Unit | **Rantsho Floodplain Wetland** | | | |
| HGM type | Floodplain wetland | | | |
| Wetland area (ha) | 95.0 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 4.9 | 3.1 | 2.8 | 7.0 |
| PES Score (%) | 51% | 69% | 72% | 30% |
| **Ecological Category** | **D** | **C** | **C** | **E** |
| **Combined Impact Score** | 4.5 | | | |
| **Combined PES Score (%)** | 55% | | | |
| **Combined Ecological Category** | **D** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 13b** | | | |
| Assessment Unit | **Rantsho CVB Wetland** | | | |
| HGM type | Channelled VB wetland not laterally maintained | | | |
| Wetland area (ha) | 71.4 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 2.8 | 1.6 | 1.6 | 4.9 |
| PES Score (%) | 72% | 84% | 84% | 51% |
| **Ecological Category** | **C** | **B** | **B** | **D** |
| **Combined Impact Score** | 2.7 | | | |
| **Combined PES Score (%)** | 73% | | | |
| **Combined Ecological Category** | **C** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 13b** | | | |
| Assessment Unit | **Rantsho UCVB Wetland** | | | |
| HGM type | Unchannelled VB wetland | | | |
| Wetland area (ha) | 108.1 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 4.7 | 2.8 | 3.4 | 7.0 |
| PES Score (%) | 53% | 72% | 66% | 30% |
| **Ecological Category** | **D** | **C** | **C** | **E** |
| **Combined Impact Score** | 4.5 | | | |
| **Combined PES Score (%)** | 55% | | | |
| **Combined Ecological Category** | **D** | | | |

EI-ES

| *WRU 13a - Rantsho Floodplain Wetland* | |
|---|---|
| | **Importance** |
| **Ecological Importance & Sensitivity** | **3.0** |
| **Hydro-Functional Importance** | **2.8** |
| **Direct Human Benefits** | **0.7** |
| **Overall Importance And Sensitivity Score** | **3.0** |
| **Overall Importance And Sensitivity Category** | **C** |

| *WRU 13b - Rantsho CVB Wetland* | |
|---|---|
| | **Importance** |
| **Ecological Importance & Sensitivity** | **3.0** |
| **Hydro-Functional Importance** | **2.5** |
| **Direct Human Benefits** | **0.3** |
| **Overall Importance And Sensitivity Score** | **3.0** |
| **Overall Importance And Sensitivity Category** | **C** |

| *WRU 13c - Rantsho UCVB Wetland* | |
|---|---|
| | **Importance** |
| **Ecological Importance & Sensitivity** | **3.2** |
| **Hydro-Functional Importance** | **3.0** |
| **Direct Human Benefits** | **0.7** |
| **Overall Importance And Sensitivity Score** | **3.2** |
| **Overall Importance And Sensitivity Category** | **B** |

REC

The REC for all three HGM units is a **C** category – which means that the FP and UCVB will require rehabilitation to reach that REC. The REC for the FP could be achieved if some of the cultivation was reduced or altered to low-impact crops from within the wetland and the removal of AIP

| | |
|---|---|
| | species was undertaken. The REC for the UCVB could similarly be achieved through the reduction in the area of cultivation within the wetland unit as well as through the rehabilitation of the erosional features which are spreading from the southwestern corner of the HGM unit. While these features appear to have been partially rehabilitated in the past, the rehabilitation appears to have been undertaken using earthen dams, and a more permanent structure may be more appropriate. However, where it is not possible to reduce the extent of cultivation in the wetlands, potential rehabilitation measures must be considered, which includes the rehabilitation of inflowing streams such that the WRU is buffered from water quality and sediment inputs to some extent. Furthermore, the REC for all three HGM units can be achieved through the creation of an integrated catchment management plan such that the landowners within the catchment can contribute meaningfully to reducing their impact on these important wetlands. |
| Operational Scenarios/Rules | From an assessment of the catchment, it appears that a large proportion (>50%)of the arable land is currently cultivated in the catchment. While there is still a sizeable proportion of the catchment that is not cultivated, these areas either fall within other wetlands or watercourses, or they coincide with steep valleys or rocky hilltops which are unlikely to be cultivated. The most prominent risk to the WRU is the construction of a large dam on the Rantsho River or the further construction of dams on the tributaries of the Rantsho River without appropriate studies to inform the necessary mitigation measures. FP and CVB wetlands require significant seasonal influxes of water and sediment to maintain the wetland areas adjacent to the channels. |
| Eco Specifications | To maintain the current state of the Rantsho Wetland Complex, no further cultivation or other intensive land uses must be permitted to expand into the remaining intact portions of the wetlands. Furthermore, no further infrastructure such as dams or roads must be permitted within the remaining intact portions of the wetland. Additionally, there must be no further degradation of the water quality such that it impacts the downstream freshwater ecosystems. Agricultural and livestock operations must periodically be monitored for discharge into WRU 13. There must be no further encroachment of woody alien invasive vegetation into any of the wetland areas, and efforts should be made to remove the current population of *Salix babylonica* individuals that line sections of the channel in the FP and CVB wetlands. In addition, AIPs must be managed within a 200 m radius of the wetland to avoid additional AIP propagules entering the HGM unit. |

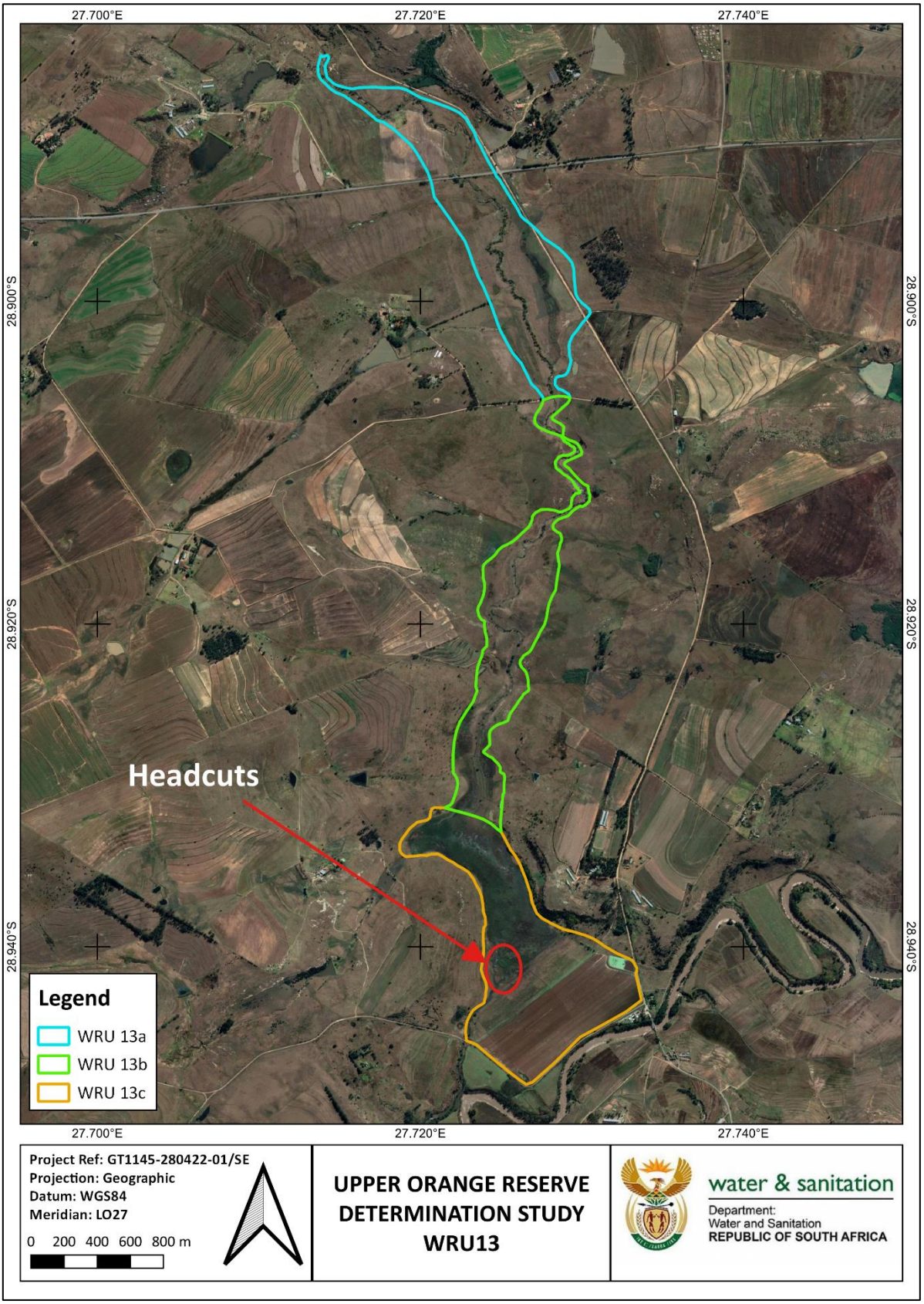


**Figure 4-19 Overview of WRU 13 with the red circle showing the location of the head cut features in the UCVB wetland.**

**Figure 4-20** **Middle section of the floodplain wetland before it loses confinement. Dark patches adjacent to the channel indicate wetland vegetation and lateral seep processes that support wetland habitat. Trees along the channel are *Salix babylonica*.**

**Figure 4-21** **Picture taken from the toe of the wetland looking upstream. Green fields in the foreground are cultivated land. The green band in the middle of the picture is the extensive unchannelled valley-bottom and reedbed.**

## 4.10 WRU 15 – Jagersfontein Discontinuously Channelled Valley-Bottom Wetland

| Factor | Comment |
|---|---|
| WRU Number | WRU 15 |
| HGM Unit Type(s) | DCVB |
| Description of WRU | WRU 15 is a large contiguous series of wetlands that originate from four different river/watercourse systems and coalesce into a valley-bottom wetland (**Figure 4-22**). The wetland type can be considered to be a discontinuously channelled valley-bottom wetland as the channels are not consistent throughout the HGM unit. The catchment of this wetland is predominantly natural with scattered agricultural activities and the relatively small development associated with Jagersfontein town and the diamond mine. The entire wetland complex is approximately 1900 ha in size and flows along the Vanzylspruit and the Prosesspruit Rivers. The wetland is mainly characterised by wet grasslands and patches of sedge meadows that are characterised by longer wetness periods. The bottom portion of the HGM unit, where the stream systems converge, is characterised by a large stand of *Phragmites australis* and other large emergent wetland vegetation (**Figure 4-23**). The northern arm of the wetland receives water inputs from the Jagersfontein town, including the diamond mine and the wastewater treatment works, which appears to have caused some water quality concerns in the downstream wetland in the form of grey-coloured water which smells of sewage and white foam forming on the surface of the water downstream of the WWTW (**Figure 4-24**). The central two arms that flow from west to east are both characterised by straightened channels – possibly as a result of the railway embankment and associated culverts beneath the embankment. Large areas of erosion were also observed onsite. |
| Unique Features | N/A |
| Vegetation types | Dry Highveld Grassland Group 2 (NBA, 2018); Xhariep Karroid Grassland (Mucina and Rutherford, 2006) |
| Threat Status | LT |

PES[5]

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 15 | | | |
| Assessment Unit | Jagersfontein Valley Bottom Wetland | | | |
| HGM type | Channelled VB wetland not laterally maintained | | | |
| Wetland area (ha) | 1907.3 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 1.5 | 1.5 | 6.7 | 4.1 |
| PES Score (%) | 85% | 85% | 33% | 59% |
| Ecological Category | B | B | E | D |
| Combined Impact Score | 3.2 | | | |
| Combined PES Score (%) | 68% | | | |
| Combined Ecological Category | C | | | |

EI-ES

| *WRU 15 - Jagersfontein DCVB Wetland* | |
|---|---|
| | Importance |
| Ecological Importance & Sensitivity | 2.8 |
| Hydro-Functional Importance | 2.8 |
| Direct Human Benefits | 0.3 |
| Overall Importance And Sensitivity Score | 2.8 |
| Overall Importance And Sensitivity Category | C |

[5] It should be noted that the assessment was undertaken prior to the slurry dam incident that occurred on the 11th of September 2022 and does not account for the impact that this spill may have had on the PES, EI-ES or REC of the wetland complex.

| | |
|---|---|
| REC | The REC for the Jagersfontein WRU is a **C** category. This REC can be maintained through the maintenance of appropriate buffer zones between the Jagerfontein town and associated infrastructure and the wetland which could improve the quality of the water entering the HGM unit. Due to the proximity of the WWTW and the Jagersfontein Diamond Mine to the wetland complex and the negative impact these factors are having on the wetland, it would be necessary to work with local government and communities to improve the state of the water entering the wetland complex. |
| Operational Scenarios/Rules | The immediate catchment of the WRU is predominantly uncultivated and is utilised for grazing, while a large proportion of the upstream catchment to the north of the WRU is cultivated. However, there are still large areas of uncultivated and undeveloped land within the catchment with the potential for expansion of cultivation and development in the catchment. If the expansion of agricultural practices occurs within the catchment the capacity of the wetland complex to provide water quality enhancing ecosystem services, as well as streamflow regulation and increased grazing ecosystem services will be compromised. Further cultivation and development must be carefully planned considering the wetland and appropriate mitigation measures. Additionally, the sewerage works in Jagersfontein Town may come under increasing stress should the town population increase. If not upgraded, the sewerage works will continue to periodically spill untreated sewage into the WRU 15 which will be transported into the wetland. This will place increasing pressure on the wetland to provide water quality enhancement services and will have long-term adverse impacts on the biota within the DCVB wetland. |
| Eco Specifications | To maintain the REC, it is necessary to maintain the hydrological functioning of the HGM units in such a way that the patterns of water retention and distribution are not altered further than they are. Therefore, no additional dams must not be constructed within the wetland and no additional roads must be constructed within the wetland either. Furthermore, while no cultivation has yet taken place in the wetland, no intensive cultivation should be permitted in the remaining intact portions of the wetland and an appropriate buffer zone. The wetland is widely utilised for grazing, but the grazing numbers must be kept at an acceptable level to prevent further erosion in the discontinuously channelled portion of the HGM unit. Also, annual monitoring of water quality in the HGM unit downstream of Jagersfontein town must be undertaken to ensure that the WWTW, the diamond mine and the town of Jagersfontein are not contributing to a significant decline in the water quality and the biota in the wetland. Water quality parameters that should be monitored include diatoms, *E. coli*, temperature, turbidity and electrical conductivity at a minimum. |

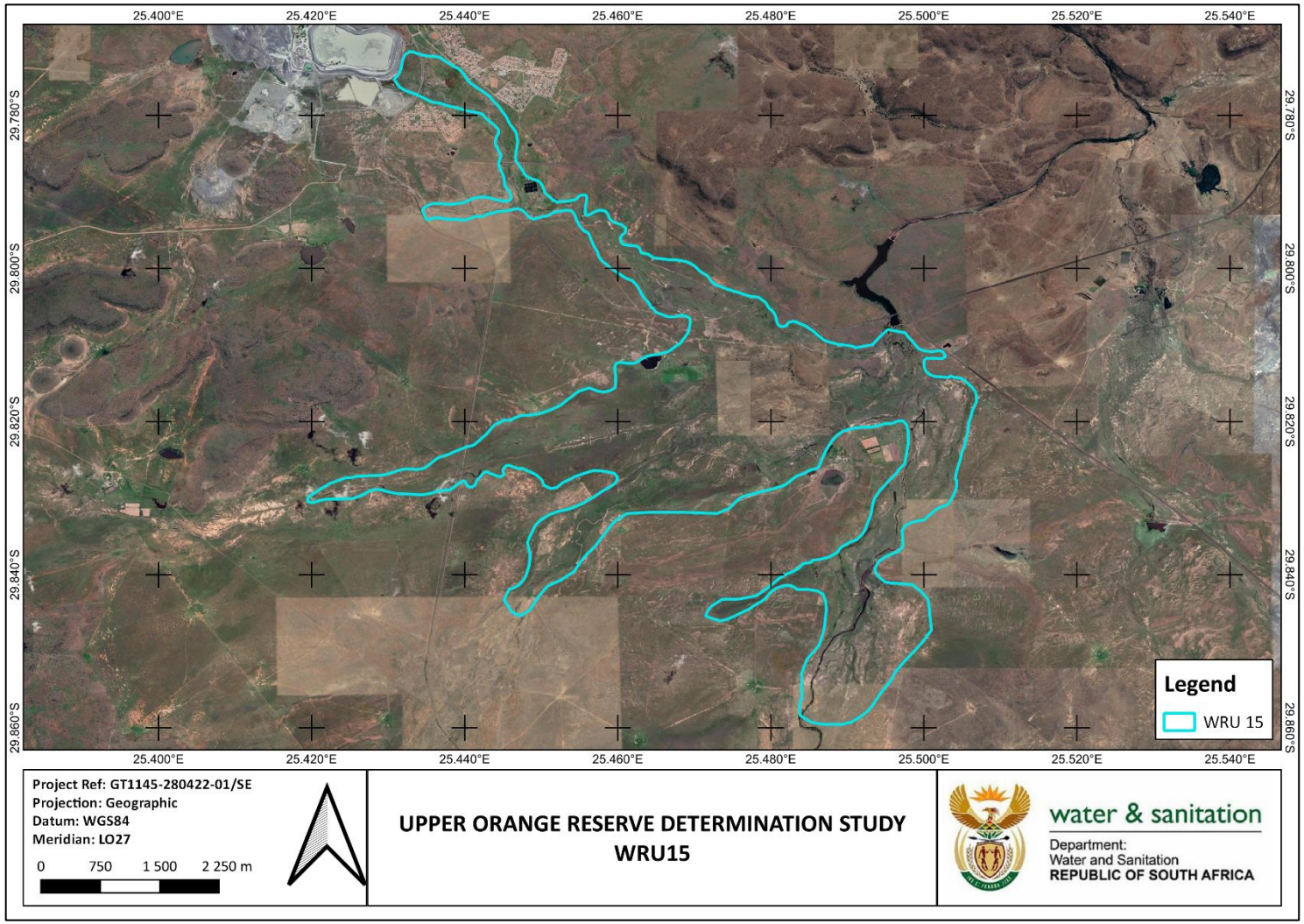


**Figure 4-22 Overview of WRU 15. The town of Jagersfontein is located at the head of the northern most arm and the Prosesspruit River flows from west to east through the central arm of the wetland complex.**

**Figure 4-23** **Large reedbed at the confluence of the four valley-bottom wetlands.**

**Figure 4-24** **Photograph of the northern-most wetland arm with foam and signs of pollution evident within the channel**

## 4.11 WRU 16 – Barkley Pass Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 16 |
| HGM Unit Type(s) | UCVB, CVB and HSS |
| Description of WRU | WRU 16 is a significant wetland complex consisting of multiple valley-bottom and hillslope seep wetlands which, in total, spread across an area of approximately 230 ha (**Figure 4-25**). This large wetland complex is situated on a tributary of the Langkloofspruit River which is a tributary of the Kraai River – an extremely important water source to the Orange River. The wetlands are high up in their catchment and are therefore not impacted significantly by catchment-related impacts. These systems are controlled by a local base level which is set by a sill of resistant rock which has formed a large waterfall feature. This base level has allowed the upstream systems to grade themselves to an appropriate longitudinal slope for their discharge and should therefore have a relatively low risk of erosion. The wetlands and their immediate catchment are utilised for grazing, as the entire wetland complex is owned by a sheep farmer. Discussions with the landowner revealed that livestock stocking rates were low on the farm and that the grazing pressure was not excessive |
| Unique Features | The WRU is located at approximately 2000 m above sea level and is characterised by a unique vegetation assemblage. The vegetation is dominated by *Carex acutiformis*, *Kylinga erecta, Cyperus longus* and *Eleocharis dregeana* with some additional species that are unique to high-altitude wetlands. In addition, this wetland complex is relatively intact as it is situated at the head of a catchment in a remote location. These wetlands are representative of rare intactness for wetlands in South Africa. |
| Vegetation types | Drakensberg Grassland Group 5 (NBA, 2018); Lesotho Highland Basalt Grassland (Mucina and Rutherford, 2006) |
| Threat Status | CVB: CR; HSS: LT |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 16a** | | | |
| Assessment Unit | **Barkley Pass Valley Bottom Wetlands** | | | |
| HGM type | Channelled VB wetland laterally maintained (i.e., with substantial lateral inputs) | | | |
| Wetland area (ha) | 189.5 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 0.0 | 0.3 | 0.4 | 1.0 |
| PES Score (%) | 100% | 97% | 96% | 90% |
| **Ecological Category** | **A** | **A** | **A** | **B** |
| **Combined Impact Score** | 0.4 | | | |
| **Combined PES Score (%)** | 96% | | | |
| **Combined Ecological Category** | **A** | | | |

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | **WRU 16b** | | | |
| Assessment Unit | **Barkley Pass Seep Wetlands** | | | |
| HGM type | Seep | | | |
| Wetland area (ha) | 47.4 ha | | | |
| PES Assessment | **Hydrology** | **Geomorphology** | **Water Quality** | **Vegetation** |
| Impact Score | 0.0 | 0.3 | 0.4 | 1.0 |
| PES Score (%) | 100% | 97% | 96% | 90% |
| **Ecological Category** | **A** | **A** | **A** | **B** |
| **Combined Impact Score** | 0.4 | | | |
| **Combined PES Score (%)** | 96% | | | |
| **Combined Ecological Category** | **A** | | | |

<table>
<tr><td>EI-ES</td><td>
<table>
<tr><th colspan="2">WRU 16a - Barkley Pass DCVB Wetland</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>3.8</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.2</td></tr>
<tr><td>Direct Human Benefits</td><td>0.3</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.8</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>B</td></tr>
</table>
<table>
<tr><th colspan="2">WRU 16b - Barkley Pass Seep Wetlands</th></tr>
<tr><td></td><td>Importance</td></tr>
<tr><td>Ecological Importance & Sensitivity</td><td>3.2</td></tr>
<tr><td>Hydro-Functional Importance</td><td>2.0</td></tr>
<tr><td>Direct Human Benefits</td><td>0.3</td></tr>
<tr><td>Overall Importance And Sensitivity Score</td><td>3.2</td></tr>
<tr><td>Overall Importance And Sensitivity Category</td><td>B</td></tr>
</table>
</td></tr>
<tr><td>REC</td><td>The REC of both WRU 16a and WRU 16b is a category A. This wetland complex is in very good condition, and the REC can be maintained at this level through the maintenance of the current level of farming and grazing practices within the wetlands and their catchments.</td></tr>
<tr><td>Operational Scenarios/Rules</td><td>The catchment of this wetland complex is small and is predominantly owned by a single landowner. The current landowner is a sheep farmer and judging by the shallow nature of the soils and the high altitude of the wetland, it is unlikely that there will be any land use changes in the near future. However, the intensity of grazing in the wetland and the catchment must be kept at sustainable levels as unsustainable stocking rates will have an adverse impact on the vegetation structure and composition in the catchment. This could result in changes to vegetation composition and cover and the mobilisation of sediment into these sensitive and important wetlands.</td></tr>
</table>

| | |
|---|---|
| Eco Specifications | To maintain the current integrity of these wetlands and the REC, no land use changes should be permitted within the wetlands themselves. Only very specific, low-impact land uses must be permitted in the catchments of these wetlands unless appropriate studies and mitigation measures are implemented. No infrastructure such as roads or dams must be allowed within the wetlands, and the encroachment of AIP species must be managed in the wetlands and their catchments. |

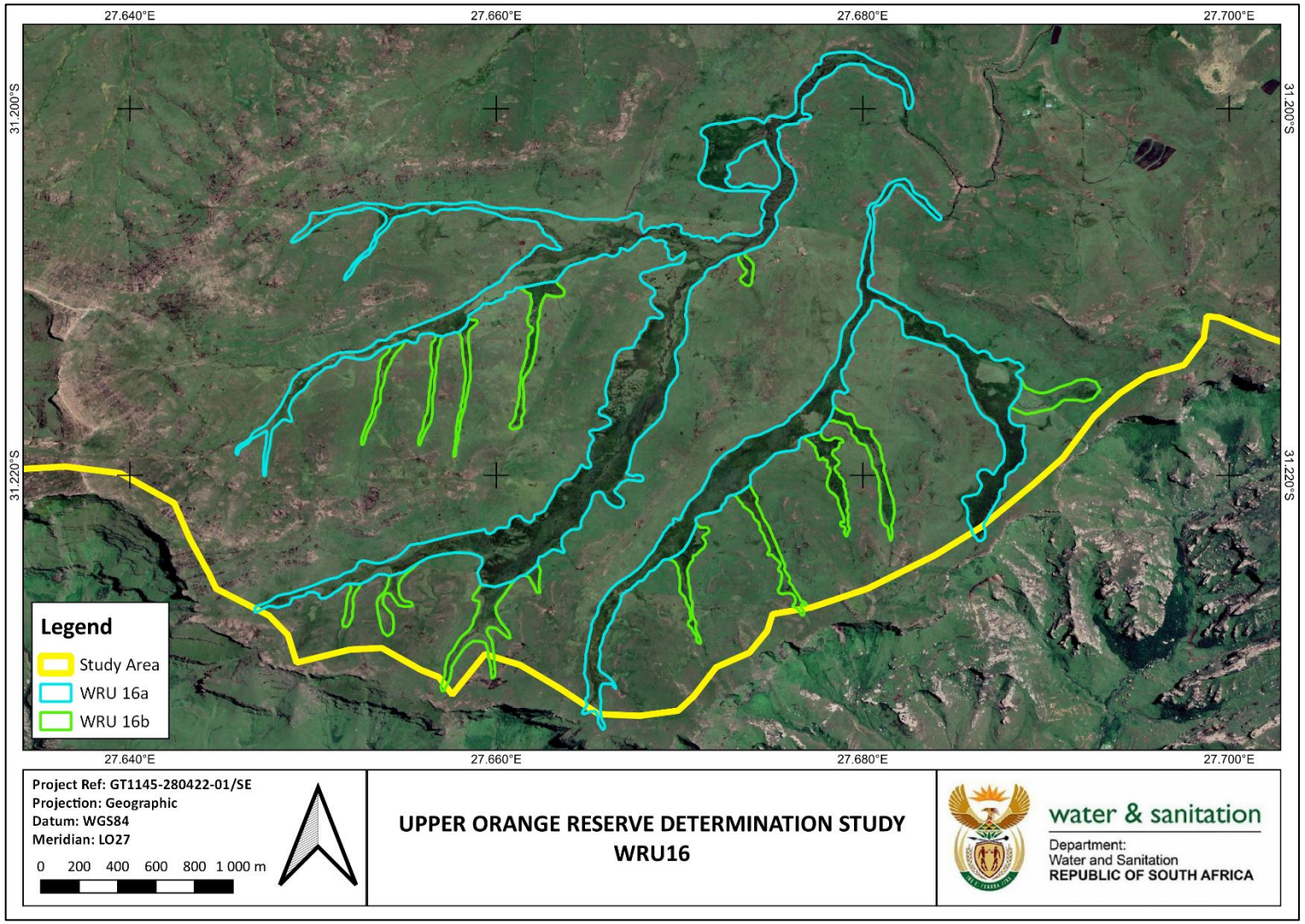
27.640°E
27.660°E
27.680°E
27.700°E
31.200°S
31.220°S
Legend
Study Area
WRU 16a
WRU 16b
Project Ref: GT1145-280422-01/SE
Projection: Geographic
Datum: WGS84
Meridian: LO27
0 200 400 600 800 1 000 m
UPPER ORANGE RESERVE DETERMINATION STUDY
WRU16
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

**Figure 4-25 Overview of WRU 16.**

## 4.12 WRU 17 – Tiffindell Seep Wetland Complex

| Factor | Comment |
|---|---|
| WRU Number | WRU 17 |
| HGM Unit Type(s) | UCVB and HSS |
| Description of WRU | WRU 17 is similar to WRU 16 in that it is a high-altitude wetland complex consisting of a series of hillslope seeps and valley-bottom wetlands which cover a total area of 190 ha (**Figure 4-26**). The remote nature of these wetlands has resulted that the majority of their catchments remain relatively natural. However, a large number of cattle and sheep were observed in these catchments and the wetlands themselves, and grazing evidence was widespread in the wetlands and catchments. These wetlands are characterised by very shallow soils and the predominance of *Merxmuellera disticha* and *Merxmuellera macowanii* (**Figure 4-27** and **Figure 4-28**). In some of the deeper portions of the valley-bottom wetlands, a combination of the nutrient-poor and very cold water has resulted in the formation of peat. These wetlands form an important part of the headwaters of the Bell River, which is a large tributary of the Kraai River. |
| Unique Features | The WRU is located at approximately 2000 m above sea level and is therefore characterised by a unique vegetation assemblage. |
| Vegetation types | Drakensberg Grassland Group 5 (NBA, 2018); Lesotho Highland Basalt Grassland (Mucina and Rutherford, 2006) |
| Threat Status | HSS: LT |

PES

| Wetland PES Summary | | | | |
|---|---|---|---|---|
| Wetland name | WRU 17 | | | |
| Assessment Unit | Tiffindell Seep Wetlands | | | |
| HGM type | Seep | | | |
| Wetland area (ha) | 196.0 ha | | | |
| PES Assessment | Hydrology | Geomorphology | Water Quality | Vegetation |
| Impact Score | 0.3 | 0.4 | 0.4 | 1.4 |
| PES Score (%) | 97% | 96% | 96% | 86% |
| **Ecological Category** | **A** | **A** | **A** | **B** |
| **Combined Impact Score** | 0.6 | | | |
| **Combined PES Score (%)** | 94% | | | |
| **Combined Ecological Category** | **A** | | | |

EI-ES

| *WRU 17 - Tiffindell Seep Wetlands* | |
|---|---|
| | **Importance** |
| **Ecological Importance & Sensitivity** | **3.0** |
| **Hydro-Functional Importance** | **2.0** |
| **Direct Human Benefits** | **0.2** |
| **Overall Importance And Sensitivity Score** | **3.0** |
| **Overall Importance And Sensitivity Category** | **C** |

REC

The REC of both WRU 17 is a category **A**. This wetland complex is in particularly good condition, and the REC can be maintained at this level through the maintenance of sustainable farming and grazing practices within the wetlands and their catchments.

Operational Scenarios/Rules

The catchment of this wetland complex is small and is predominantly owned by two landowners. Judging by the shallow nature of the soils and the high altitude of the wetland, it is unlikely that there will be any land use changes in the near future. This is due to the highly inarable nature of the shallow soils and the inaccessibility of the area. However, the intensity of grazing in the wetland and the catchment should be

| | |
|---|---|
| | maintained at sustainable levels. Unsustainable stocking rates may well have a negative impact on the vegetation structure and composition in the catchment. This could result in changes to vegetation composition and cover and the mobilisation of sediment into these sensitive and important wetlands. |
| Eco Specifications | To maintain the current integrity of these wetlands and the REC, no land use changes must be permitted within the wetlands themselves, and only very specific, low-impact land uses should be allowed in these catchments. No infrastructure such as roads or dams must be allowed within the wetlands, and the encroachment of AIP species should be managed in the wetlands and their catchments. |

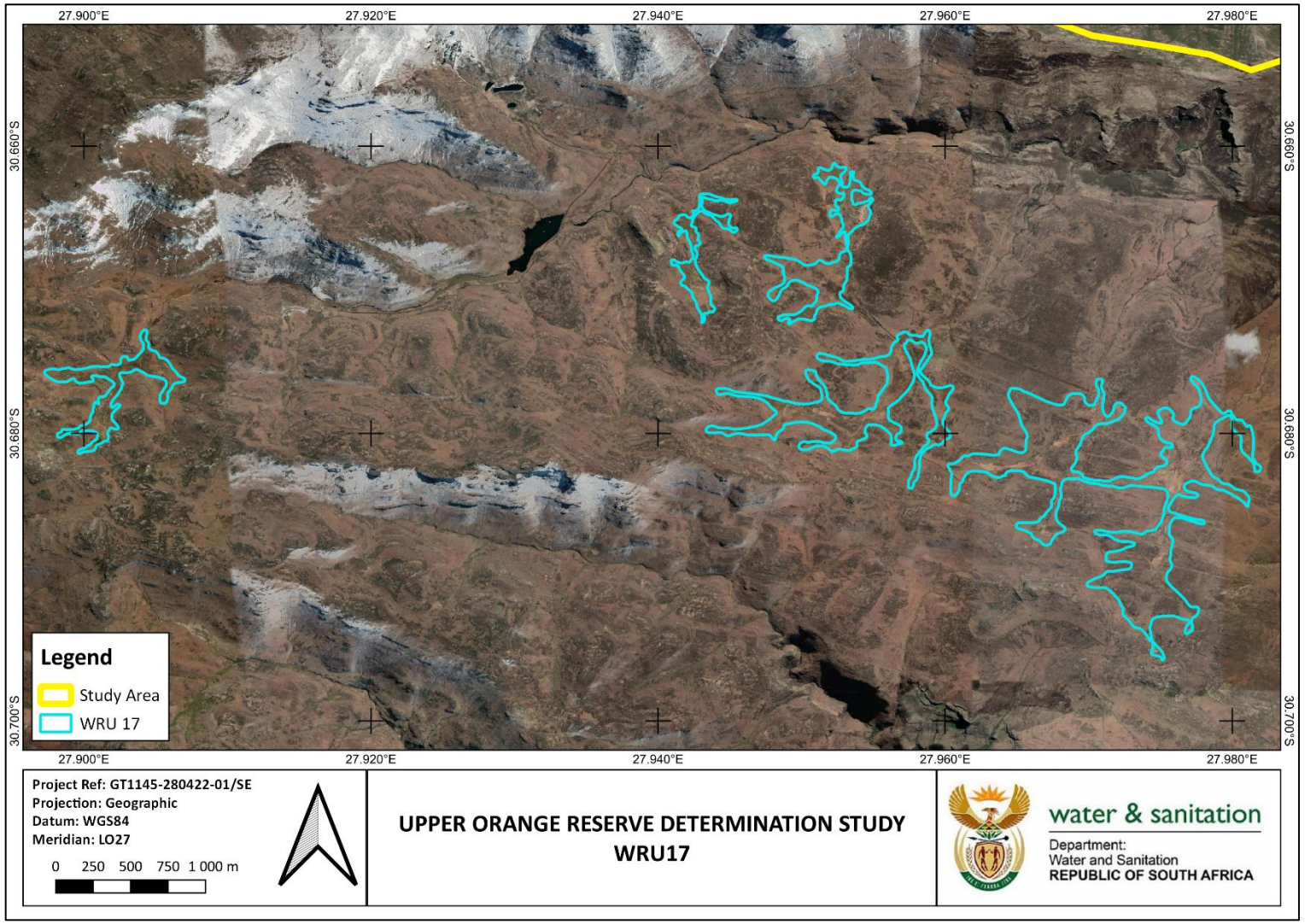
27.900°E
27.920°E
27.940°E
27.960°E
27.980°E
30.660°S
30.680°S
30.700°S
Legend
Study Area
WRU 17
Project Ref: GT1145-280422-01/SE
Projection: Geographic
Datum: WGS84
Meridian: LO27
0 250 500 750 1 000 m
UPPER ORANGE RESERVE DETERMINATION STUDY
WRU17
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

**Figure 4-26 Overview of WRU 17.**

**Figure 4-27** **Broad valley-bottom wetland with some seeps feeding into it. The darker colour in the landscape indicates the approximate valley-bottom wetland extent.**

**Figure 4-28** **An example of an intact hillslope seep wetland dominated by *Merxmuellera disticha*.**

# 5. RECOMMENDATIONS AND CONCLUSIONS

## 5.1 Summary of recommendations

A number of key recommendations have been made throughout this report, which are summarised in **Table 5-1.**

**Table 5-1 Summary of key recommendations made per WRU, and further recommendations on the requirement for the quantification of ecological water requirements (EWRs)**

| WRU Number | Summary of key recommendations | Require EWR quantification |
|---|---|---|
| WRU 02 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further AIP encroachment in wetland. | No |
| WRU 03 | Conduct desktop assessment of wetland every 3-5 years. | No |
| WRU 04 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. | No |
| WRU 05 | Conduct desktop assessment of wetland every 2-3 years. No further agriculture in wetland. No further dams or roads to be constructed in the wetland. No further boreholes/windmills to be drilled in the catchment without groundwater studies. | Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. |
| WRU 06 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further dams or roads to be constructed in the wetland. No further AIP encroachment in wetland. | Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate. |
| WRU 10 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further agricultural runoff to be discharged into the wetland. | No |
| WRU 11 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further dams or roads to be constructed in the wetland. Sediment sources into depression wetlands must be rehabilitated. Buffer zones around depression wetlands must be maintained. | Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate. |
| WRU 12 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. | No |
| WRU 13 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further dams or roads to be constructed in the wetland. Monitor discharge from livestock operations annually. | Yes. These wetlands are under high levels of pressure and the EWR is at risk of being compromised. Opportunity to rehabilitate. |

| | | |
|---|---|---|
| WRU 15 | Conduct desktop assessment of wetland every 3-5 years. No further agriculture in wetland. No further dams or roads to be constructed in the wetland. Monitor water quality parameters within wetland annually, including diatoms, *E. coli*, temperature, turbidity and electrical conductivity at a minimum. | No |
| WRU 16 | No further agriculture in wetland. No further AIP encroachment in wetland. | No |
| WRU 17 | No further agriculture in wetland. No further AIP encroachment in wetland. No further dams or roads to be constructed in the wetland. | No |

# 6. REFERENCES

BirdLife South Africa 2016. Important Bird Areas 2016. [Vector geospatial dataset]. Available from https://www.birdlife.org.za/what-we-do/important-bird-and-biodiversity-areas/

Department of Water Affairs, South Africa, September 2013. The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: Status Quo assessment, Integrated Unit of Analysis delineation and biophysical node identification. Prepared by: IWR Water Resources. Authored by: Mallory S, Louw D, Deacon A, Holland, M, Huggins G, Kotze P, Mackenzie J, Scherman P, Van Jaarsveld P,. DWA Report, RDM/WMA05/00/CON/CLA/0213.

Department of Water and Sanitation. 2017. Development of Procedures to Operationalise Resource Directed Measures. Main Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Report no RDM/WE/00/CON/ORDM/0117.

Department of Water and Sanitation, South Africa. February 2022. A High Confidence Reserve Determination Study for Surface Water, Groundwater and Wetlands in the Upper Orange Catchment: Resource Units Report. No: RDM/WMA13/00/CON/COMP/0422.

Endangered Wildlife Trust 2019. Crane sightings and nest sites 2019. [Vector geospatial dataset].

Grenfell, M.C, Ellery, W.N, Grenfell, S.E. 2008. Tributary valley impoundment by trunk river floodplain development: a case study from the KwaZulu-Natal Drakensberg foothills, eastern South Africa. *Earth Surface, Processes and Landforms*: 33(13): 2029-2044. DOI: https://doi.org/10.1002/esp.1652

Lötter, M.C. & Le Maitre, D. 2021. Fine-scale delineation of Strategic Water Source Areas for surface water in South Africa using Empirical Bayesian Kriging Regression Prediction: Technical report. Prepared for the South African National Biodiversity Institute (SANBI), Pretoria. 33 pages.

Macfarlane DM, Ollis DJ and Kotze D. 2020. *WET-Health (Version 2): A refined suite of tools for assessing the present ecological state of wetland ecosystems*. WRC Report No. TT 820/20, Water Research Commission, Pretoria.

Nel, J, Driver, AL, Strydom, W, Maherry, A, Petersen, C, Hill, L, Roux, D, Nienaber, S, Van Deventer, H, Swartz, E, Smith-Adao, L. 2011. ATLAS of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. WRC Report No. K5/1801.

Nel J.L., Driver, A. and Swartz, E.R. 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A, Council for Scientific and Industrial Research: Stellenbosch, South Africa.

Rountree, M.W., H. Malan and B. Weston (2013). Manual for the Rapid Ecological Reserve Determination for Inland Wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission Study. Report No 1788/1/13. Water Research Commission, Pretoria.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.

Van Deventer, H, Van Niekerk, L, Adams, J, Dinala, MK, Ridhwannah, G, Lamberth, S, Lotter, M, Mbona, N, MacKay, F, Nel, J. Ramjukadh, C-L, Skowno, A, Weerts, S. 2019. National Wetland Map 5 – An improved spatial extent and representation of inland aquatic and estuarine ecosystems in South Africa. 10.1101/640441.

WRC. 2012. Water Resources of South Africa, 2012 Study (WR2012). WRC Project No. K5/2143/1