Aquatic assessment in terms of Section 24G of NEMA application for Bosse Dam, Lower Schoonberg Farm, Western Cape

Prepared by: Dr. Jackie Dabrowski of Confluent Environmental (Pty) Ltd

For: Cape EAPrac

November 2019, updated April, 2021

confluent

aquatic consulting & research

Jackie@confluent.co.za, +27 83 2563159

DECLARATION OF CONSULTANTS INDEPENDANCE

This report was compiled by Jacqueline (Jackie) Dabrowski, the Director of Confluent Environmental (Pty) Ltd. Jackie holds a Ph.D. in Veterinary Science and her post-graduate studies were in the field of freshwater ecology. She has conducted research and published scientific articles on a range of topics including aquatic food webs, fish health, and trends in water quality, branchiopod diversity, and land-use impacts on water quality. Her consulting work has focussed on a range of environmental assessments of dams, rivers, estuaries, ephemeral watercourses and wetlands at various locations in South Africa.

At the time of conducting this study, I declare that:

- I am an independent specialist consulting in the field of Aquatic Science;
- I do not have any financial interest in the undertaking of the activity, apart from remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I do not have any vested interest in the proposed activity proceeding;
- I will not engage in any conflicting interests in the undertakings of the activity;
- I undertake to disclose to the competent authority any relevant information with the potential to influence the decision of the competent authority or the objectivity of the report; and,
- I will provide the competent authority with access to all information at my disposal regarding the application, whether this information is favourable to the applicant or not.

Jackie Dabrowski (Ph.D., Pr.Sci.Nat. *Aquatic Science*)
SACNASP Registration Number 115166

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Project Background

Confluent Environmental (Pty) Ltd was requested by Cape EAPrac to conduct an aquatic specialist assessment in terms of Section 24G of the National Environmental Management Act (NEMA; Act No. 107 of 1998) of the unlawful clearing of vegetation in and below an existing dam. A pre-directive was also received from the Breede-Gouritz Catchment Management Agency (BGCMA) stating that certain activities had commenced without appropriate water use authorisation in terms of Section 21 of the National Water Act (NWA; Act No. 36 of 1998). These activities were listed as follows:

a) taking water from a water resource;
b) storing water;
c) impeding or diverting the flow of water in a watercourse; and,
i) altering the bed, banks, course or characteristics of a watercourse.

1.2 Description of the Unauthorised Activity

A pre-existing dam (known as Bosse Dam) on Lower Schoonberg, Farm number RE/108, was cleared of vegetation and sediment in the dam basin to allow for repair and reinforcement of the dam wall. Activities commenced in late 2018 / early 2019. The dam had been leaking through the embankment resulting in an increased risk of dam failure and poor function. Vegetation associated with the watercourse below the dam embankment has been completely cleared, and was reportedly dominated by *Eucalyptus* spp. trees. Approximately 6 hectares of vegetation was cleared from along the Suikerboslaagte Stream (downstream of the dam embankment) and 12.3 hectares was cleared along the Brak Stream, into which the Suikerboslaagte Stream flows. This area, including the cleared vegetation was burnt in a wild fire towards the end of 2018, and the cleared plant material has been used as infill, along with sediment from the dam, in parts of the channel below the dam embankment (Figure 1). This has subsequently led to an inability to identify the exact path of the watercourse channel, as the area has been completely modified.

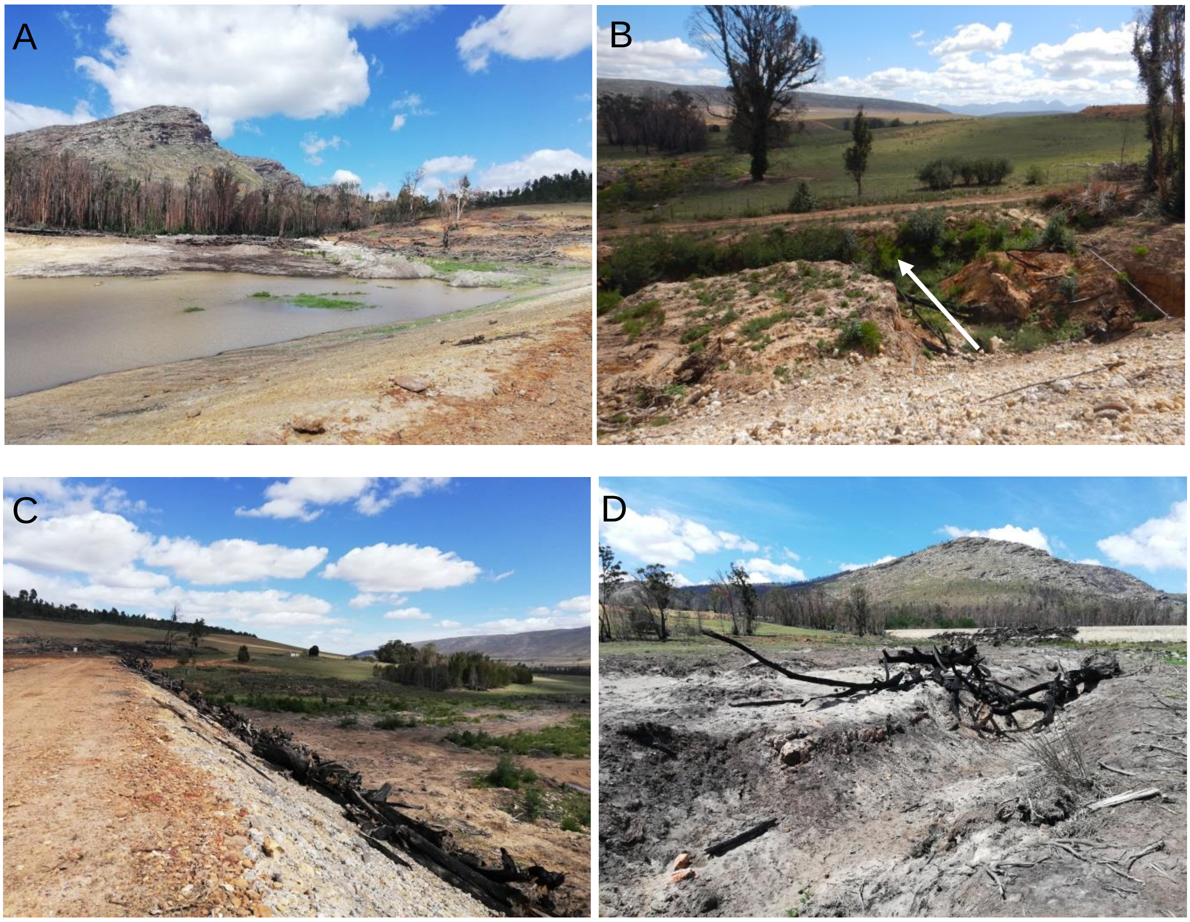

Figure 1. Photos depicting various aspects of the Bosse dam clearance and related activities, including: A) Clearing of vegetation and removal of excess sediment from the dam basin; B) the original spillway below the embankment, where erosion and under-cutting of the banks has occurred (white arrow); C) the repaired dam embankment showing burnt stumps placed for erosion control; and D) burnt trees in the watercourse channel, below the embankment (used with sediment for infilling).

The dam in its current state was assessed by a dam engineer at the request of the BGCMA. Jan Brink (2019, updated in 2020) provided a summary of the dam dimensions (Table 1). Previous dimensions of the dam were unknown, apart from the volume which appears to be 59 450 m^3 according to a historical Validation and Verification conducted at the site.

Table 1. Summarised dimensions of Bosse Dam following clearing.

Dimensions	
Location	33°49'06" S, 22°37'40" E
Wall type	Earthfill
Wall height	10.5 m
Storage capacity	163 500 m^3
Spillway type	Bywash
Crest length	273 m
Crest width	9 m

Points raised in the dam engineer’s report (Brink, 2019) that are relevant to the health of aquatic ecosystems are listed as follows:

- The dam embankment which is 1:2 upstream and 1:1.5 downstream. This is relatively steep for the type of material used in construction and may render the embankment more susceptible to erosion.
- Burnt tree stumps placed on the downstream slope encourage, rather than prevent erosion, and should be removed.
- The new spillway is an uncontrolled by-wash channel with no formal return channel to a natural watercourse, and will probably result in erosion along the left flank during overflow events.

1.3 Scope of Work

The scope of work covers the following aspects:

- Compilation of aquatic specialist inputs to a Section 24G application for the development which complies with the relevant legislation pertaining to the National Environmental Management Act (Act No. 107 of 1998);
- The report will be compiled according to DEA & DP specialist reporting requirements for impact assessments (Brownlie, 2005);
- Assessment of the direct and indirect implications of the dam clearance and activities taking into consideration pre-existing impacts at the site.
- Rehabilitation plan for affected watercourses.

1.4 Assumptions and Limitations

- A major limitation of this assessment is the recent disturbance (infilling, fire and vegetation clearance) that has occurred adjacent to, and within the watercourses at the site. This has obscured the natural path of the watercourse and made it challenging to correctly classify the hydrogeomorphic units;
- With ecology being dynamic and complex, there is the likelihood that some aspects (some of which may be important) may have been overlooked. Similarly, sampling by its nature, means that generally not all aspects of ecosystems can be assessed and identified; and,
- This assessment is based on the findings of a visual assessment of the site combined with available desktop resources. This study was not informed by detailed hydraulic, hydrological, faunal or floral assessments.

2. CATCHMENT CONTEXT

The site is located in the Gouritz Water Management Area, positioned in Quaternary catchment J34E. The Mean Annual Runoff for the catchment is 16.70 mm and the Mean Annual Precipitation is recorded at 426.68 mm which can fall at any time of the year, and is weakly bimodal (Figure 2).

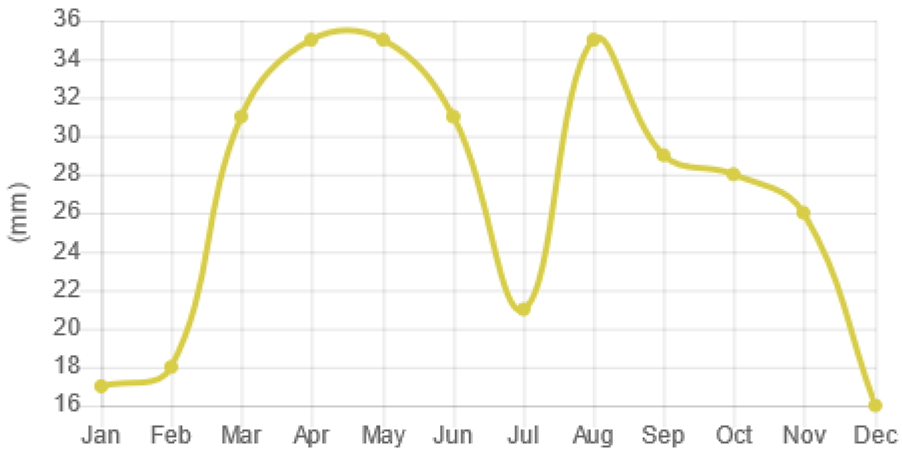

Figure 2. Mean monthly rainfall for the project area.

The watercourse flowing into the dam is the Suikerboslaagte Stream which is identified as a perennial watercourse with sections identified near the dam as a channelled valley-bottom wetland. Below the dam embankment the stream is classified as non-perennial and continues its course into the Brak River, a 1st order, non-perennial river, approximately 1km downstream. A small area is identified as a channelled valley-bottom wetland near the confluence of the Suikerboslaagte and Brak Streams (Figure 4). The Suikerboslaagte Stream arises in the hills to the south of the dam with source zones in Skoonberg Mountain (1 118 m.a.m.s.l.).

2.1 Ecoregion and Vegetation

The study area is located within the Southern Fold Mountains (Ecoregion level 2: 19.01). The terrain is described as lowlands, hills and mountains with moderate to high relief. Altitude in these regions ranges from 100 to 1 300 m.a.s.m.l. Mean annual precipitation is between 0-400 mm.

The vegetation types mapped at the site consist of North and South Outeniqua Sandstone Fynbos, and Langkloof Shale Renosterveld (Figure 3) according to Mucina and Rutherford (2006). The conservation status of South Outeniqua Fynbos is listed as “Vulnerable” and North Outeniqua Fynbos is “Least Threatened”. Cleared areas around the dam and downstream occur predominantly in Langkloof Shale Renosterveld, which is classified as “Critically Endangered”. Although this area has been agriculturally developed for many decades, resulting in extremely modified vegetation/landscape, it is important to identify areas still retaining natural (critically endangered) vegetation for conservation and restoration purposes.

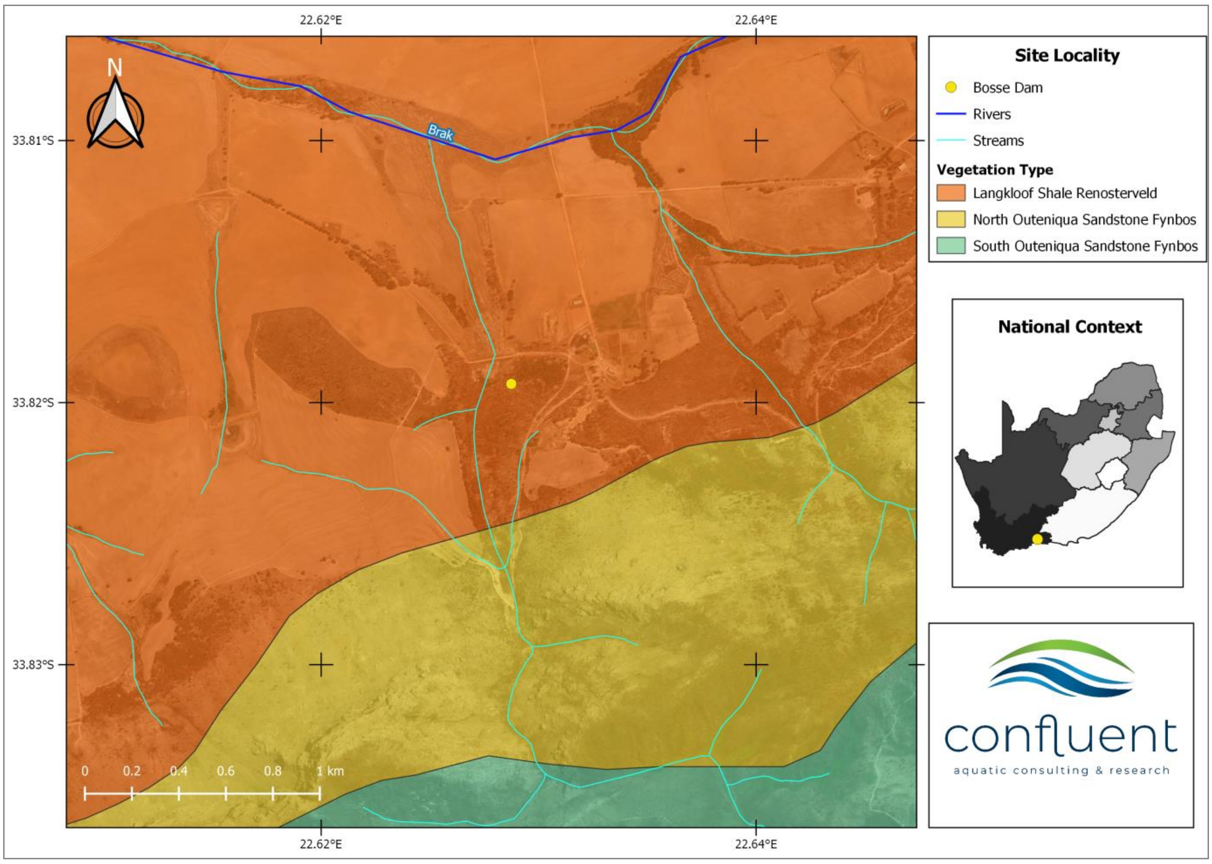

Figure 3. Map depicting the study area in relation to mapped vegetation types according to Mucina and Rutherford (2006).

2.2 National Freshwater Ecosystem Priority Areas (NFEPA)

The dam site and surrounding area are classified as a channelled valley-bottom wetland according to NFEPA (Figure 4). The NFEPA spatial layer also identifies a natural channelled valley bottom wetland near the confluence of the Brak and Suikerboslaagte Streams. The dam and downstream areas are situated in the Sub-Quaternary Reach (SQR) number 8910, which is categorised as an **Upstream Management Area**. SQRs in this category are described by Nel *et al.,* (2011) as follows:

“These are sub-quaternary catchments in which human activities needs to be managed to prevent the degradation of downstream FEPAs and Fish Support Areas.”

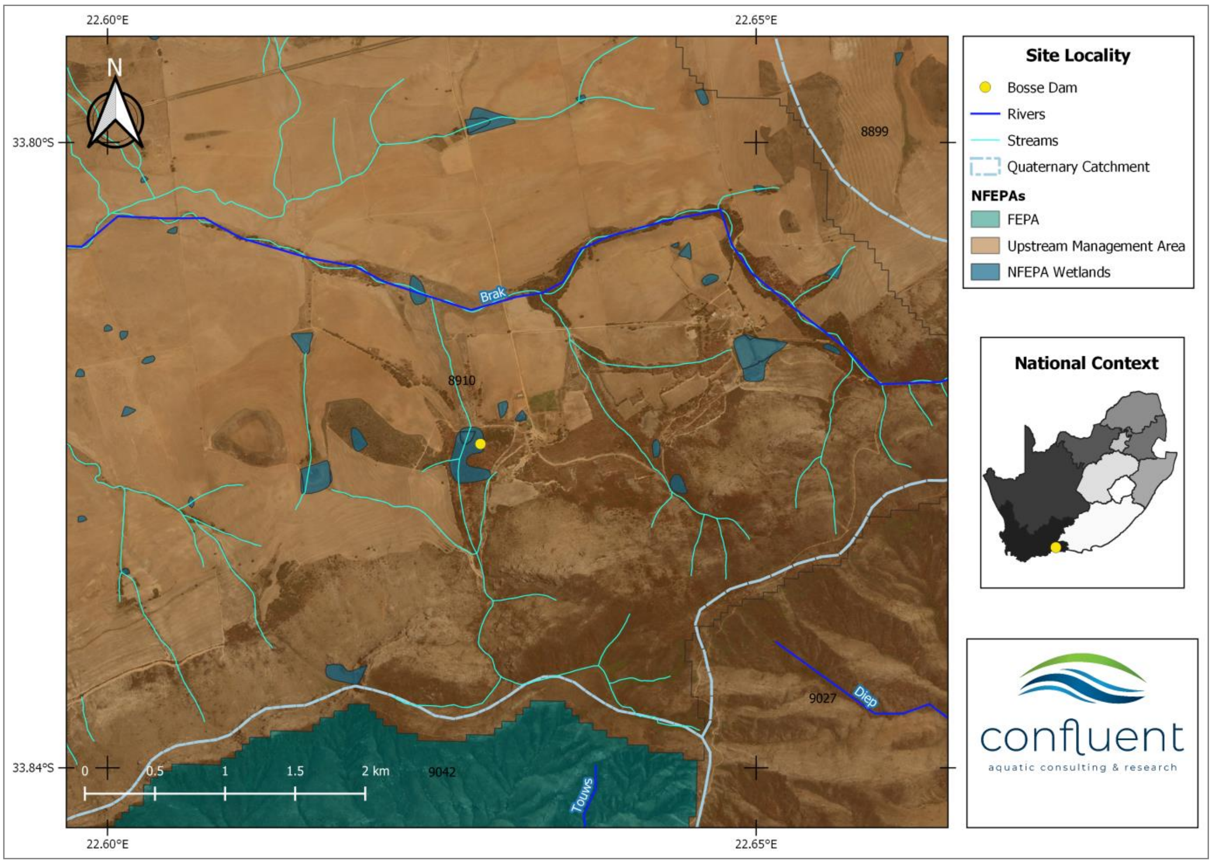

Figure 4. Map of the study area in relation to NFEPA sub-quaternary reaches, showing the study area within an Upstream Management Area and NFEPA Wetland.

2.3 Conservation Status

The Western Cape Biodiversity Spatial Plan (WCBSP; 2017) covers both terrestrial and freshwater habitats. According to the plan, the study area falls within several categories mapped by the WCBSP, each with distinct management objectives. The dam and stream at this location are classified as Critical Biodiversity Area 2 (CBA2: Degraded) and Ecological Support Area 2 (ESA2: Restore; Figure 5). The terrestrial areas upstream, and surrounding, the dam are categorised as Critical Biodiversity Area (CBA, Terrestrial) and Ecological Support Area 1 (ESA1). The majority of work (vegetation clearing and sediment removal) has occurred in CBA2 and ESA2 areas. The objectives of the WCBSP is to manage and minimise further impacts to ecological processes and functioning, and where possible, restore and rehabilitate areas to improve these processes and connectivity for aquatic and non-aquatic faunal movement.

The WCBSP defines systems in these categories as follows:

Critical Biodiversity Area: “*Areas in a natural condition which are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure*.”

The management objective for systems in this category is to:

"Maintain in a natural or near-natural state with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity- sensitive land-uses are appropriate."

Critical Biodiversity Area 2 (Degraded): "*Areas in a degraded or secondary condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure."*

The management objective for systems in this category is to:

"Maintain in a natural or near-natural state, with no further loss of habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land-uses are appropriate."

Ecological Support Area: *"Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of PAs or CBAs, and are often vital for delivering ecosystem services."*

The management objective for systems in this category is to:

"Maintain in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised."

Ecological Support Area 2 (Restore): *"Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of PAs or CBAs, and are often vital for delivering ecosystem services."*

The management objective for systems in this category is to:

"Restore and / or manage to minimise impact on ecological processes and ecological infrastructure functioning, especially soil and water related services, and to allow for faunal movement."

The study area is located in the Garden Route Biosphere Reserve and a section in the Gouritz Cluster Biosphere Reserve.

Figure 5. Map of the study site in relation to the Western Cape Biodiversity Spatial Plan (WCBSP).

2.4 Historical Context

Historical aerial imagery was obtained from the Chief Directorate: National Geo-spatial Information. Bosse Dam was constructed on Lower Schoonberg Farm many decades ago, and is visible on historical aerial photographs from 1968 (Figure 6). Downstream of the embankment was a straight line of trees which was probably *Eucalyptus* trees planted as a windbreak. The less linear line of vegetation almost parallel to the west of the windbreak was probably the original watercourse which has been obscured by recent clearing.

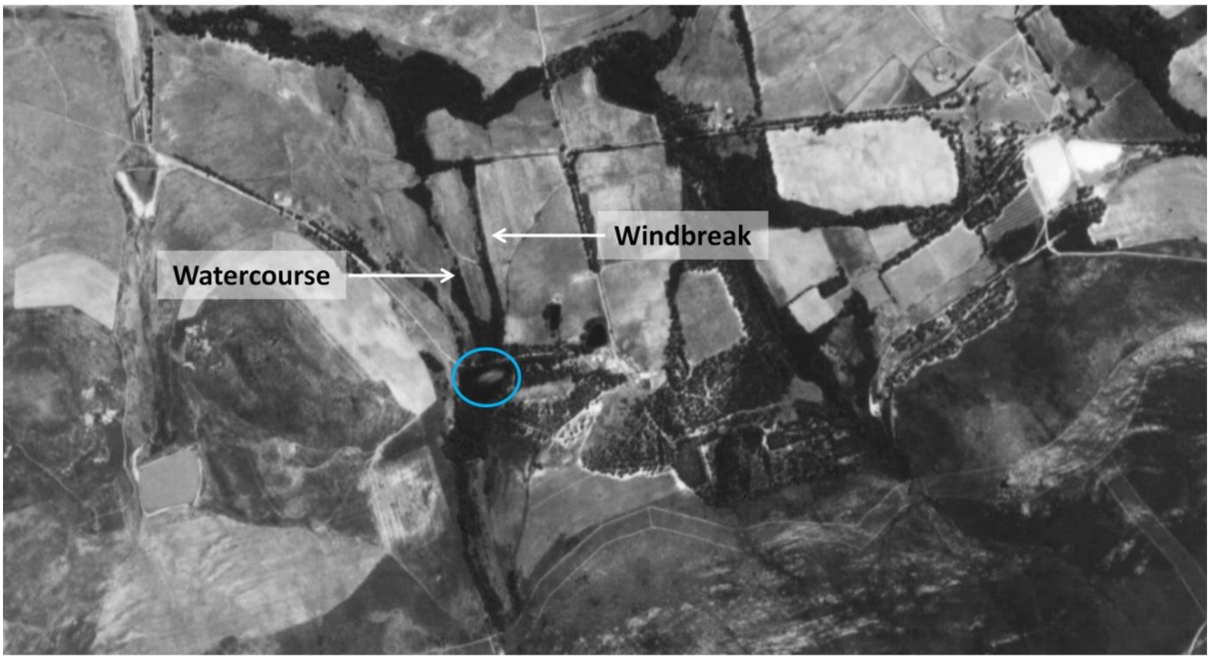

Figure 6. Historic aerial photo dated **1968** showing evidence of Bosse Dam (blue) and agricultural activities.

Between the end of October 2018 and January 2019 the vegetation bordering the dam, as well as the full extent of riparian vegetation below the dam along the watercourse flowing into the Brak River, has been cleared (Figure 7 and Figure 8). According to the land-owners, this vegetation mostly consisted of alien plants such as *Eucalyptus*, which was burnt in a wild-fire towards the end of 2018. Some of the excavated sediment from the dam and the burnt plant material has been used as infill along the watercourse, and the original watercourse downstream of the embankment cannot be easily distinguished.

Figure 7. Satellite image showing Bosse Dam (blue) dated **October 2018** prior to clearing activities.

Figure 8. Bosse Dam (blue) showing the commencement of clearing in **November 2018.**

2.5 Desktop Present Ecological State, Importance and Sensitivity

The Present Ecological State of the Brak River, of which the Suikerboslaagte stream is a tributary, is categorised as **D, Largely Modified** (DWS, 2014). The desktop PES is determined per SQR, which means that it incorporates impacts at a broader scale than the Bosse Dam and its immediate catchment. The desktop PES takes into consideration impacts such as surrounding agricultural activities along the stretch of the river, including the modification and/or clearing of land and riparian vegetation on the banks of the river, abstraction, and the accumulation of invasive species (plants and animals) present in the system.

The Ecological Importance (EI) of the SQR is listed as **Moderate**. One of the fish species likely to occur further downstream in the Brak River is *Pseudobarbus tenuis* (Slender redfin) according to the IUCN Red List the fish species has a conservation of Near Threatened and is endemic to the Gouritz River System. The Slender redfin can be typically found in all river habitats in the Gouritz System, and generally feed in pools and riffles (Garrow and Marr, 2012).

The Ecological Sensitivity (ES) of the Brak River is rated as **High.** This rating is mostly attributed to the high sensitivity of *Xenopus laevis* (African clawed frog), a riparian-wetland vertebrate, to flow and water level modifications as specific water conditions are necessary during certain stages of its life-cycle to maintain a viable population (DWS, 2014).

The recently gazetted Resource Quality Objectives for the Breede-Gouritz WMA do not provide a Recommended or Target Ecological Category for the Brak River (DWS, 2018).

3. METHODS

3.1 Site Selection and Conditions

The site was visited on 23 October 2019. There had been little to no recent rainfall and the area has experienced a severe drought. A small amount of water was observed in the Bosse Dam, but there was no flowing water or channel downstream of the dam embankment in either the Suikerboslaagte or Brak Streams.

The field assessment aimed to determine the baseline characteristics (Present Ecological State) of the affected aquatic ecosystem as well as how the clearing and modification of vegetation and bed and banks has altered this condition. Therefore the length of the Suikerboslaagte Stream, upstream and downstream of Bosse Dam, as well as to the confluence with the Brak River was assessed. The section of the Brak River that has been cleared was also inspected. This is a total distance of approximately 1.5 km.

3.2 Classification of the Watercourse

Classification of the watercourse at the site followed the methods developed by Ollis *et al*., (2013) to classify wetlands and other aquatic ecosystems (Table 2). According to this method the watercourse downstream of the Bosse Dam embankment is classified as a valley bottom wetland. It isn't possible to determine whether it was channelled or unchannelled due to the infilling and earthworks that have taken place. Although a small channel was definitely present in places. The same classification was determined for the Brak Stream in the area where clearing has occurred. Vegetation clearing has also complicated further classification as channelled or unchannelled. No distinct channels are visible in either watercourse in historic aerial imagery.

Table 2. Classification of the watercourse(s) on site using the methods described by Ollis *et al*. (2013).

Level 1	Level 2		Level 3
System	DWS Ecoregion	Vegetation	Landscape unit
Inland	19.01 Southern Fold Mountains	Langkloof Shale Renosterveld	Valley bottom Eastern slope for 500m = 5.4% Western slope for 500m = 6.4%

3.3 Present Ecological State (PES)

Based on the classification of the watercourse as a valley bottom wetland, the method selected to determine the PES was the Level 1 WET-Health assessment tool developed by Macfarlane *et al.* (2007). Data collection involved a desktop review of the extent and intensity of catchment land cover impacts and the onsite identification and recording of observable impacts to the wetland.

The desktop catchment review was undertaken using historical aerial photography for the area and supplemented by the most recent Google Earth imagery. Thereafter, onsite impacts were determined during the site visit. All relevant desktop and field data were used to complete the relevant sections of the Level 1 WET-Health tool.

The magnitude of observed impacts on the hydrological, geomorphological and vegetation components of the wetland were calculated and combined as per the tool to provide a measure of the overall condition of the wetland on a scale from 1-10. Resultant scores were then used to classify the wetland as one of six PES categories as shown in Table 3.

Table 3. Wetland present ecological state categories and impact descriptions.

Ecological Category	Description	Impact Score
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications / in good health. A small change in natural habitats and biota may have taken place but the ecosystem functions are still predominantly unchanged.	1 – 1.9
C	Moderately modified / fair condition. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	2 – 3.9
D	Largely modified / poor condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	4 – 5.9
E	Seriously modified / very poor condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.	6 – 7.9
F	Critically modified / totally transformed. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota.	8 - 10

3.4 Ecological Importance and Sensitivity

The ecological importance of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales (Duthie, 1999). Ecological sensitivity refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Duthie, 1999). The Ecological Importance and Sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC).

The revised method for the determination of the EIS of a wetland considers the three following ecological aspects (Rountree *et al*., 2013):

- **Ecological importance and sensitivity**
  - Biodiversity support including rare species and feeding/breeding/migration;
  - Protection status, size and rarity in the landscape context;
  - Sensitivity of the wetland to floods, droughts and water quality fluctuations.

- **Hydro-functional importance**
  - Flood attenuation;
  - Streamflow regulation;
  - Water quality enhancement through sediment trapping and nutrient assimilation;
  - Carbon storage.

- **Direct human benefits**
    - Water for human use and harvestable resources;
    - Cultivated foods;
    - Cultural heritage;
    - Tourism, recreation, education and research.

Each criterion is scored between 0 and 4, and the average of each subset of scores is used to derive a score for each of the three components listed above. The highest score is used to determine the overall Importance and Sensitivity category of the wetland system (Table 4).

Table 4. Ecological importance and sensitivity categories. Interpretation of average scores for biotic and habitat determinants

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

4. RESULTS

4.1 Wetland Indicators

4.1.1 Terrain Unit

The longitudinal profile for the Suikerboslaagte Stream from the hills upstream of the dam to the approximate confluence with the Brak Stream is shown in Figure 9. Below the dam wall the terrain slopes gently until it becomes approximately flat. The area in the vicinity of the confluence is also very gently sloping with very broad valley sides adjacent to each watercourse. As a result the watercourse is largely unconfined in a broad valley bottom. This is why the channel when present is indistinct, as apart from disturbance related to clearing activities, the gradient is too gentle to result in the distinct formation of a channel in places.

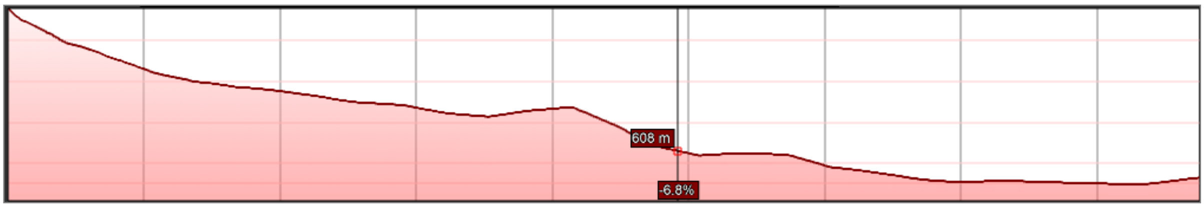

Figure 9. Longitudinal profile for Suikerboslaagte Stream with vertical line indicating the approximate location of the dam embankment.

4.1.2 Soils

Hydromorphic soils display characteristics resulting from prolonged and repeated saturation which leads to variable states of oxidation. One of the indicators that soil has been subject to a seasonally fluctuating water table (associated with a wetland) is the presence of mottling. Mottling occurs when soils alternate between aerobic (unsaturated) and anaerobic (saturated) states. Iron is dissolved under anaerobic conditions, but is oxidised during aerobic conditions forming bright reddish-orange insoluble iron compounds. Soil augering was conducted at multiple points along the Suikerboslaagte and Brak Streams, and hydromorphic soils were identified along the full lengh of both watercourses assessed (Figure 10). This indicates a seasonally inundated wetland area.

Figure 10. Soil auger sample from the area downstream of the dam embankment along the Suikerboslaagte Stream.

4.1.3 Vegetation

According to the NWA, wetlands support hydrophilic vegetation typically adapted to life in frequently saturated soils. Wetland plants identified in this assessment are presented in Table 5. They were used along with soil augering as confirmation of the presence of a wetland and do not represent an exhaustive list of species.

Table 5. Plant species identified in wetland areas of the site.

Species Name	Common Name	Wetland Plant Type
Eleocharis dregeana	Finger sedge	Obligate
Arundo donax	Giant reed	Opportunist plant (alien)
Carex acutiformis	Lesser pond sedge	Obligate (possibly alien)
Isolepis diabolica		Obligate
Cyperus sp. **(*thunbergii*?)**		Obligate
Carex sp. (possibly *glomerabilis)*	Foxtail sedge	Obligate

4.1.4 Present Ecological State

The PES of the Suikerboslaagte and Brak Streams were combined as the impacts affecting them are very similar, and they are part of the same aquatic ecosystem. Different hydrogeomorphic units cannot be distinguished between the two wetlands given historic and recent disturbance at the site.

The overall PES was classified as **E, Seriously Modified** (Table 6).This is one category lower than the desktop PES which classified the Brak River as D, Largely Modified. The major change from the pre-cleared state of the wetland is the removal of (mostly alien) vegetation, infilling and levelling of the land in the vicinity of the wetlands (Figure 11). Prior to clearing activities, the Hydrology and Vegetation components would have had a similar score to the present state (Table 6), as the highest impact would have been related to alien vegetation which has now been removed, but replaced with the new impact of infilling. The Geomorphology component has likely decreased from its prior score because infilling has more of an impact on this aspect than the presence of alien vegetation. It is therefore likely that the overall PES has not changed substantially from the original (pre-clearing) state, but that the dominant impacts have changed. Most importantly, the reversibility of the impacts differs substantially because while established methods of alien vegetation control can be applied to manage and improve the watercourse, infilling is more difficult to reverse.

As the dam was undisturbed many decades, vegetation around the dam would have consisted of a fairly diverse assemblage of wetland and riparian species, as well as the alien trees. This has now been cleared leaving the dam slopes bare and expose to erosion, with extensive areas still covered in alien trees.

It is recommended that the PES be improved to D, Largely Modified.

Table 6. Summarised scores derived using WET-Health to determine the PES of the wetland.

Components	Individual PES	Overall PES
Hydrology	**E**	**E** Seriously modified / very poor condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.
Geomorphology	**E**	
Vegetation	**F**	

Figure 11. Photos of the Suikerboslaagte (left) and Brak (right) Streams showing infilled sections (above, yellow) and channelled sections (below)

4.2 Ecological Importance and Sensitivity

The three tables below provide the scores allocated to each of the wetland importance criteria, namely ecological importance and sensitivity, hydro-functional importance and importance to humans. The EIS of the site was determined to be **High.** The most important of the three aspects assessed was the Ecological Importance and Sensitivity (Table 7). It should be noted that the confidence level for this criteria was 3.6 (out of 5) on the basis that wetland fauna and flora had not been studied to a great level of detail for this study.

The recently developed Freshwater Biodiversity Information System (FBIS) was consulted to determine whether any historical fish or macroinvertebrate samples had been recorded in the project area. One sample location was found on the Brak River which recorded the occurrence of *Sandelia capensis* (Cape Kurper) which has a conservation status of “data deficient” according to the IUCN Red List. Cape Kurper are endemic to the Western Cape where they are found in rivers and wetlands with slow-flowing water and pools. As the Brak River (mostly wetland at this site) is a small non-perennial watercourse, it has a very high sensitivity to modifications of floods, flows and water quality. All of which would be negatively influenced by recent infilling of the watercourse.

Table 7.Ecological Importance and Sensitivity importance criteria.

Ecological importance and sensitivity	Score 0-4	Confidence 1-5	Motivation
Biodiversity support	**0.3**		
Presence of Red Data species	0	3	None
Populations of unique species	0	4	None
Migration/feeding/breeding sites	1	3	Provides corridor (pre-clearing)
Landscape scale	**1.4**		
Protection status of wetland	1	4	None except within WCBSP
Protection status of vegetation type	3	4	Critically Endangered
Regional context of the ecological integrity	1	3	Similar wetlands, many degraded
Size and rarity of the wetland types present	1	3	Similar wetlands elsewhere
Diversity of habitat types	1	4	Appears mostly uniform
Sensitivity of the wetland	**2.6**		
Sensitivity to changes in floods	2	4	Valley bottoms are moderate
Sensitivity to changes in low flows	3	4	Unchannelled sections more sensitive
Sensitivity to changes in water quality	3	4	Naturally low nutrient waters
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**2.6**	**3.6**	

Table 8: Hydro-functional importance criteria.

<table>
<tr><th colspan="3">Hdyro-functional importance</th><th>Score 0-4</th><th>Confidence 1-5</th><th>Motivation</th></tr>
<tr><td rowspan="8">Regulating & supporting benefits</td><td colspan="2">Flood attenuation</td><td>2</td><td>4</td><td>Broad valley attenuates flooding</td></tr>
<tr><td colspan="2">Streamflow regulation</td><td>3</td><td>3</td><td>Provide water to Brak Stream</td></tr>
<tr><td rowspan="5">Water quality enhancement</td><td>Sediment trapping</td><td>2</td><td>3</td><td>Low gradient, high retention time</td></tr>
<tr><td>Phosphate assimilation</td><td>2</td><td>3</td><td>High retention time</td></tr>
<tr><td>Nitrate assimilation</td><td>1</td><td>3</td><td>High retention time</td></tr>
<tr><td>Toxicant assimilation</td><td>1</td><td>3</td><td>High retention time</td></tr>
<tr><td>Erosion control</td><td>2</td><td>4</td><td>Low gradient, high retention time</td></tr>
<tr><td colspan="2">Carbon storage</td><td>2</td><td>4</td><td>Should have abundant plants</td></tr>
<tr><td colspan="3">HYDRO-FUNCTIONAL IMPORTANCE</td><td>1.75</td><td>3.3</td><td></td></tr>
</table>

Table 9: Direct human benefit importance criteria.

<table>
<tr><th colspan="2">Direct human benefits</th><th>Score 0-4</th><th>Confidence 1-5</th><th>Motivation</th></tr>
<tr><td rowspan="2">Subsistence benefits</td><td>Water for human use</td><td>1</td><td>4</td><td>Probably low use</td></tr>
<tr><td>Harvestable resources / cultivated foods</td><td>0</td><td>4</td><td>None present</td></tr>
<tr><td rowspan="2">Cultural benefits</td><td>Cultural heritage</td><td>1</td><td>3</td><td>None known</td></tr>
<tr><td>Tourism and recreation
Education and research</td><td>1</td><td>4</td><td>Langkloof attracts tourists</td></tr>
<tr><td colspan="2">DIRECT HUMAN BENEFITS</td><td>0.6</td><td>3.6</td><td></td></tr>
</table>

5. IMPACT ASSESSMENT OF ACTIVITIES AT BOSSE DAM

This section was prepared according to guidelines for specialists published by DEA & DP (Brownlie, 2005). The basis for the impact assessment is the upgrading and maintenance of a dam embankment and clearing associated with the watercourse downstream. The assessment considers direct, indirect and cumulative impacts to the aquatic ecosystem that may have arisen during the construction and maintenance phase, and during the operational phase of the dam.

Individual impacts are rated according to criteria which include their intensity, duration and extent. The ratings are then used to calculate the consequence of the impact which can be either negative or positive as follows:

Consequence = type x (intensity + duration + extent)

Where type is either negative or positive. The significance of the impact is then calculated by applying the probability of occurrence to the consequence as follows:

Significance = consequence x probability

The criteria and their associated ratings are shown in Table 10.

Table 10. Categorical description for impacts and their associated ratings

Category	Description	Rating`
Intensity	Negligible	1
	Very Low	2
	Low	3
	Moderate	4
	High	5
	Very High	6
	Extremely High	7
Duration	Immediate	1
	Brief	2
	Short Term	3
	Medium Term	4
	Long Term	5
	Ongoing	6
	Permanent	7
Extent	Very Limited	1
	Limited	2
	Local	3
	Municipal Area	4
	Regional	5
	National	6
	International	7
Probability	Highly Unlikely	1
	Rare	2
	Unlikely	3
	Probably	4
	Likely	5
	Almost Certain	6
	Certain	7

Categories assigned to the calculated significance ratings are presented in Table 11.

Table 11. Value ranges for significance ratings

Significance rating	Range	
Major (-)	-147	-109
Moderate (-)	-108	-73
Minor (-)	-72	-36
Negligible (-)	-35	-1
Neutral	0	0
Negligible (+)	1	35
Minor (+)	36	72
Moderate (+)	73	108
Major (+)	109	147

confluent

Each impact was considered from the perspective of whether losses / gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence is also determined and rated as low, medium or high (Table 12).

Table 12. Definition of reversibility, irreplaceability and confidence ratings

Rating	Reversibility	Irreplaceability	Confidence
Low	Permanent modification, no recovery possible.	No irreparable damage and the resource isn't scarce.	Judgement based on intuition.
Medium	Recovery possible with significant intervention.	Irreparable damage, but is represented elsewhere.	Based on common sense and general knowledge
High	Recovery likely.	Irreparable damage, and is not represented elsewhere.	Substantial data supports the assessment

5.1 Layout and Design Phase Impacts

As the dam was built many years ago (ca. 1940s) the impacts of the layout and design phase were not considered in this assessment.

5.2 Construction Phase Impacts

As the dam was built many years ago (ca. 1940s) the impacts of the construction phase were not considered in this assessment.

5.3 Operational Phase Impacts

Maintenance activities including vegetation clearing, excavations in the dam and infilling of the downstream watercourse(s) were all considered as operational phase impacts. Most of these activities have ceased since commencement of the Section 24G application, but may continue once the application has concluded. Therefore mitigation measures will apply to ongoing and future maintenance activities.

5.3.1 Removal of Vegetation

Approximately 6 ha of vegetation was cleared from along the Suikerboslaagte Stream, 12.3 ha along the Brak Stream, and 1.3 ha around the dam. According to the land-owner, this vegetation largely consisted of alien tree species, which is supported by vegetation upstream and downstream of the cleared area of the Brak Stream. However, adjacent to cleared areas of the Suikerboslaagte Stream are sections of indigenous wetland vegetation indicating that similar plant communities may have been cleared along with aliens during work along this watercourse. Vegetation was cleared using heavy machinery such as bulldozers and backacters which are highly detrimental to habitat, soil and non-target vegetation associated with wetlands. It is also likely that aquatic and littoral vegetation around the dam would have consisted of several indigenous species.

Recommended mitigation measures

- Implement a riparian buffer zone along watercourses (including the dam) where no heavy machinery is permitted to enter, and vegetation is to be rehabilitated;
- Where alien infestations occur directly along watercourses and within buffer zones, **ring bark** large trees to kill them, remove medium-sized trees by **sawing them down and painting herbicide on stumps**, and remove small trees using **tree-**

poppers (available in 3 sizes). The purpose of this approach is to protect top-soil, prevent erosion, protect indigenous plants, and retain shade over the watercourse.

- All alien woody debris must be **removed** from the watercourse(s), whether it has fallen over naturally or been cut down.
- If alien trees need to be burnt, small piles must be made outside of the riparian areas and can be burnt with a permit only.
- Encourage and support the growth of indigenous vegetation which may begin to regenerate from the existing seedbank by constantly following up on alien tree removal using tree poppers and hand-pulling of seedlings.
- No vegetation (or other material) must be dumped adjacent to, or within, any watercourse.
- Where trees have fallen, or been dumped into the watercourse, they should be removed from the channel.

5.3.2 Dam Embankment Erosion

Currently the dam embankment is steep, without vegetation cover, and had numerous large burnt tree trunks placed on it. All of these factors increase the susceptibility of the embankment to erosion which will compromise dam safety and further degrade the watercourse downstream.

Recommended mitigation measures

- Burnt tree trunks should not be placed on the dam embankment, and should be removed immediately.
- The embankment should be re-vegetated using an appropriate grass cover by hydro-seeding or by hand if necessary. Compaction, exposure and the arid climate may reduce the speed and success of re-vegetation, and therefore grass may require additional support to establish. It will be important to consider:
    - Including a seed mixture such as fynbos reclamation mix which is available from Sakata;
    - Perennial grass species should be commercially available indigenous species such as *Themeda triandra, Heteropogon contortus, or Ehrharta calycina;*
    - Provision of mulch and water until vegetation cover becomes established;
    - Provide additional erosion control and seed protection by pinning biodegradable, woven mats over the seeded area such as coir, jute or coconut fibre (Figure 12). A product such as SoilSaver from Kaytech can fulfil this purpose.
    - Inspect and re-seed areas that fail to establish.

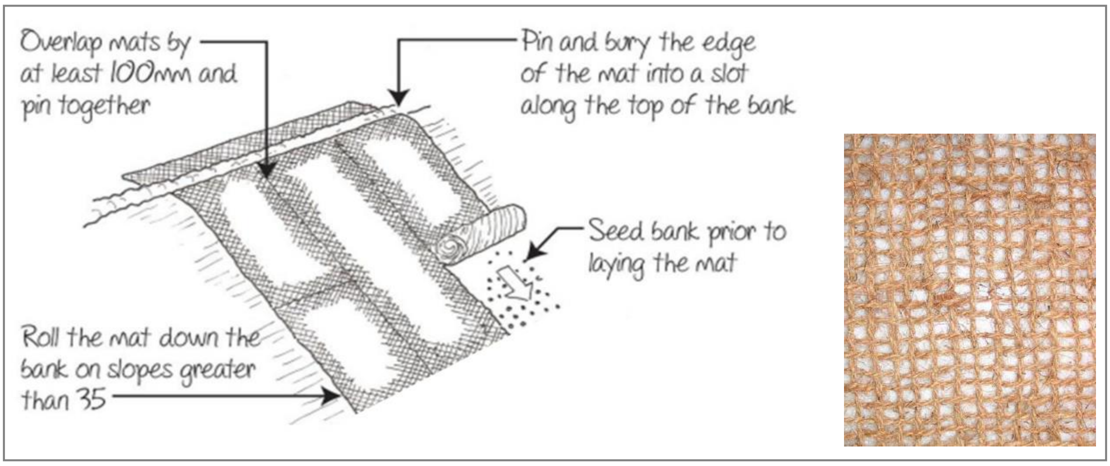

Figure 12. Example of the suggested application method of coir matting in seeded areas with an inset showing woven coir mat material (From Day *et al*., 2016).

5.3.3 Watercourse Channel and Habitat Loss

Vegetation clearing and infilling have obscured the original path of the watercourse for both the Suikerboslaagte and Brak Streams. This practice is not permissible in future, and the impacts of current clearing need to be mitigated in order to restore and improve the ecological state of both watercourses. The primary step to ensure the protection of both watercourses is to define a buffer zone around the watercourses within which mitigation and rehabilitation measures must be implemented. This exercise is constrained by the lack of a clearly defined channel along with the classification of the watercourse as being more characteristic of wetlands in certain areas. Furthermore, historical imagery does not indicate a defined channel in either watercourse. Therefore, it is proposed that a 15 m wide corridor be delineated which begins at the new spillway and follows the best approximation of the channel to the confluence with the Brak Stream which should have a 20 m corridor (as it is a larger stream; Figure 13). The areas within the watercourse buffer should be treated according to the mitigation measures recommended below.

<u>Recommended mitigation measures</u>

- Heavy machinery must never be permitted in the buffer zone;
- The length of the buffer zone should be fenced with a single electric strand to prevent access by livestock, but allow for the movement of aquatic associated fauna like otters and water mongoose for instance;
- The channel should be allowed to reform naturally in the landscape, and if it deviates significantly from the selected corridor then fencing should be re-routed to maintain the buffered area around the watercourse;
- Alien vegetation must be strictly controlled within the buffer zone in order to prevent re-establishment;
- The length of the buffered area must be inspected after every overspill or heavy rainfall event to check for erosion hotspots and the appearance of a channel;
- The spillway needs to be checked after every overspill or heavy rainfall to check for erosion which must be addressed if it occurs.

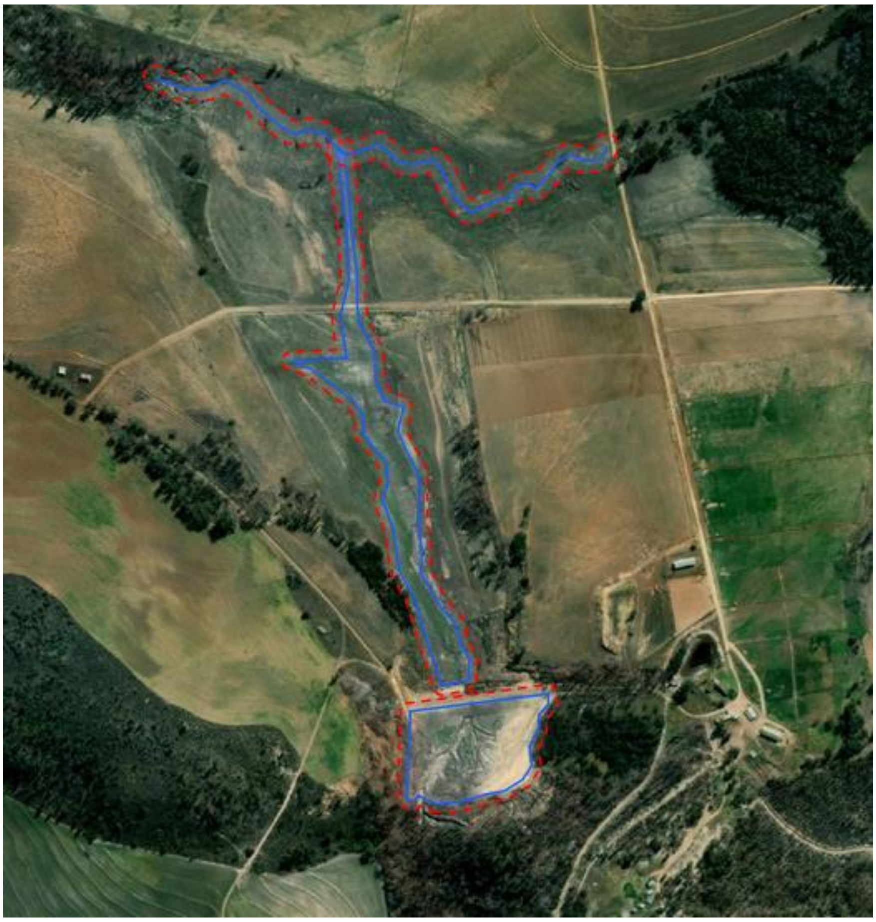

Figure 13. Proposed buffer corridors for the Bosse Dam, Suikerboslaagte (15 m) and Brak (20 m) Streams. Buffers are along the best estimation of the natural path of the watercourse.

Table 13. Summarised impact rating table for operational phase impacts

Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Impact: Removal of Vegetation								
Without mitigation	Very High (6)	Long-term (5)	Limited (2)	Likely (5)	Moderate (-65)	Medium	Medium	Medium
With mitigation	Low (3)	Short-term (3)	Very limited (1)	Rare (2)	Negligible (-14)	High	Low	Medium
Impact: Dam Embankment Erosion								
Without mitigation	Low (3)	Medium term (4)	Very limited (1)	Probably (4)	Negligible (-32)	Medium	Low	High
With mitigation	Negligible (1)	Brief (2)	Very limited (1)	Rare (2)	Negligible (-8)	High	Low	High
Impact: Watercourse Channel and Habitat Loss								
Without mitigation	Very High (6)	Ongoing (6)	Limited (2)	Almost certain (6)	Moderate (-84)	Medium	Medium	Medium
With mitigation	Moderate (4)	Medium term (4)	Very limited (1)	Unlikely (3)	Negligible (-27)	Medium	Medium	Medium

5.4 Cumulative Impacts

The abstraction and storage of water in Bosse Dam has been occurring for many years, and was therefore not considered in the cumulative impact assessment. However, the clearing of vegetation (alien or indigenous) associated with watercourses occurs frequently in agricultural areas, resulting in the cumulative loss of riparian / wetland habitat and the associated ecological functions at multiple spatial scales. Therefore the mitigation measures proposed to protect and reinstate the watercourse and associated habitat must be implemented, and clearing using this approach must not be practiced elsewhere on the farm.

6. RISK ASSESSMENT

According to the Section 21 c) and i) Risk Assessment Matrix, the risk posed to aquatic ecosystem health by the unauthorised activities at Bosse Dam in their mitigated state was **Low** (Table 14). Methods used to determine the risk are explained in Appendix 1 of this report. The assessment considers the risks in their mitigated state, and it is therefore imperative that measures to mitigate impacts are fully implemented for the level of risk to apply. For clarity, the mitigation measures proposed for the risk assessment are the same as those for the impact assessment.

Table 14. Risk Assessment Matrix for activities related to Section 21 c) and i) at Suikerboslaagte and Brak Streams.

No.	Phases	Activity	Aspect	Impact	Flow Regime	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	PES AND EIS OF WATERCOURSE
1		Removal of Vegetation	Disturbance of soil	Soil erosion; Infilling; Compaction; Sedimentation	5	5	5	5	5	1	3	9	1	3	1	1	6	54	Low	70	• Implement a riparian buffer zone along watercourses where no heavy machinery is permitted to enter, and vegetation is to be rehabilitated; • A cover crop should be planted within the buffer zone to protect the soil and improve the micro-climate for the germination of indigenous plant seeds that may be preserved in the seed bank.	
			Loss of vegetation	Habitat loss; Altered micro-climate (no shade); Reduction in alien plants	5	5	5	5	5	1	2	8	1	2	1	1	5	40	Low	70	• Where alien plants occur within buffer zones, ring bark large trees to kill them, remove medium-sized trees by sawing them down and painting herbicide on stumps, and remove small trees using tree-poppers. • All alien woody debris must be removed from the watercourse(s). • Encourage and support the growth of indigenous vegetation which may begin to regenerate from the existing seedbank by constantly following up on alien tree removal using tree poppers and hand-pulling. • No vegetation (or other material) must be dumped adjacent to, or within, any watercourse. • Where trees have fallen, or been dumped into the watercourse, they should be removed from the channel.	

Operational Phase		Watercourse channel and habitat loss	Total loss of aquatic habitat	5	5	5	5	5	1	2	8	1	2	1	1	5	40	Low		Heavy machinery must never be permitted in the buffer zone • The length of the buffer zone should be fenced to prevent access by livestock, but allow for the movement of aquatic associated fauna like otters and water mongoose for instance; • The channel should be allowed to reform naturally in the landscape, and if it deviates significantly from the selected corridor then fencing should be re-routed to maintain the buffered area around the watercourse; • Alien vegetation must be strictly controlled within the buffer zone in order to prevent re-establishment; • A cover crop should be planted within the buffer zone to protect the soil and improve the micro-climate for the germination of indigenous plant seeds that may be preserved in the seed bank. • The length of the buffered area must be inspected after every overspill or heavy rainfall event to check for erosion hotspots and the appearance of a channel; • The spillway needs to be checked after every overspill or heavy rainfall to check for erosion which must be addressed if it occurs.	**PES** : E, Seriously Modified; **EIS** : High
	Dam Embankment Maintenance	Steep, unvegetated slope	Soil erosion; Sedimentation in the watercourse	1	2	1	1	1.3	1	2	4.3	1	2	5	2	10	43	Low	75	• Burnt tree trunks should not be placed on the dam embankment, and should be removed. • The embankment should be re-vegetated using an appropriate grass cover by hydro-seeding or by hand if necessary. Compaction, exposure and the arid climate may reduce the speed and success of re-vegetation, and therefore grass may require additional support to establish. (See recommended mitigation measures in the impact assessment for specific steps)	

6.1 Summary of Mitigation Measures

For the sake of clarity, a summary of the required mitigation measures stipulated in risk matrix is provided below. As explained, in order for the risk rating to remain 'Low' all of these measures need to be put in place and monitored.

- Implement a riparian buffer zone along watercourses where no heavy machinery is permitted to enter, and vegetation is to be rehabilitated;
- A cover crop of indigenous grass should be planted within the buffer zone to protect the soil and improve the micro-climate for the germination of indigenous plant seeds that may be preserved in the seed bank;
- Where alien plants occur within buffer zones, ring bark large trees to kill them, remove medium-sized trees by sawing them down and painting herbicide on stumps, and remove small trees using tree-poppers or hand-pulling.
- All alien woody debris must be removed from the watercourse(s) where it has not yet been buried;
- Encourage and support the growth of indigenous vegetation which may begin to regenerate from the existing seedbank by constantly following up on alien tree removal using tree poppers and hand-pulling;
- No vegetation (or other material) must be dumped adjacent to, or within, any watercourse;
- Where trees have fallen, or been dumped into the watercourse, they should be removed from the channel;
- Burnt tree trunks should not be placed on the dam embankment, and should be removed;
- The dam embankment should be re-vegetated using an appropriate indigenous grass cover by hydro-seeding or by hand if necessary;
- Compaction, exposure and the arid climate may reduce the speed and success of re-vegetation, and therefore grass may require additional support to establish (See recommended mitigation measures in the impact assessment for specific steps).

6.2 Recommended Monitoring

In Section 5.3.3. of this report, it is recommended that a buffer zone be established and fenced along the 'best guess' of the original watercourses, as indicated in Figure 13. In order to reduce the risk of excessive erosion and to accurately provide the watercourse with an effective buffer, it is imperative that the course of development of the watercourse be monitored.

The recommended frequency of monitoring is **twice per annum** (every 6 months) and immediately **following overspill events** in the Bosse Dam for a period of the **next 5 years**. A record of monitoring must be maintained with photographic evidence of the progress and issues that require maintenance or attention. Monitoring can be conducted by the farm manager, but photographic records must be kept and made available to the BGCMA for inspection. One follow-up visit by an aquatic ecologist should be made to monitor progress 12 – 18 months following the commencement of rehabilitation. The following must be monitored:

- Vegetation establishment along the buffered watercourse in terms of the presence of aliens and indigenous wetland plants;

- Any channel erosion of the 'new' watercourse (following overspill events) is taking place within the buffered area. If the channel deviates from the buffered path, then the buffer zone will need to be expanded / moved to accommodate the watercourse;
- Identify woody debris in both watercourses for removal. This can be burnt (with a permit) in small piles outside of the watercourse and buffer areas;
- Inspect both watercourses for dumping of vegetation or soil in the watercourse, and for evidence of the use of heavy machinery in the buffered area;
- Inspect the dam embankment to ensure that burnt stumps have been removed and that vegetation to control erosion has established.

6.3 Maintaining Mitigation Measures

It is likely that during the implementation of the mitigation measures recommended in this report there may be occasions where maintenance and management actions will be required that could entail further work within watercourses. Although it is not possible to conceive of all situations that may arise, a number of situations are considered likely to occur that will require interventions.

6.3.1 Removal of Woody Material

The recommendations within this report stipulate that no heavy machinery must be used within the buffered area of the watercourse, but also stipulates that large amounts of woody material should be removed from the watercourse. Where large accumulations of woody material are still exposed, or become exposed during flow events, they need to preferably be removed using chainsaws and can be removed using a bakkie at limited access points. At all times, disturbance and damage to indigenous plants must be minimised.

Should removal of woody debris be required from other areas of the property, where using heavy machinery could be more cost-effective, it must be noted that this approach will require an environmental authorisation under NEMA and the NWA. The area around and upstream of the Bosse Dam for example. Working with heavy machinery in a watercourse is likely to result in the movement of > $10m^3$ of soil and poses a risk to the bed and banks, which triggers Section 21(i) of the NWA. Alternatively, Working for Water are authorised to undertake alien clearing in watercourses and can be appointed to do the required clearing.

6.3.2 Removal of Alien Trees

Most of the large alien trees within the watercourses downstream of the Bosse Dam have been removed. However, a number of large trees still remain in the littoral zone of the dam and upstream of the dam. These trees should be controlled. In order to limit further disturbance of the watercourse habitat and riparian zone it is recommended that the mitigation measures suggested for alien tree control in the buffer zones also be applied to this area. These were to ring bark large trees to kill them, remove medium-sized trees by sawing them down and painting herbicide on stumps, and remove small trees using tree-poppers or hand-pulling. Use of heavy machinery must be excluded in areas adjacent to the watercourse and dam. This is to prevent damaging remnant indigenous plants and to prevent erosion and compaction of the soil. Therefore, sawing and removal of medium sized trees needs to be done by hand. Reduced disturbance to the soil will also reduce re-growth by alien trees and encourage regeneration of indigenous plants that may still be present in the seed bank. If large, dead trees fall over into the watercourse, these can be sawn into smaller pieces and dragged out using a tractor located outside of the riparian area.

6.3.3 Erosion Following Overspill Events

Minor erosion of the stream channel is to be expected following overspill events, as the watercourse will need to traverse a new path through the landscape. However, if severe erosion occurs, this may need to be rehabilitated and prevented from causing further degradation. The maintenance and management options required will depend on the extent and nature of erosion, which will be assessed during bi-annual monitoring or following overspill events.

7. REHABILITATION PLAN

Rehabilitation efforts must focus on disturbed areas within and around watercourses. Riparian buffer zones have been delineated to focus and direct rehabilitation actions within these areas.

7.1 Riparian Buffer Zone Delineation

Buffer zones have been defined as a strip of land with a use, function or zoning specifically designed to act as barriers between human activities and sensitive water resources with the aim of protecting these water resources from adverse negative impacts. Appropriate buffers were estimated based on buffer zone guidelines developed by Macfarlane and Bredin (2017). These guidelines estimate required buffer zone widths based on a combination of input parameters which include, *inter alia*, the land use and associated impacts, basic climatic and soil conditions, and the PES and EIS of affected watercourses.

The recommended buffer zone around the **Bosse Dam and Suikerboslaagte Stream is 15 m**, and around the **Brak Stream is 20 m**. The wetland area of the Suikerboslaagte is becoming more evident through satellite imagery, and therefore the buffer is 15 m from the delineated edge of the wetland (Figure 13). Whereas the buffer for the Brak Stream is 20 m measured from the channel as wetland features are less distinct.

7.2 Management of Riparian Buffer Zones

As riparian buffer areas are considered sensitive habitat and have been identified for rehabilitation, they are managed differently to surrounding terrestrial areas. A simplified and user-friendly approach has been adopted for outlining the management guidelines for riparian buffer zones using a list of ‘Do’s and Do Not’s’:

<u>**DO**</u>

- Mark out riparian boundaries as soon as possible using available materials such as painted rocks, wooden stakes, spraypaint etc.
- Ensure all farm workers area aware of riparian buffer areas and know the Do’s and Do Not’s.
- Remove alien vegetation using hand-held equipment only (saws, tree poppers, clippers, stump herbicides).
- Remove woody material from alien clearing from the riparian zone for disposal by chipping or burning.

- Fence off the riparian buffer from cattle or other livestock using a single electrical strand.
- Actively plant suitable indigenous plants or an indigenous grass seed mix where the natural seedbank is failing to regenerate.
- Conduct regular instructions every 4-6 months to monitor erosion and alien vegetation regrowth.

DO NOT

- Drive or use heavy machinery or heavy vehicles in the riparian buffer zone.
- Discard or burn woody material from cleared aliens into the watercourse.
- Remove any indigenous plants.
- Ignore erosion or alien regrowth.

7.3 Revegetation

The natural seedbank will have the opportunity to regenerate in place where it has not been destroyed by hot fires, soil disturbance or extended cover with alien trees. Regeneration of indigenous, natural vegetation must be monitoring along watercourses and within riparian buffer zones. This monitoring should also identify when alien follow-up control must be conducted to support the regrowth of indigenous plants.

Should the natural vegetation fail to regenerate and provide adequate soil cover along watercourses, this will render the riparian area susceptible to erosion. Dense vegetation cover is the best method of erosion control, and these areas will need to be actively revegetated.

Important criteria for the selection of suitable plant species include the following points (Day *et al*., 2016):

- Locally indigenous species.
- Species suitable for the rehabilitation objectives.
- Species for which the availability, costs and maintenance requirements are in keeping with realistic costs and other project parameters.

The vegetation type at the site is mapped as Langkloof Shale Renosterveld, and recommended species for planting have been made according to observations on site as well as the vegetation type (Table 15). Not all of the listed species need to be planted, the list provides a range of species that could be available at wholesale nurseries at a reasonable cost and are suitable for use at the site. Any combination of the listed trees, shrubs and grasses should be used, but the greater the diversity the better.

Primary stabilisation of unvegetated slopes (including the dam wall) can be accomplished using a suitable indigenous grass seed mix that includes *Cynodon dactylon* and *Eragrostis curvula.*

Table 15. Suitable indigenous plants for revegetation of riparian buffer zones

	Scientific name	Common name	Source
Small Trees	*Halleria lucida*	Tree fuschia	Wholesale nurseries
	Osteospermum	Bietou	Wholesale nurseries

	moniliferum		
	Searsia undulata	Kuni-bush	Wholesale nurseries
Shrub	*Helichrysum petiolare*	Kooigoed	Cuttings / nurseries
	Helichrysum anomalum		Wholesale nurseries
	Helichrysum teretifolium	Dune scrub everlastimg	Wholesale nurseries
	Cliffortia graminea		Wholesale nurseries
Grass	*Themeda triandra*	Red grass	Seed from wholesale nurseries
	Cynodon dactylon	Bermuda grass	Seed from nurseries, widely available
	Eragrostis curvula	Weeping love grass	Seed available from seed distributers
Ground cover	*Carpobrotus mellei*	Sour fig	Grow from cuttings / nurseries

7.4 Soil erosion

Most of the watercourse areas downstream of the Bosse Dam have a very low gradient and are thus unlikely to become erosion hotspots. However, the dam wall, areas around the dam, and the spillway could become eroded. These areas must be monitored following rainfall events, and erosion must be controlled to prevent the formation of large dongas and excessive soil loss.

Where slopes are being revegetated a product such as KayTech's Soil Saver which is biodegradable hessian matting can be used. The product should be laid and pegged over seeded and mulched areas to protect slopes from erosion while still allowing seeds to germinate (Figure 12).

7.5 Spillway rehabilitation

It has been recommended that the dam's spillway have a more formal return channel to the watercourse downstream. This need not be a complex engineering structure provided it follows a gentle gradient and acts to disperse flow into the wetland below, instead of channelling it. An example of a combination of a grass and rock-based swale is included in Figure 14. In this example the grass cover would be left to grow, obscuring the rocks. The rocks are only in steeper sections, while grass only can be used in low gradient areas. The return channel should be broad with a low gradient. Where it joins the wetland area below it should spread water as opposed to channelling flow which could result in erosion or channel incision.

Figure 14. Example of a simple spillway, grassed on low gradient and protected with natural rock in earth on steeper slope. Vegetation has been mowed, but leaving vegetation like grass to grow between stones will provide additional protection.

8. CONCLUSIONS

Activities to manage and maintain watercourses following wild fires at Lower Schoonberg Farm resulted in aspects of degradation of two watercourses due to the methods of vegetation removal and subsequent infilling that has occurred. However, the removal of alien vegetation provides the opportunity to rehabilitate watercourses at the site. Identification of the watercourse path and accurate classification of hydrogeomorphic units was compromised due to the channel and vegetation being obscured by earth-moving and vegetation removal. However, one year on from the original assessment (April 2021) aerial photography indicates a clearer delineation of the wetland areas and this was updated.

Watercourses at the site were classified as valley bottom wetlands with a Present Ecological State of E, Seriously Modified. In order to mitigate the impacts of clearing, and rehabilitate both streams to a PES of D, the best approximation of each watercourse was mapped and buffered. The Suikerboslaagte Stream and Bosse Dam have a buffer of 15 m (total) and the Brak Stream has a buffer of 20 m (total). Mitigation measures must be fully implemented in buffer zones in order to maintain the ‘Low’ risk determined by the Section 21 c) and i) Risk Assessment Matrix. Future efforts to control alien vegetation on Schoonberg Farm must follow recommendations given in this report, and be cognisant of the presence of watercourses which could have riparian zones or wetland areas which require protection.

Although the Risk Assessment Matrix was included in this report, it was determined as the process continued that Bosse Dam had been unlawfully enlarged, and therefore a WUL would automatically be required for the additional Section 21b storage.

9. REFERENCES

Brownlie, S. (2005). Guideline for involving biodiversity specialists in EIA processes: Edition 1. CSIR Report No ENV-S-C 2005 053 C. Republic of South Africa, Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town.

Day, L., King, H. and Rountree, M. (2016). The development of a comprehensive manual for river rehabilitation in South Africa. Water Research Commission Report TT 646/15.

DWS (Department of Water and Sanitation) (2014) A desktop assessment of the present ecological state and ecological sensitivity per sub-quaternary reaches for secondary catchments in South Africa. RQIS-RDM:
http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx accessed on 10 November 2018.

DWS (Department of Water and Sanitation) (2018) Determination of Water Resources Classes and Resource Quality Objectives in the Breede-Gouritz WMA. Report No. RDM/WMA8/00/CON/CLA/0717.

Garrow, C. and Marr, S. (2012). Swimming on the Edge of Extinction. The perilous state of the indigenous freshwater fishes of the Western Cape. Valmac, Port Elizabeth.

Kleynhans, C.J. (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). *Journal of Aquatic Ecosystem Health* 5: 41-54

Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Peterson, C., Hill, L., Roux, D.J., Nienaber, S., van Deventer, H., Swartz, E. and Smith-Adao, L.B. (2011) *Atlas of freshwater ecosystem priority areas in South Africa: Maps to support sustainable development of water resources*. Water Research Commission Report No. TT 500/11.

Sanchez-Bayo, F. and Wyckhuys, K.A.G. (2019) Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation, 232: 8-27.

Van Niekerk, L., Taljaard, S., Adams, J.B., Fundisi, D., Huizinga, P., Lamberth, S.J., Mallory, S., Snow, G.C., Turpie, J.K., Whitfield, A.K. and Wooldridge, T.H. (2015) Desktop Provisional Ecoclassification of the Temperate Estuaries of South Africa. Water Research Commission Report No. 2187/1/15.

10. APPENDIX 1: RISK ASSESSMENT MATRIX METHODS

The risk assessment matrix (Based on DWS 2016 publication: Section 21 c) and i) water use Risk Assessment Protocol) was implemented to assess risks for each activity associated with the construction and operational phase.

The first stage of the risk assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are as follows:

- An activity is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that is possessed by an organisation.
- An aspect is an 'element of an organizations activities, products and services which can interact with the environment'. The interaction of an aspect with the environment may result in an impact.
- Environmental impacts are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity.
- Resources are components of the biophysical environment and include the flow regime, water quality, habitat and biota of the affected watercourse.
- Severity refers to the degree of change to the status of each of the receptors (Table 16). An overall severity score is calculated as the average of all scores receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- Spatial extent refers to the geographical scale of the impact (Table 17).
- Duration refers to the length of time over which the stressor will cause a change in the resource or receptor (Table 18)
- Frequency of activity refers to how often the proposed activity will take place (Table 19
- Frequency of impact refers to the frequency with which a stressor (aspect) will impact on the resource (Table 20).

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria (refer to the table below). The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity, impact, legal issues and the detection of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 20. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary.

In accordance with the method stipulated in the risk assessment key, all impacts for flow regime, water quality, habitat and biota were scored as a 5 (i.e. average Severity score of 5) as all activities occurred within the delineated boundary of the wetland.

Table 16: Scores used to rate the impact of the aspect on resource quality (flow regime, water quality, geomorphology, biota and habitat)

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland.	

Table 17: Scores used to rate the spatial scale that the aspect is impacting on.

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

Table 18: Scores used to rate the duration of the aspects impact on resource quality

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5

Table 19: Scores used to rate the frequency of the activity

Annually or less	1
Bi-annually	2
Monthly	3
Weekly	4
Daily	5

Table 20: Scores used to rate the frequency of the activity’s impact on resource quality

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

Table 21: Scores used to rate the extent to which the activity is governed by legislation

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5

Table 22: Scores used to rate the ability to identify and react to impacts of the activity on resource quality, people and property.

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Table 23: Rating classes

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

Table 24: Calculations used to determine the risk of the activity to water resource quality

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence x Likelihood