RIVER REHABILITATION AND MANAGEMENT PLAN FOR THE PROPOSED WAGENBOOM & DARLING IRRIGATION BOARDS: WATER DISTRIBUTION SCHEME AND PIPELINE, CERES, WESTERN CAPE PROVINCE

Prepared for

EnviroAfrica cc

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GLOSSARY OF TERMS

Alien vegetation/ plant species	Plants that do not occur naturally within the area but have been introduced either intentionally or unintentionally.
Endangered	Organisms in danger of extinction if causal factors continue to operate.
Endemic species	Species that are only found within a pre-defined area. There can therefore be sub-continental (e.g. southern Africa), national (South Africa), provincial, regional or even within a particular mountain range.
Biodiversity	The number and variety of living organisms on earth, the millions of plants, animals and micro-organisms, the genes they contain, the evolutionary history and potential they encompass and the ecosystems, ecological processes and landscape of which they are integral parts.
Habitat	In relation to a specific species, a place or type of site where such species naturally occurs.
Indigenous Vegetation	Vegetation occurring naturally within a defined area. In relation to a specific area, a species that occurs, or has historically occurred, naturally in a free state in nature within that specific area, but excludes a species introduced in that area as a result of human activity.
Red Data Listed Species	Organisms that fall into the Extinct in the Wild (EW), critically endangered (CR), Endangered (EN), Vulnerable (VU) categories of ecological status.
Species of Conservation Concern	The term SCC in the context of this report refers to all RDL (Red Data) and IUCN (International Union for the Conservation of Nature) listed species as well as protected species of relevance to the project.
Watercourse	as defined by the National Water Act, 1998 (Act 36 of 1998): "A river or spring; A natural channel in which water flows regularly or intermittently; A wetland, lake or dam into which, or from which, water flows; and Any collection of water which the Minister may by notice in the Government Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks."

LIST OF ABBREVIATIONS

DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
ECO	Environmental Control Officer
EM	Environmental Manager
EMPr	Environmental Management Programme
GPS	Global Positioning System
NFEPA	National Freshwater Ecosystem Priority Area
NWA	National Water Act, 1998 (Act 36 of 1998)
PPE	Personal Protective Equipment
RRMP	River Rehabilitation and Management Plan
SAS	Scientific Aquatic Services
TDS	Total Dissolved Solids
VEGRAI	Riparian Vegetation Response Assessment Index
WMA	Water Management Area
WUA	Water Use Athorisation

Table A: Information required for maintenance and management activities for a single/ multiple owner(s) along a watercourse.

MMP Requirements	Section in Report
Provide a map (at an appropriate scale) of the watercourse or stretch of watercourse being applied for within the stretch where maintenance activities will take place being clearly defined – consideration must be made to mapped features relating to Critical Biodiversity Areas (CBAs) and National Freshwater Ecosystem Priority Areas (NFEPAs).	Section 3 Refer to Watsan Africa (2018) report
GPS coordinates must be provided for all site(s) at which maintenance activities will take place and included on the map which defines the stretch of watercourse. Coordinates must be provided in degrees, minutes and seconds using the Hartebeesthoek94 WGS84 co-ordinate system**.** Where numerous properties/sites are involved (e.g. linear activities), you may attach a list of property descriptions and co-ordinates to this form.	Section 2
Specialist assessment to be undertaken to determine (NOTE: information relating to the specifications and Terms of Reference used for the appointment of all specialist inputs must be provided).	Section 1.2 Refer to Watsan Africa (2018) report
Hydrological (incl. flood hydrological data etc.) and geomorphological assessment of watercourse functioning.	
The relevant Present Ecological Status (PES) of the stretch of watercourse in question, if not available an assessment is to be done to determine PES in accordance with the Department of Water and Sanitation (DWS) guidelines.	
What is the reason/cause for the maintenance activities based on an ecological and hydrological assessment of the watercourse within the context of the larger catchment.	Section 2 and Section 4
What are the drivers of system functioning within the watercourse and what is the ecological objective – based on historical condition and PES.	Section 3 Refer to Watsan Africa (2018) report
What is the management objective given the ecological status of the watercourse based on historical and PES data; as set out in agreement with the person(s) responsible for undertaking the maintenance activities.	
What is the impact on the watercourse/river system (resource quality characteristics: flow regime, geomorphology, water quality, habitat and biota) for a minimum of 500m both up and downstream of the proposed maintenance activities, with the mitigation measures included;	
An appropriate assessment for risk for each of the proposed types of maintenance activities and linked management actions in terms of the risk matrix for General Authorisations (GA) of Section 21 (c) and (i) by the DWS (GN 509 of 2016) or where applicable.	Section 4
Mapped biodiversity features such as Critical Biodiversity Area, Ecological Support Area, National Freshwater Ecosystem Priority Area (NFEPA), and the National list of Ecosystems that are threatened and in need of protection (2011) gazetted in terms of Section 52 of the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEMBA), the Western Cape Biodiversity Spatial Plan 2017, as well as relevant provincial specific plans and classifications etc. Please consult the website www.bgis.sanbi.org.za to determine mapped features.	Refer to Watsan Africa (2018) report
Include a description of existing or previous protection measures or reinforcements (eg. gabions or groynes etc.) and infrastructure. Describe any evidence of erosion and/or siltation at the various sites and outlining possible causal factors and maintenance practices.	Section 2 and 3
Provide historical maps and data (images/flow/water quality/land use) of the river channel (if available) in order to assess the natural to changing flow patterns of the watercourse to determine cause of maintenance and possible impact of the maintenance activities, to inform mitigation measures.	Refer to Watsan Africa (2018) report
Provide a photographic record for the condition of the riparian habitat around maintenance sites, with the presence of important and/or sensitive habitat/species noted.	Refer to Watsan Africa (2018) report
For sites prone to flood damage, a description regarding the history and effect of past floods and include dates of most recent events must be provided. This must inform the process to understand what actions are required along the stretch of the watercourse to reduce such impacts to the resource quality characteristics.	Refer to Watsan Africa (2018) report
Explain the risks associated with the no-go option for the MMP i.e. the risk of not undertaking the maintenance activities as stated in the MMP.	Supreme Court Ruling. No-go Alternative not considered

1 INTRODUCTION

Scientific Aquatic Services (SAS) was appointed to compile a River Rehabilitation and Management Plan (RRMP) to provide technical specialist input for the Environmental Authoristion and Water Use Authorisation (WUA) processes for the proposed diversion structure and 2.7 km pipeline within the Wabooms Rivier near Ceres, Western Cape Province, hereafter referred to as the “proposed water scheme”.

This RRMP was compiled to provide mitigation measures to manage the current, perceived and potential impacts on the Wabooms River associated with the construction and rehabilitation of the proposed water scheme and to protect the river from further degradation. This report does not, however, consider long term management and monitoring of the Ecological Water Requirements (EWR) and monitoring of the aquatic health of the Wabooms River. A seperate Aquatic Monitoring Plan will need to be compiled and implemented post construction of the water scheme.

This RRMP follows a system that seeks to achieve a required end state and describes how activities that have, or could have a negative impact on the river will be controlled and monitored and also identifies the responsible parties and relevant timeframes (where applicable) which will be tasked with implementing these measures. The key aims of the RRMP include:

- Maintenance of the present state of the freshwater ecology associated with the Wabooms River, impacted by the proposed activitiesd (refer to Section 2 below);
- Prevention of further degradation of the receiving environment; and
- Prudent monitoring to ensure timeous detection of, and response to damage as a result of rehabilitation and operational activities associated with the proposed water scheme.

This RMMP advocates the use of several environmental management tools and mitigatory measures that are appropriate for the specific proposed water scheme and fits into the overall planning process of the rehabilitation, management and operational phases of the proposed water scheme and should be implemented by the proponent as soon as it has been approved by all the relevant authorities.

1.1 Structure of this report

This report investigates the need for rehabilitation and maintenance activities for the proposed water distribution scheme. The report has been structured in the following way:

Chapter 1: Introduction
Provides an introduction, the structure of this report, the assumptions and limitations, as well as the relevant legislation.

Chapter 2: Project Description
Provides the location of the proposed water scheme as well as a brief summary of the proposed activities.

Chapter 3: Receiving Freshwater Environment
This section includes a summary of the desktop and site assessment findings undertaken by Watsan Africa (2018).

Chapter 4: Legal Framework
This section provides a breakdown of the legal framework relevant to the proposed water scheme as well as the compilation of this RMMP.

Chapter 5: Impact Assessment Outcomes
This section gives a summary of the impact assessment outcomes (both as part of the National Environmental Management Act, 1998 (Act No. 107 of 1998) and the National Water Act, 1998 (Act No. 36 of 1998) as per the Department of Water and Sanitation's Risk Assessment Matrix.

Chapter 6: River Rehabilitation and Management Plan
This section comprises of site specific details pertaining to the construction mitigation and rehabilitation measures that must be implemented. A list of the roles and responsibilities of all individuals involved in the implementation of this RMMP is provided.

Chapter 7: Monitoring Plan
This section provides the required monitoring actions during construction, rehabilitation and post-construction of the proposed water scheme. Long-term montoring of the EWR and aquatic health is not included in the scope of this RMMP.

Chapter 8: Conclusion
This section summarises the key findings and recommendations based on the recommended rehabilitation and management actions listed and the overall requirements in order to ensure the best possible reinstatement and rehabilitation of the watercourses affected by the proposed water scheme.

1.2 River Rehabilitation and Management Plan Framework

1.2.1 Principles of the River Rehabilitation and Management Plan

To assist in achieving the objectives of the RRMP, a set of principles were applied which contributed to formulating action plans and specific management measures.

Loss of biodiversity puts aspects of the economy, wel-lbeing and quality of life at risk, and reduces socio-economic options for future generations. This is of particular concern for the poor in rural areas who have limited assets and are more dependent on common property resources for their livelihoods. The importance of maintaining biodiversity and intact ecosystems for ensuring the on-going provision of ecosystem services, and the consequences of ecosystem change for human well-being, were detailed in a global assessment entitled the Millennium Ecosystem Assessment (MEA, 2005), which established a scientific basis for the need for action to enhance management and conservation of biodiversity.

Sustainable development is enshrined in South Africa's Constitution and laws. The need to sustain biodiversity is directly or indirectly referred to in a number of Acts, not least the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) and is fundamental to the notion of sustainable development. In addition, international guidelines and commitments, as well as national policies and strategies are important in creating a shared vision for sustainable development in South Africa.

Impacts on biodiversity can largely take place in four ways:

- **Direct impacts:** are impacts directly related to the water scheme including project aspects such as site clearing and diversion/abstraction of water.

- **Indirect impacts:** are impacts associated with the water scheme that may occur within the zone of influence associated with the water scheme, such as the surrounding terrestrial areas and downstream areas on the watercourse.
- **Induced impacts:** impacts that directly attributable to the project but are expected to occur due to the activities of the project. Factors included here are urban sprawl and the development of associated industries.
- **Cumulative impacts:** can be defined as the sum of the impact of a project as well as the impacts from past, existing and reasonably foreseeable future projects that would affect the same biodiversity resources. Examples include numerous industrial developments within the same drainage catchment.

Given the limited resources available for biodiversity management and conservation, as well as the need for development, efforts to conserve biodiversity need to be strategic, focused and supportive of sustainable development. This is a fundamental principle underpinning South Africa's approach to the management and conservation of its biodiversity and has resulted in the identification of spatial biodiversity priorities or biodiversity priority areas.

'Mitigation' is a broad term that covers all components of the 'mitigation hierarchy' defined hereunder. It involves selecting and implementing measures – amongst others – to conserve biodiversity and to protect the users of biodiversity and other affected stakeholders from potentially adverse impacts as a result of anthropogenic activities. The aim is to prevent adverse impacts from occurring or, where this is unavoidable, to limit their significance to an acceptable level.

The mitigation hierarchy, as advocated by DEA *et al.* (2013) in general consists of the following in order of which impacts should be mitigated:

1. **Avoid/prevent impact:** can be done through utilising alternative sites, technology and scale of projects to prevent impacts. In some cases, if impacts are expected to be too high, the "no project" option should also be considered, especially where it is expected that recommended mitigations measures will not be adequate to limit environmental damage and eco-service provision to suitable levels;
2. **Minimise impact:** can be done through the utilisation of alternatives that will ensure that impacts on biodiversity and ecosystem services provision are reduced. Impact minimisation is considered an essential part of any development project;
3. **Rehabilitate impact:** is applicable to areas where impact avoidance and minimisation are unavoidable. As such, impacted areas must be returned to conditions which are ecologically similar to the pre-project condition or an agreed post project land use, for example arable land. Rehabilitation cannot, however, be considered as the primary mitigation toll as even with significant resources and effort of rehabilitation usually does not lead to adequate replication of the diversity and complexity of the natural system. Rehabilitation often only restores ecological function to some degree to avoid ongoing negative impacts and to minimise aesthetic damage to the setting of a project. Practical rehabilitation should consist of the following phases in best practice:
    a. **Structural rehabilitation** which includes physical rehabilitation of areas by means of earthworks, potential stabilisation of areas as well as any other activities required to develop a long term sustainable ecological structure;
    b. **Functional rehabilitation** which focuses on ensuring that the ecological functionality of the ecological resources associated with the project and its footprint supports the intended land uses. In this regard, special mention is made of the need to ensure the continued functioning and integrity of the watercourses throughout and after the rehabilitation phase.
    c. Biodiversity reinstatement which focuses on ensuring that a reasonable level of biodiversity is re-instated to a level that supports the local land uses. In this regard special

mention is made of re-instating vegetation to levels which will allow the natural climax vegetation community or community suitable for supporting the intended land use.

d. Species reinstatement which focuses on the re-introduction of any ecologically important species which may be important for socio-cultural reasons, ecosystem functioning reasons and for conservation reasons. Species reinstatement need only occur if deemed necessary.

4. **Offset impact:** The significance of residual impacts should be identified on a regional as well as national scale when considering biodiversity conservation initiatives. If the residual impacts lead to irreversible loss of irreplaceable biodiversity, the residual impacts should be considered to be of a *very high significance* and offset initiatives are not considered an appropriate way to deal with the magnitude and/or significance of the biodiversity loss. In the case of residual impacts determined to have *medium to high significance*, an offset initiative may be investigated. If the residual biodiversity impacts are considered of low significance no biodiversity offset is required.

A summary of how the above relates specifically to the proposed water diversion scheme in terms of measures which must be applied in order to ensure the minimisation of negative impacts and maximisation of positive impacts as a result of the water scheme is provided below:

- **Avoiding impacts** by not performing environmentally detrimental actions;
- **Minimising impacts** by limiting aspects of an action, optimising processes, structural elements and other design features; and
- **Rectifying impacts** through rehabilitation, restoration, etc. of the affected environment.

1.2.2 Objectives of the River Rehabilitation and Management Plan

The objectives of the RRMP are to:

- Meet the requirements of relevant local and regional authorities;
- Identify a range of mitigation measures which could reduce and mitigate the potential impacts on the receiving environment to minimal or acceptable levels;
- Manage activities in order to maintain and/ or improve ecological integrity of the water scheme;
- Maximise the service provision of the Wabooms River;
- To re-introduce indigenous floral species;
- To provide improved and more suitable habitat for faunal species;
- Maximise the ecological functioning of the Wabooms River;
- Detail specific actions deemed necessary to assist in mitigating the potential environmental impact on watercourse area;
- Ensure as far as is practicable that the measures contained in the report are implemented; and
- Propose mechanisms for monitoring compliance with the RRMP and reporting thereon.

2 PROJECT DESCRIPTION

The study area is located within the Breede-Gouritz Catchment Management Agency's (BGCMA) jurisdiction within the Western Cape Province, approximately 23km north west of Worcester and approximately 6,5km east of the R301 and R43 intersection (as the crow flies). The water scheme is located within and alongisde the Wabooms River, which has extensive agricultural lands surrounding the river and a limited natural ecological buffer (Figure 1 and 2).

The project involves the construction of a new distribution structure and pipeline, according to and in line with a Supreme Court Ruling (dated 22 February 2017), to distribute listed water for the Darling

brug and Wagenboom Irrigation Boards. This Supreme Court Ruling was made in response to illegal water abstractions occurring between the proposed new weir location (Geographical co-ordinates 33°29'55.06"S 19°16'48.07"E) and the existing weir (Geographical co-ordinates 33°30'35.87"S 19°15'23.71"E) within the Wabooms River, resulting in the irrigation boards receiving significantly less water than their lawful abstraction rights allow for. As such, it was ordered in the court ruling that water would be abstracted further upstream from the existing weir and piped down to the existing weir, before it is split between the two irrigation boards.

Consultation with Ms Elkerine Rossouw (Water Use Specialist) from the BGCMA and Ms Lizbe Bester from Sarel Bester Engineers was undertaken on 20th March 2019 along with the Environmental Assessment Practitioner (EAP) (EnviroAfrica cc) in order to obtain further clarity on the proposed diversion system,. the BGCMA requirements and the requirements of this RMMP.

The following sections provide a detailed breakdown of the proposed plans for the water scheme:

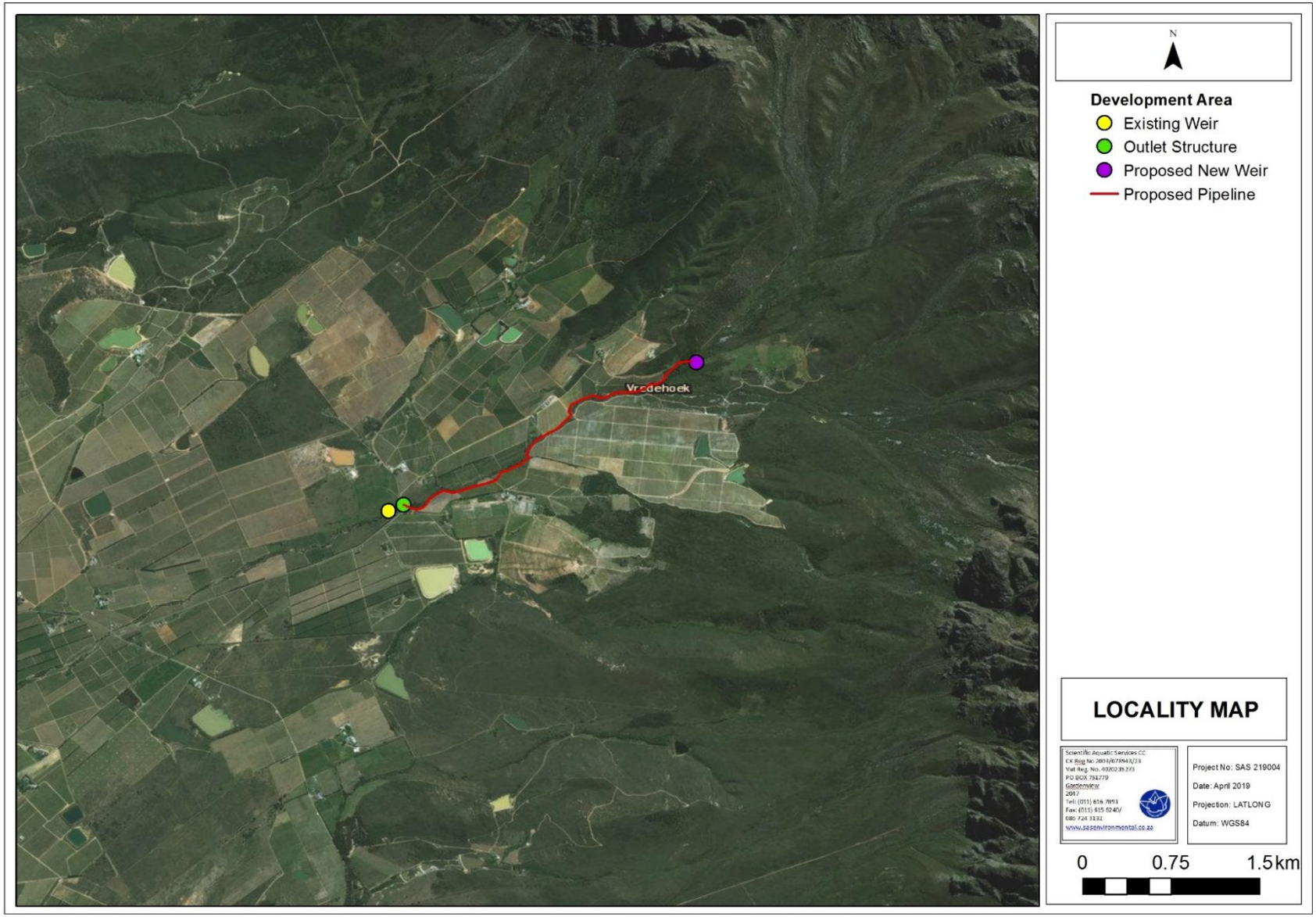


Figure 1: Locality map of the water scheme in relation to the surrounding areas presented on a digital satellite image.

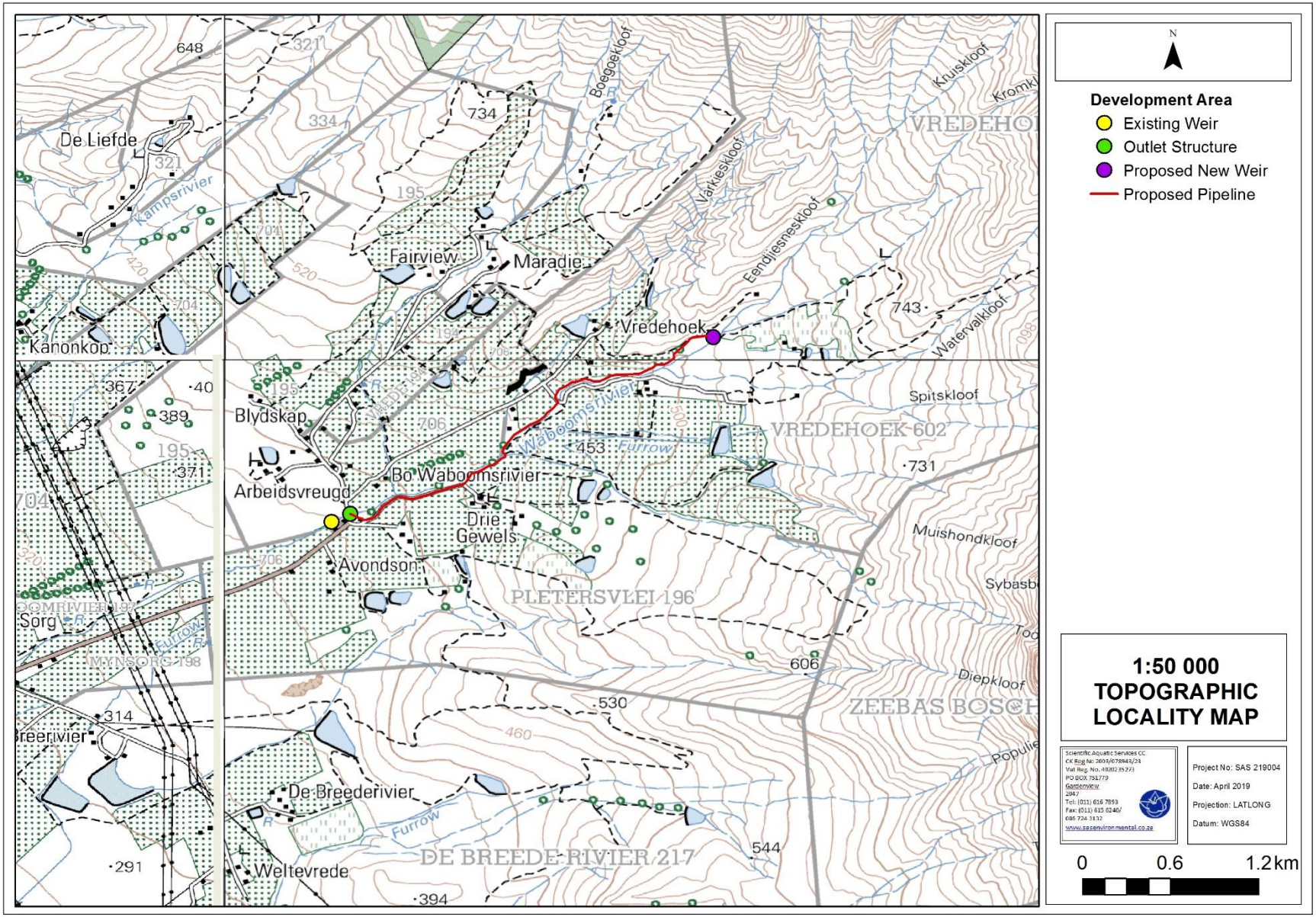


Figure 2: Topographical map of the water scheme in relation to the surrounding areas presented on a digital satellite image.

2.1 Existing Weir and Diversion Chamber

An existing diversion chamber is located in the Wabooms River (Geographical co-ordinates 33°30'35.87"S 19°15'23.71"E) which is utilised by the Darling Brug and Wagenboom Irrigation Boards. This diversion weir was historically created and comprises a concrete slab within the river which splits all water entering the system, with 50% being directed downstream where the Darling Brug abstraction pipe is located, and 50% is diverted to a diversion chamber for the Wagenboom Irrigation board (Figure 3).

Figure 3: (Top left) existing diversion weir within the Wabooms River; (top right) downstream of the weir a pool has formed, water is abstracted from this pool for the Darling Brug Irrigation board; (bottom) diversion of water to a diversion chamber for the Wagenboom Irrigation Board.

The Wabooms River is a perennial system, however, large water fluctuations are noted within the summer and winter months. During the rainy season, the Wabooms River is known to overtop its banks, with extensive erosion of the embankments and tree root exposure noted within the system. All excess winter flow water will flow over the existing concrete weir largely inimpeded. During the summer, low flow season all water is diverted, however, due to the age of the concrete weir, incision upstream and downstream of the weir was noted (see Figure 4: Top right) and therefore a certain volume of water will flow underneath the concrete slab developed as part of the diversion weir. Similarly, the active channel comprises large cobbles, boulders and sandy soils. As such, a substantial volume of water is anticipated to flow under the concrete slab of the weir.

2.2 New Weir and Diversion Chamber

According to the Supreme Court Ruling, the water within the Wabooms River will be split according to an 80/20 ratio within a proposed new division chamber, some 2.6 km upstream of the existing weir. The active channel of the river at the proposed weir location is approximately 5m wide and dominated by large cobbles creating riffles and pools. A single track culvert bridge has been historically created below the proposed weir location which is utilised by the local farmers to access properties on either side of the river.

Figure 4: Proposed location of the new diversion weir. An existing bridge crossing is noted within the upper reaches of the Wabooms River.

The proposed diversion weir and chamber will comprise the following:

a) A new weir within the upper reach of the Wabooms River will be created, including a concrete slab and apron to catch all water within the Wabooms River during the low flow season. This weir will be designed to allow water to overtop the weir during high flows;
b) A diversion chamber into which all water abstracted via the weir will divert the water according to the following:
    a. 17.51% of the Mean Annual Run-off (MAR), to ensure the Category D ecological state, will be diverted back to the Wabooms River for the Ecological Water Requirements (EWR) of the Wabooms River reserve, as determined by Sarel Bester Engineers in consultation with Watsan Africa *et al* (2018);
    b. Of the remaining 82,5% (hereafter referred to as the “remaining water”), a 80/20 ratio will be implemented. Eighty percent (80%) of the remaining water will be abstracted via the new proposed 350mm pipeline (as per detail provided in Section 2.3 below) and 20% will be abstracted via the existing piped Vredehoek system to other lawful users (Arbiedsvruegd Trust and Vredehoek Trust).
c) The EWR water will be diverted back to the Wabooms River via a pipe and released slightly downstream of the existing bridge crossing.

Figure 5 below provides a three dimensional rendition of the proposed weir and water diversion chamber.

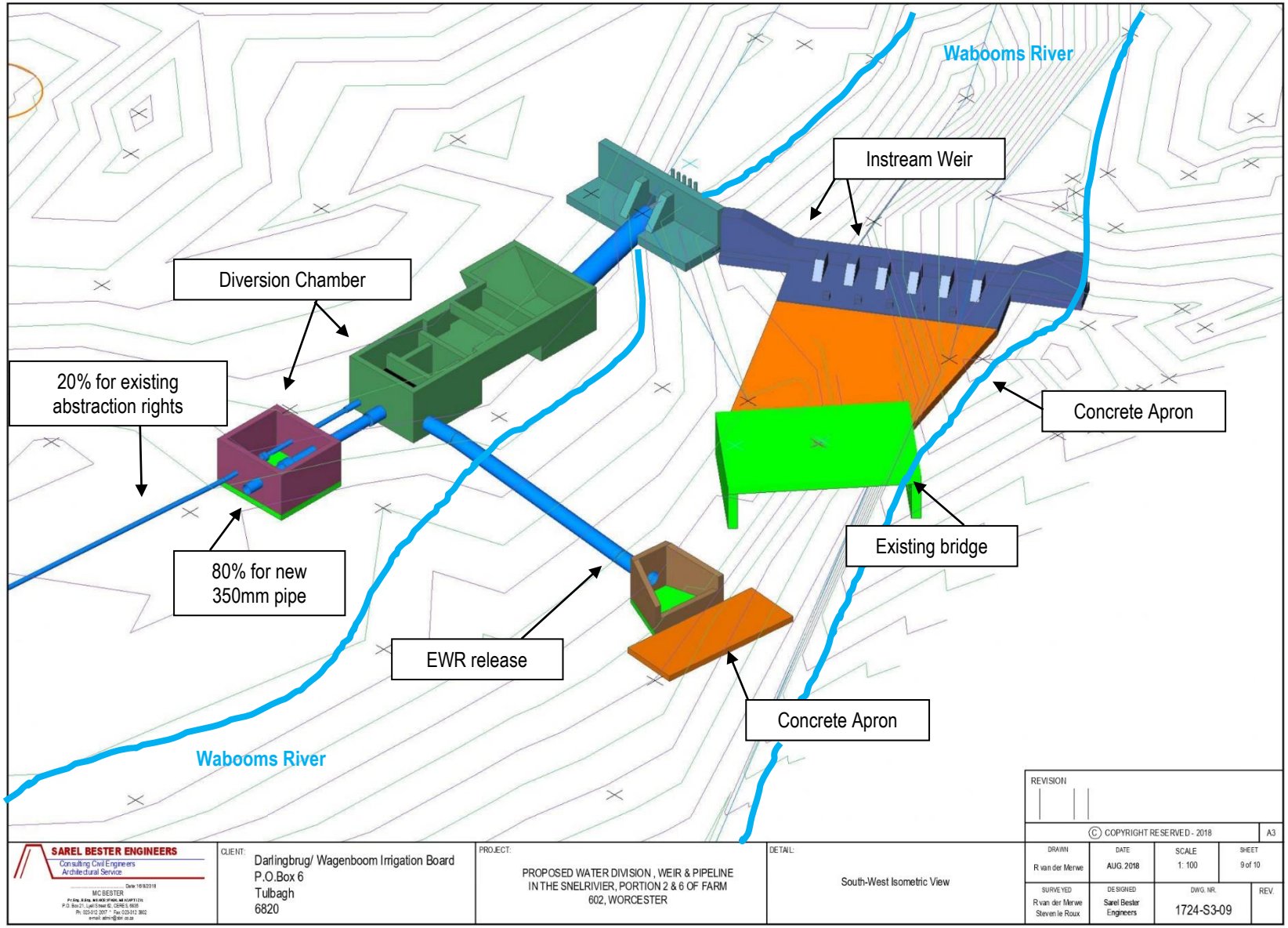


Figure 5: 3-D isometric view of the proposed water diversion, weir and pipeline as provided by Sarel Bester Engineers (2018).

2.3 New 350mm pipeline

As stipulated in Section 2.2 above, eighty percent (80%) of the remaining water will be distributed within a new pipeline (350mm diameter) approximately 2.7km in length, along the northern and southern embankments of the Wabooms River. The bulk of this pipeline will be trenched within the existing farm roads alongside the riparian edge of the Wabooms River. One pipeline crossing is proposed (Geogrphical co-ordinates 33°30'19.79S 19°16'1.51E and 33°30'20.85"S 19°16'1.88"E) over the Wabooms River, where a pipe bridge will be developed. Due to the cobble bed noted within the river and its embankments, directionally drilling the pipeline below the river is not a feasible option. The proposed conceptual plan for the pipe bridge is represented in Figure 6 below.

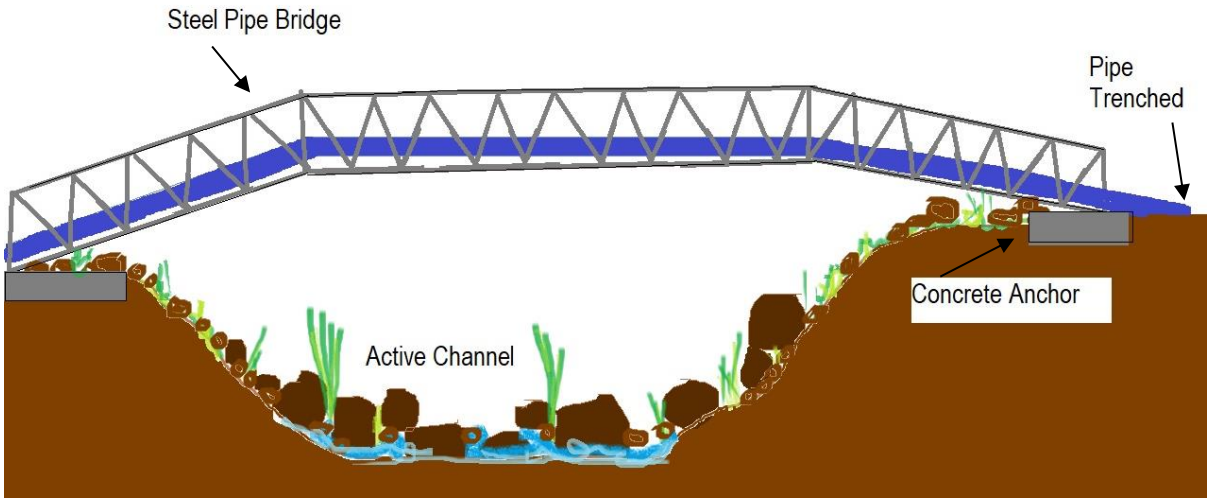


Figure 6: Conceptual diagram showing a steel pipe bridge spanning the active channel of the river, anchored on either embankment. The proposed pipeline is initiated in dark blue and will be trenched leading up to and following from the pipe bridge.

The water will then be released from the 350mm diameter pipeline above the existing road bridge crossing (Geographical co-ordinates 33°30'34.07"S 19°15'27.82"E) back into the Wabooms River, approximately 120m upstream of the existing weir (as described in from where it will distributed to Darling Brug and Wagenboom Irrigation Boards.

3 RECEIVING ENVIRONMENT

The following information on the ecological characteristics of the water scheme are taken from a report entitled: “Proposed Water offtake weir on Portion 2 of the Farm Snelrivier 602, Worcester: Preliminary Techncial Report V1.2. Water Use Licence Application: a reguirement of Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (Watsan Africa *et al.* 2018), which also provides further information if required.

The Wabooms River’s upper catchment falls within the Matroosberg Mountain Catchment. The Wabooms River is approximately 11km in length, confluencing to the south west with the Breede River. The Mean Annual Run-off (MAR) for the catchment is approximated to be 8.362 million m^3, with most of this water flowing through the system during the rainy winter months (May – September). The following provides applicable important background information:

- The proposed water scheme falls within quaternary catchment H10F;
- The proposed water scheme falls within the Breede Management Area (WMA) and the sub-Water Management Area (sub-WMA) is the Upper Breede subWMA;
- According to the DWS (2012) database, the PES of the Waboomsriver is a Category D (Largely modified); and
- The Wabooms River is considered of Low Ecological Importance (EI) and has a moderate Ecological Sensitivty (ES).

A summary of the results of the freshwater resource assessment (Watsan Africa, 2018) of the Wabooms River is provided in **Table 1**.

Table 1: Summary of the results of the freshwater resource assessment of the Wabooms River associated with the water scheme.

PES	SASS Scoring	EIS	Ecoservices
Upper reach: Instream – Near Pristine Ripairan – Largely Modified Lower reach: Instream -D Largely modified Ripairan – Largely Modified	Upper reach: Score – 100 No. of taxa – 14 ASPT – 7.1 Lower reach: Score – 40 No. of taxa – 7 ASPT – 5.7	Low/marginal Indigenous Fish species potentially present: *Sandelia capensis* *Galaxias zebratus* *Pseudobarbus burchelli*	High Most of the ecoservices provided are considered High.

In terms of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et. al*, 2013), the Wabooms River is classified as an inland systems (i.e. systems having no existing connection to the ocean, but which are inundated or saturated with water, either permanently or periodically), located within the Western Folded Mountains Ecoregion. The applicable wetland vegetation (WetVeg) groups are the Southwest Alluvium Fynbos and Southwest and Shale Fynbos. The characterisation of the Wabooms River is summarised in **Table 2**.

Table 2: Characterisation of the freshwater resources identified within the study area.

Watercourse	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) type
Wabooms River	**Valley floor:** The base of a valley, situated between two distinct valley side-slopes**.**	**River:** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.

Visual representation of the Wabooms River in relation to the proposed water scheme is provided in Figure 7 below. It must be noted that the delineation as provided in the figure below was undertaken using desktop methods as undertaking a field delineaton was not part of the scope of this project. The above-mentioned delineation is, however, accurate enough to inform the contents of this RMMP.

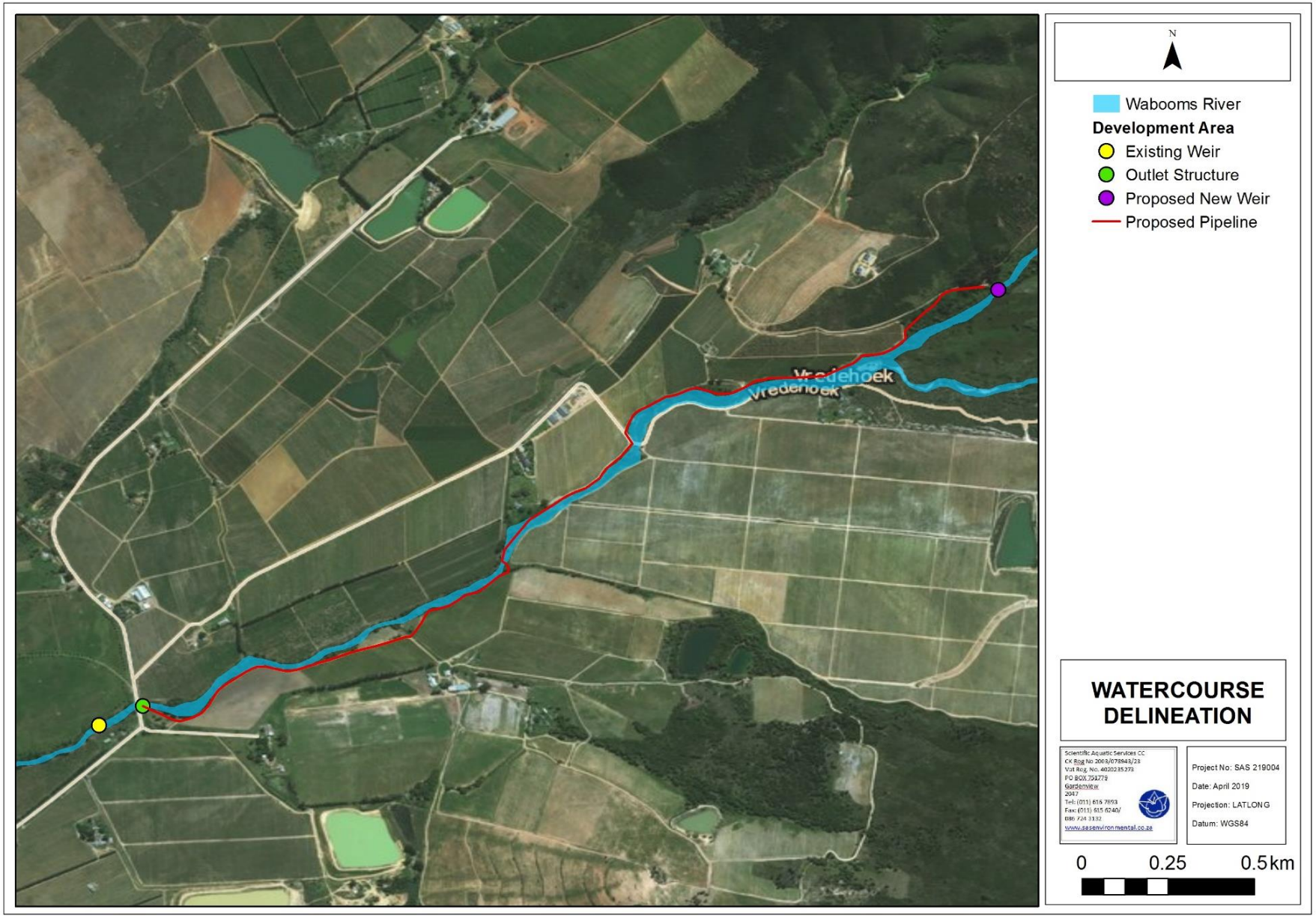


Figure 7: Delineation of the Wabooms River in relation to the proposed water scheme.

4 LEGAL FRAMEWORK FOR THIS RIVER REHABILITATION AND MANAGEMENT PLAN

The following legislative documents were considered and the aspects which are pertinent to watercourse management including the rehabilitation of disturbed areas, were utilized.

- The National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA);
- National Environmental Management: Biodiversity Act, 2014 (Alien and Invasive Species Regulations, 2014);
- The National Water Act, 1998 (Act No. 36 of 1998) (NWA); and
- Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998)

Section 21 of the National Water Act (Act No. 36 of 1998) lists the following activities as water uses:

- Section 21 (c): impeding or diverting the flow of water in a watercourse; and
- Section 21(i): altering the bed, banks, course or characteristics of a watercourse.

It should be noted that the abstraction of water within the Wabooms River by the Darling Brug and Wagenboom Irrigation Boards is considered an existing lawful water use and as such a Water Use Authorisation for Section 21(a) is not required. The rehabilitation process is set to minimize the impacts of the construction of the new weir and diversion chamber as well as the trenching of the new pipeline along the Wabooms River.

These activities trigger a Section 21(c) and (i) water use as it refers to the National Water Act, 1998 (Act No. 36 of 1998) as well as activities 12 and 19 of the Environmental Impact Assessment Regulations Listing Notice 1 of 2014 (as amended) as it relates to the National Environmental Management Act, 1998 (Act No. 107 of 1998). The conditions for Section 21(c) and (i) activities, in terms of Government Notice 509 of 2016 require that a RRMP be developed and must address the following:

1. Identify a RRMP domain, preferably from a whole -catchment perspective;
2. Identify an accountable, representative body that should take unbiased custodianship of the RRMP and drive its implementation;
3. Identify key stakeholders;
4. Divide the river into useful management units;
5. Identify major drivers of river disturbance and instability - human and natural, and their primary and secondary effects;
6. Complete a risk assessment as per the Department of Water and Sanitation (DWS) Risk Assessment Matrix (Section 4) for identified impacts and their mitigation activities;
7. Solicit input from stakeholders on their priorities and objectives;
8. Define best practice measures for rehabilitation and maintenance implementation;
9. Design a plan for ecological monitoring which is specifically linked to the stated objectives; and
10. Develop an implementation programme and review mechanism.

The report should contain supporting technical information used to ensure low risk to resource quality such as:

a) Impact assessment and mitigation report completed by an independent consultant as required by the National Environmental Management Act, 1998 (Act No. 107 of 1998) and the National Water Act, 1998 (Act No. 36 of 1998);
b) All the relevant specialist reports supporting the proposed mitigation measures;

i. Specialists Reports must address the level of modification /risk posed to resource quality ie: flow regime, water quality, geomorphological processes, habitat and biota of the watercourses and contain Present Ecological state (PES) and Ecological Importance and Sensitivity (EIS) data for relevant watercourses.

c) Environmental Management Plan (EMP) giving effect to all actions required to mitigate impacts (What, When, Who, Where and How);
d) Best practices applicable to these activities, where applicable;
e) Generic designs and method statements, where applicable;
f) Norms and standards, where available;
g) Monitoring programme that must include "present day" conditions to be used as base line values;
h) Monitoring, auditing and reporting programme (reports must be send on request to the region or Catchment Management Agency (CMA)); and;
i) Internalized controls and auditing, where applicable.

Please refer to **Appendix B** for additional legislative requirements.

5 IMPACT ASSESSMENT OUTCOMES

During the development of this RRMP, consideration was given to both historical and current impacts, including potential impacts that may result from the planning, construction and operational phases of the proposed water scheme. An impact assessment was undertaken by the Freshwater Ecologist (Watsan Africa, 2018) to identify the potential impacts on the freshwater ecology of the weir, diversion chamber and pipeline. The potential freshwater ecological impacts associated with the planning, construction and operational phase of the proposed water scheme are provided in **Table 3**.

Table 3: Potential mitigated impacts associated with the water scheme (Watsan Afrcia. 2018).

	DEA&DP* Impact Scoring					DWS*
Possible Impact	**Extent**	**Duration**	**Intensity**	**Significance**	**Probability**	**Risk Assemment scoring**
Clearing of the weir site	Local	Medium term	Low	Low	Probable	Moderate
Stockpiling of building material	Local	Short term	Low	Low	Low	Low
Construction of the weir	Local	Short term	Medium	High	Probable	Moderate
Abstraction of water	Regional	Long term	Medium	High	Probable	High
Construction and operation of the pipeline	Regional	Long term	Medium	Medium	Probable	Moderate

DEA&DP = Department of Environmental Affairs and Development Planning significance Impact scoring.
DWS = Department of Water and Sanitation prescribed Risk Assessment scoring.

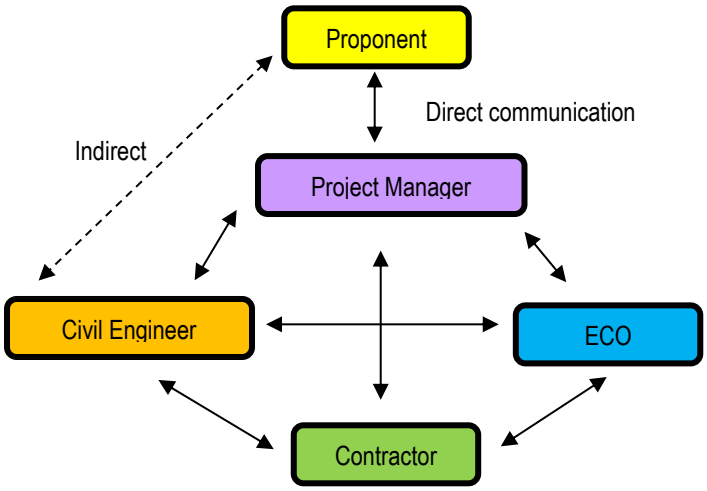
As indicated in Table 3 above, a high significance scoring is associated with the construction of the weir and abstraction of water as well as the moderate risk scorings for the clearing of the weir site, construction of the weir and construction and operation of the pipeline. A site specific rehabilitation and monitoring plan is therefore considered imperative to mitigate and monitor the impacts on the Wabooms River and surrounding area, as far as possible.

6 RIVER REHABILITATION AND MANAGEMENT PLAN

6.1 Roles and Responsibilities

The following table provides a summary of the various parties that are involved with the implementation of this RRMP as well as their responsibilities.

Table 4: Summary of various parties involved with the implementation of this RRMP.



Party	Responsibility
Proponent	• The Proponent will be responsible for the appointment of a suitably qualified independent Environmental Control Officer (ECO) for the construction phase of the project; • A management body (I.e. Project Manager) must be appointed to ensure compliance with the RRMP; • The Proponent will be responsible for ensuring all Contractors receive a copy of this document and understand its contents; • The Proponent is responsible to ensure there is sufficient funding for the required rehabilitation and management actions as set out in this RMMP; and • The Proponent can also be the Project Manager should they not wish to appoint a separate project manager.
Project Manager	• The Project Manager must ensure a clear communication line between all parties working on the project, to ensure all environmental concerns and measures as stipulated within this RMMP are implemented/adhered to; • The Project Manager should have direct communication with the Proponent; • The Project Manager should call a meeting with all responsible parties should there be conflict/ remediation requirements to ensure a suitable solution is found and implemented; • The Project Manager must ensure that there is sufficient funding and resources for an ECO to adequately perform their role and • The lead project manager must ensure that the RRMP is implemented and that suitable penalties are in place for non-conformance to the RRMP by contractors (as indicated by the ECO).
Registered Civil Engineer	• Issue all instructions/ drawings to the Contractor; • Must immediately inform the Project manager and ECO if any changes to the project are envisaged; • Must immediately inform he Project Manager and ECO if any aspects of the RRMP and/or Record of Decision (RoD) for the relevant authorities connot be complied with; and • Must remain in communication with the ECO and the Project Manager to ensure that any design changes required are issued to the Contractor.

Environmental Control Officer (ECO)	• The ECO is the person responsible for the monitoring of the implementation of the RRMP during the implementation of the activities and for reporting on the degree of compliance. The ECO should ideally be appointed at the start of construction activities and be responsible for ensuring that all rehabilitation activities are implemented. The ECO is mandated to do the following: • Ensure that all contractors/ subcontractors/ employees/ construction workers are fully aware of their environmental responsibilities. This should take the form of an initial environmental awareness-training program in which requirements of this document will be explained; • Monitor site activities on a regular basis to ensure that there is minimal environmental impact due to construction activities. A monitoring report should be submitted to the Contractor, the Civil Engineer (should there be any design changes required) and the Project Manager; • Ensure that a 'hotline' exists for reporting incidents and resolving any problems rapidly; • The ECO must regularly audit the operation and establish whether the measures in the RRMP are applied, where after the ECO reports to the lead project manager; • All reports compuiled by the ECO must be submitted to the relevant compliance office within the DWS and the DEA&DP; • The ECO has the authority to stop works if in his/her opinion there is/may be a serious threat to or impact on the environment caused directly by the construction operations; and • Conduct a final environmental audit and a review of management and rehabilitation measures. • Should the appointed ECO not have any freshwater ecological experience, a suitably qualified Freshwater Ecologist should be apointed to assist the ECO as and when needed.
Contractor	• The Contractor/s in this case refers to any contractor/s on site, including the building contractor/s and sub-contractors on any item of infrastructure being erected or demolished; • Such contractor/s will take full responsibility for each of his/her employees and any penalties imposed; • The Contractormust immediately inform the Project Manager and Eco if any changes to the project are envisaged and if any acpects of this RMMP or the RoD cannot be complied with; • All design change instructions must come from the Project Manager and/or Civil Engineers; • It is the responsibility of the Contractor/s to ensure that the measures stipulated within this RRMP are adhered to; and. • Should the Contractor require clarity on any aspect of the RRMP the Contractor must contact the ECO for advice.

6.2 Site Specific Rehabilitation and Management Plan

A detailed site specific RRMP has been developed for the proposed water scheme, as described in Section 2 of this report. Successful rehabilitation depends upon cogent conceptual planning, research and design flexibility. The proposed site-specific mitigation measures for the construction and rehabilitation phases are listed in Tables 5 through 7.

Table 5: General mitigation measures for the Planning, construction, rehabilitation and operational phses that must be applied for the entire length of the water scheme.

General – applicable to all activities associated with the water scheme					
Timeframes / Project Phase	**Planning and Construction Phase**		**Rehabilitation**	**Post Rehabilitation**	
Parties Responsible:	**Proponent**	**Project Manager**	**Civil Engineer**	**ECO**	**Contractor**

Pollutant and Waste Management

- No discharge of effluents or polluted water is permitted into or surrounding the Wabooms River or its associated 1 in 100 year floodline;
- If soil contamination occurs surrounding the Wabooms River or within its associated 1 in 100 year floodline (due to a spill), the soil should be removed from the site and disposed of appropriately.

Construction Equipment

- Dedicated parking area for construction vehicles must be located away (approximately 32m, outside of the NEMA zone of regulation) from the delineated Wabooms River, and its associated riparian habitat and drip trays must be located beneath any parked and leaking equipment along with lubricant/fuel absorbing media (moss/peat type products) within the drip trays to contain spilled material. This must be undertaken to prevent compaction of the soil and disturbance of the watercourse habitat and flow regime;
- All materials used to construct the instream weir and outlet structures should not generate toxic leachates or lead to significant changes in pH or dissolved salt concentrations. In this regard pH should not change by more than 5% between upstream and downstream areas and the Total Dissolved Solids (TDS) value should not increase by more than 15%; and
- No vehicles may indiscriminately be moved through the Wabooms River. During construction the footprint areas of the water scheme must be kept to a minimum. All vehicles must use one single designated track and turn-around areas should be located outside of the riparian zone.

Soil Management

- Excavated soils removed should be stockpiled outside of the delineated riparian area of the Wabooms River;
- Excavated materials should not be contaminated and it should be ensured that the minimum surface area is taken up, however the stockpiles may not exceed 2m in height;
- Mixture of the lower and upper layers of the excavated soil should be kept to a minimum, so as for later usage as part of rehabilitation activities; and
- All exposed soils must be protected for the duration of the construction phase with a suitable geotextile (e.g. Geojute or hessian sheeting) in order to prevent dust generation resulting in vegetation smothering and sedimentation of the watercourse. This is especially important since the surrounding landscape is utilised for harvestable fruits that may be sensitive to excessive dust.

Concrete Mixing

- All wet and dry material should be stored within the contruction camp, which is located outside of the delineated Wabooms River and associated 32m NEMA zone of regulation. These materials should be covered and contained to prevent contact with rainfall or runoff;
- Concrete and cement-related mortars can be toxic to aquatic life. Proper handling and disposal should minimize or eliminate discharges into watercourses. High alkalinity associated with cement, which can dramatically affect and contaminate both soil and ground water. The following recommendations must be adhered to:
    - Fresh concrete and cement mortar should not be mixed near the Wabooms River. Mixing of cement may be done within the Construction camp, above the 1:100 year floodline, may not be mixed on bare soil, and must be within a lined, bound or bunded portable mixer. Consideration must be taken to use ready mix concrete;
    - No mixed concrete shall be deposited directly onto the ground within the Wabooms River or its associated riparian habitat. A batter board or other suitable platform/mixing tray is to be provided onto which any mixed concrete can be deposited whilst it awaits placing;
    - A washout area should be designated outside of the 1:100 year floodline, and wash water should be treated on-site or discharged to a suitable sanitation system (USEPA. 2005);
    - Cement bags must be disposed of in the demarcated hazardous waste receptacles and the used bags must be disposed of through the hazardous substance waste stream; and
    - Spilled or excess concrete must be disposed of at a suitable landfill site. Chain of custody documentation must be provided.

General – applicable to all activities associated with the water scheme					
Timeframes / Project Phase	Planning and Construction Phase		**Rehabilitation**	Post Rehabilitation	
	Proponent	**Project Manager**		**ECO**	**Contractor**

Soil Management

- Exposed slopes especially along the riparian area are highly prone to erosion, so drainage control features such as earth berm, perimeter berm/swales, diversions (see below) can be used to intercept and convey runoff from above disturbed areas. This helps to reduce potential sedimentation from exposed areas**. (**Walker. 199 *et al*. and USEPA. 2005)
    - **Brush layering** is when branches are placed perpendicular to the slope contour. This method is effective for earth reinforcement and mass stability. Brush layers break up the slope length, preventing surface erosion, and reinforce the soil with branch stems and roots, providing resistance to sliding or shear displacement. Brush layers also trap debris, aid infiltration on dry slopes, dry excessively wet sites, and mitigate slope seepage by acting as horizontal drains. Brush layers facilitate vegetation establishment by providing a stable slope and a favourable microclimate for growth of vegetation (USEPA. 2005);
    - **Live gully repair** is a technique that is similar to branch packing but is used to repair rills and gullies. Live gully repairs offer immediate reinforcement and reduce the velocity of concentrated flows. They also provide a filter barrier that reduces further rill and gully erosion and must be used where gully erosion is taking place on the project footprint (USEPA. 2005).
- Any gullies occurring as a result of erosion from the construction activities must be actively repaired;
- Stream banks must be reprofiled to the pre-construction upstream and downstream slopes (a 1:3 profile ratio is not recommended as this will change the flood patterning of the watercourse. The existing embankments associated with the Wabooms River were noted to be steep), covered with a geotextile product such as hessian, with commercially available products such as Geojute, which is to be staked to the surface of the slopes and indigenous riparian vegetation should be re-instated for all areas disturbd by construction activities; and
- Edge effects of activities including erosion and alien/ weed control need to be strictly managed in these area.

Alien Vegetation Clearing

- During the site inspection undertaken by the freshwater specialist, various alien and invasive plant species were identified within the Wabooms River riparian habitat. All alien and invasive vegetation must be removed from the Wabooms River and its associated riparian habitat in order to comply with existing legislation (amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) and Section 28 of the National Environmental Management Act, 1998 (Act No. 107 of 1998)) as provided in **Appendix B**;
- Alien and invasive vegetation have a number of detrimental effects on water quality, from nutrient enrichment to increased erosion and excessive water use, which is especially relevant in dry areas or in important catchments. Invasive species are highly likely to colonise disturbed areas, even after rehabilitation and follow-up clearing must be done until healthy vegetation returns to the site (DWA.2008e, DWAF. Unknown date, MacFarlane, D.M., Wadeson. R *et al,* 2007). Please refer to **Annexure C** for further details pertaining to alien vegetation control;
- Alien vegetation should be manually removed as far as feasibly possible and spot chemical treatment can be undertaken utilising products safe for within watercourses. All directions as stipulated on the proposed herbicide must be struictly adhered to.
- All large tree species should be phased out slowly by stumping, with spot chemical treatment, or whatever is deemed most appropriate by a suitably qualified botanist. At no point should the roots of these trees be excavated as they assist with anchorage and embankment stability along the Wabooms River. All removed trees should be replaced with a suitable indigenous species, as guided by a suitably qualified botanist;
- All removed alien plant species must be disposed of at a registered garden refuse site and may not be burned or mulched on site; and
- No invasive plant species may be introduced to the water scheme and surrounding areas during the construction phases of the project and particular attention must be paid to ensure that any imported material is certified weed-free.

General – applicable to all activities associated with the water scheme					
Timeframes / Project Phase	Planning and Construction Phase		Rehabilitation	Post Rehabilitation	
	Proponent	**Project Manager**		**ECO**	

- All areas impacted upon during construction, must be monitored post rehabilitation until basal vegetation cover has been re-established; and
- The area surrounding the Wabooms River must be managed for all alien vegetation and the area revegetated with indigenous terrestrial vegetation in order to create a transitional zone between the terrestrial and the aquatic environment.

Table 6: Specific mitigation measures for the planning, construction, rehabilitation and operational phases that must be applied for the new weir, diversion chamber and outlet structures.

New Weir, Diversion Chamber and pipeline outlet structures					
Timeframes / Project Phase	**Planning and Construction Phase**		Rehabilitation	Post Reha+6bilitation	
Parties Responsible:	**Proponent**	**Project Manager**	**Civil Engineer**	**ECO**	**Contractor**

Instream Construction Activities

- It is imperative that all instream works be undertaken during the dry, summer months as the Wabooms River is known for its high volumes of water during the rainy season (Watsan Africa. 2018);
- Excavation within the Wabooms River should be limited in extent (only to what is necessary for the weir and diversion structure) and the smallest machinery possible utitlised in order to limit the impact within the active channel and to ensure that the hydrological patterns within the watercourse return to normal as soon as possible after construction;
- As noted suring the site visit undertaken in January 2019, surface water still flows within the Wabooms River upper reaches during the summer months and therefore a channel diversion will be required as part of the instream construction activities (Figure 9 below provides an example of a diversion channel);
- The diversion of flow will lead to an altered flow regime and inundation period of the reach of the Wabooms River downstream of the construction site. It is recommended that the diversion channel ensures that the pattern, flow and timing of the upstream area is retained through a diversion structure to the downstream reach;
- A dewatered area (Figure 9) should be created for the proposed instream weir and EWR outlet structure construction (in one coffer area) and a second area for the proposed pipeline outlet structure downstream.
- Cobbles and sediment traps must be implemented within the diversion channel as well as downstream of the construction dewatered area in order to prevent excess silt entering the downstream, reaches of the system (Figure 9);
- The diversion sandbags utilised for the dewatered area/coffer dam should be filled with *in situ* material so as to prevent foreign materials being introduced into the Wabooms River;
- Sediment traps should be installed downstream of the construction area and spaced at 20 metre intervals for 60 metres below the dewatered area. Sediment traps can be created by pegging an appropriate geotextile across the entire width of the channel, held down by cobbles/boulders or by geotextile wrapped hay bales spanning the width of the channel and staked into position (Figure 8);

Figure 8: Example of types of sediment traps within instream systems.

New Weir, Diversion Chamber and pipeline outlet structures

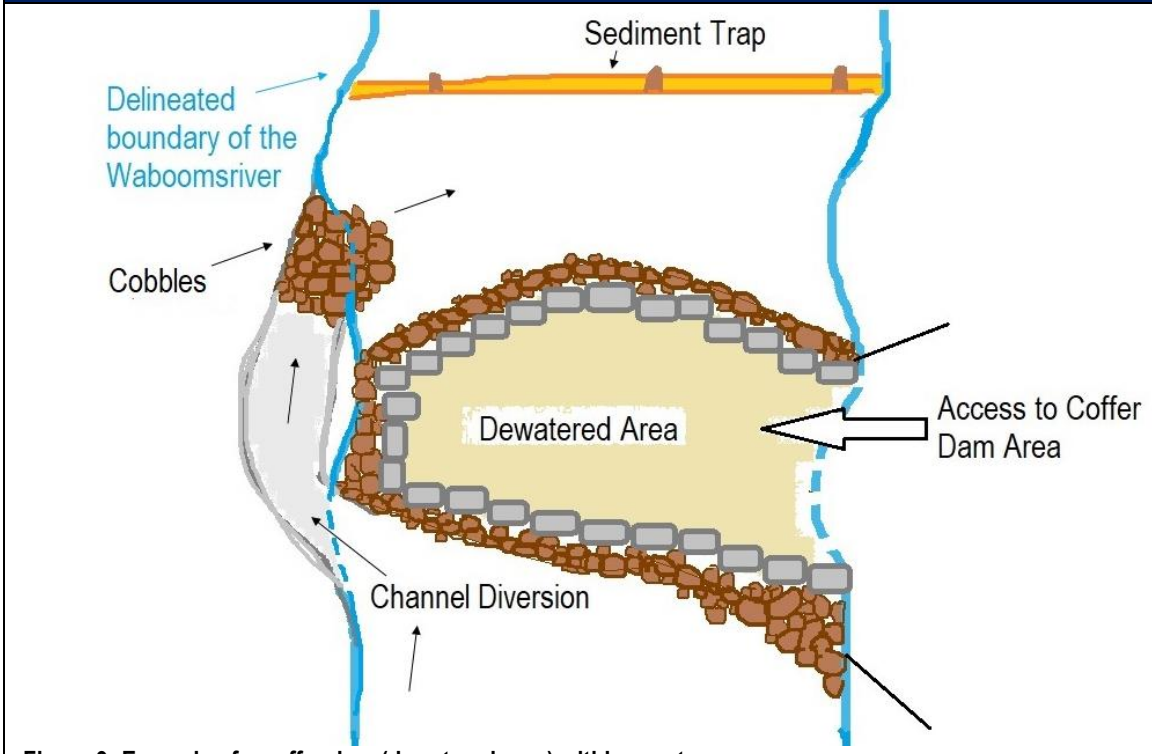


Figure 9: Example of a coffer dam (dewatered area) within a watercourse.

- The pipe outlet structure and the EWR outlet structure should be designed in such a way that water is released at the same level as the Waboomsrivie ractive channel in order to prevent the creation of turbulent flow which will lead to incision and erosion; and
- Energy dissipating structures should be constructed at the pipe outlet, such as the use of reno mattresses, rip,rap, concrete baffles and/or loose cobbles.

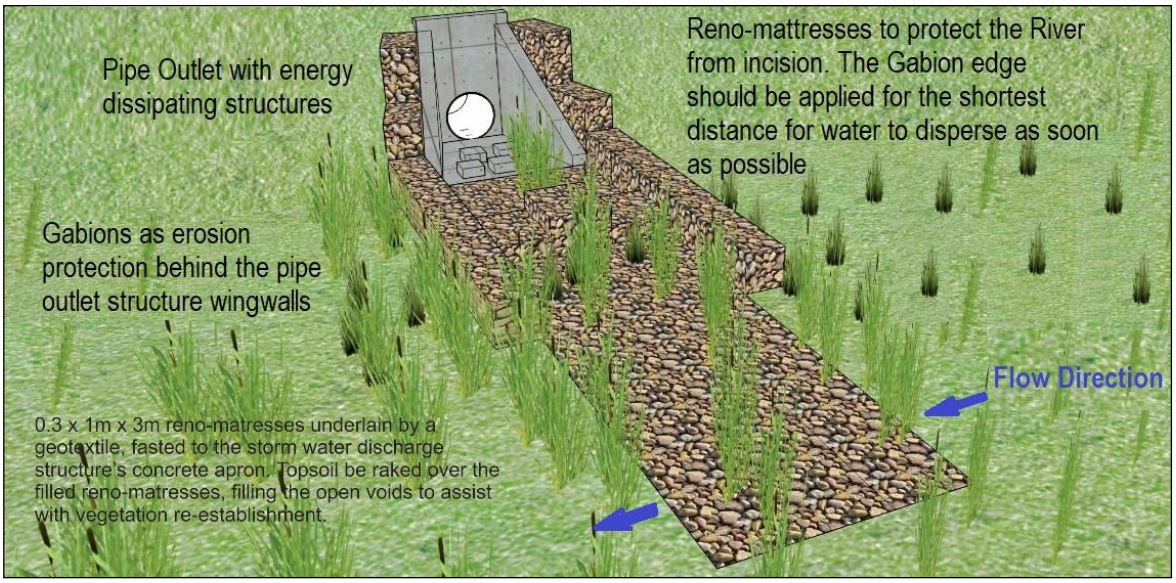


Figure 10: Diagrammatic representation of the pipe outlet back into the Wabooms River**.**

New Weir, Diversion Chamber and pipeline outlet structures					
Timeframes / Project Phase	Planning and Construction Phase		**Rehabilitation**	Post Rehabilitation	
Parties Responsible:	**Proponent**	**Project Manager**		**ECO**	**Contractor**

- Any excessive mud and silt generated from the construction activities must be removed from the streambed;
- All diversion channels should be backfilled and rehabilitated with indigenous vegetation;
- It must be ensured that backfilled material and constructed stream banks are suitably compacted in layers of 500mm or less in order to prevent collapse or subsidence of the backfilled stream diversion and newly created stream banks;
- The characteristics of the streambed are likely to be altered locally. In particular the rock and rubble created during the construction process is likely to have sharp edges, and not smooth surfaces that are typically associated with river rocks and pebbles. Therefore, all rock and rubble must be removed from the watercourse once construction is completed; and
- As much indigenous vegetation growth as possible must be promoted within the water scheme in order to protect soils and to reduce the percentage of impermeable surfaces.

Soil Stabilisation

- As far as possible, soft excavated material and constructed berms associated with the coffer dam areas must be removed as quickly as possible from the construction areas within and adjacent to the Wabooms River.
- Further erosion and incision within the Wabooms River must be prevented during the construction and rehabilitation phases.
- Where areas within the Wabooms River are at risk of such erosion and incision, immediate measures such as strategic placement of hessian sheets (Figure 11) or stabilisation with sandbags must be taken in order to prevent additional erosion from occurring.
- As far as possible all earthworks for reshaping and reprofiling of eroded stream banks should take place as soon as possible.

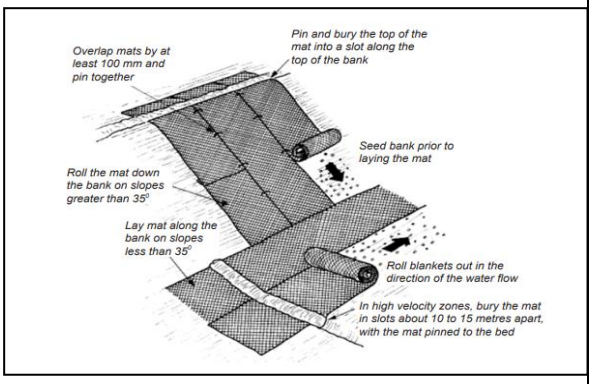


Figure 11: Use of hessian sheeting as a stabilisation method.

Timeframes / Project Phase	Planning and Construction Phase		Rehabilitation	**Post Rehabilitation**	
Parties Responsible:	**Proponent**			**ECO**	

- Simialrly, regular monitoring must be undertaken to ensure that no illegal abstraction of water is undertaken within the Wabooms River as this will have implications of the reserve.
- The weir and diversion chamber as well as both outlet structures must be inspected biannually to ensure they are functioning optimally. This is of particular importance after a flash flood within the Wabooms River as high water volumes and debris within may damage the instream weir.
- Due to the location of the new weir within the active channel of the Wabooms River, sediment and debris build-up behind the weir is considered to be limited due to the course gravels and boulders dominant in the area. Should the applicant, however, wish to remove sediment/debris build up within the Wabooms River at a later stage a suitably qualified civil engineer as well as freshwater ecologist should be consulted prior to any activities occurring; and
- The operation and maintenance manual and a emergency preparedeness plan must be compiled by the engineers indicating potential emergency works that may be required should the weir and/or diversion chamber fail or need repair. This plan should include a method statement indicating what equimment would be required and how this equipment will enter the Wabooms River. Approval from the relevant authorities will be required prior to any repairs, and all mitigation measures as stipulated for the construction phase must be adhered to, as necessary (pending the degree of work required).

Table 7: Specific mitigation measures for the planning, construction, rehabilitation and operational phases that must be applied for the proposed 350mm diameter pipeline and steel pipeline bridge.

350mm Diameter Pipeline (2.7 km in length)					
Timeframes / Project Phase	**Planning and Construction Phase**		**Rehabilitation**	**Post Rehabilitation**	
Parties Responsible:	**Proponent**	**Project Manager**	**Civil Engineer**	**ECO**	**Contractor**

Trenching

- All pipelines are located along the northern and southern embankments of the Wabooms River, with one proposed crossing.
- Trenches should not exceed 1000m at a time. Pipes should be installed and all trenches backfilled as soon as possible to reduce likelihood of erosion and increased sedimentation downstream. Care must be taken not to overcompact trenches;
- Stockpiled soil from the trenches must be stockpiled as far from the Wabooms River riparian zone as possible. For portions where trenching is to the north of the Wabooms River, stockpiles must be north of the existing gravel road. Likewise for portions to the south of the Wabooms River, stockpiles must be south of the gravel road (Figure 12);

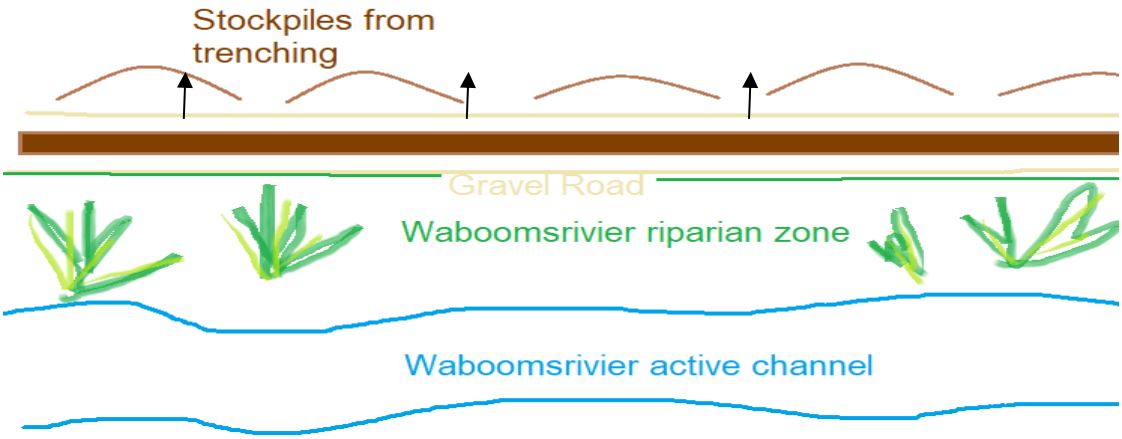


Figure 12: Schematic of location of stockpiles in relation to the river and the trenches.

- Any excess topsoil or soil excavated from the open trenches left in the construction footprint area must be levelled into the site or should be removed and disposed of at a registered disposal site; and
- Small machinery should be used instead of large excavators in areas sensitive to erosion (e.g. areas where the pipeline is located within the riparian zone and not within an existing gravel road).

Steel Bridge Crossing

- It must be ensured that the construction of the suspension bridge take place only within the approved portion of the Wabooms River. A detailed construction method statement should be provided once a Contractor has been appointed and this be approved by a suitably qualified freshwater ecologist;
- The steel bridge must span the entire width of the active channel of the Wabooms River and must be designed in such a way to withstand a 1:50 and 1:100 year flood event. Suitable anchor points will need to be developed that will anchor the bridge in place and ensure integrity and stability during a flood; and
- Due to the regular flooding of the Wabooms River, care must be taken to ensure that water can flow through the proposed steel cage with limited hindrance. Hindering movement of water will result in damage to the steel bridge and the pipeline due to the weight of the water as well as debris that may wash down.

350mm Diameter Pipeline (2.7 km in length)					
Timeframes / Project Phase	Planning and Construction Phase		**Rehabilitation**	**Post Rehabilitation**	
Parties responsible:	**Proponent**	**Project Manager**		**ECO**	**Contractor**

- The trench footprint area within the Wabooms River riparian habitat (not within the existing gravel road) should immediately be revegetated with indigenous riparian vegetation in order to prevent erosion of the trench and any other disturbed areas. This is of particular importance in areas where the pipeline will be in close proximity to the active channel, where steep eroded embankments were identified (within the middle portion of the river reach);
- If any other area associated with the Wabooms River has been compacted, it should be ripped (preferably using hand held equipment) to allow for free draining of surface water and the establishment of vegetation; and
- All invasive and alien vegetation located within the footprint area of the trench should be removed and monitored (see Table 1 for additional mitigations).

Timeframes / Project Phase	Planning and Construction Phase		Rehabilitation	**Post Rehabilitation**	
Parties responsible:	**Proponent**			**ECO**	

- The site must be monitored during the operational phase until suitable basal vegetation has established to ensure incision and erosion of the embankments does not occur;
- The steel bridge must be checked annually and the anchorage points integrity inspected; and
- After a signficant storm event, the steel bridge and pipeline must be checked for any damage and/or water leakage. Remediation must be undertaken in line with the above listed mitigation measures should repairs be required.

7 MONITORING PLAN

Prudent monitoring of the watercourse and buffer zones associated with the water scheme are of utmost importance, as this will ensure a continual flow of data, enabling all parties involved to accurately assess and manage water resource related progress and issues. To ensure the accurate gathering of data, the following techniques and guidelines should be followed. It is important to note that this report considers the aspects associated with the infrastructure development and does not provide long-term monitoring requirements to ensure aquatic health and the EWR. It is considered imperative that a separate aquatic monitoring plan be compiled and implemented during the operational phase of the water scheme to ensure that the EWR is being adequately released and to ensure the health of the river.

Table 8 below illustrates data capturing for the monitoring plan. This monitoring plan must be implemented by a competent person and the findings are to be submitted to the responsible authority for evaluation.

Table 8: Monitoring actions for the proposed water scheme.

Aspect	Monitoring Location	Frequency of sampling	Frequency of Reporting	Report Content	Equipment
Erosion Control	1. The banks of the Wabooms River where reprofiling has been undertaken as a result of construction works.	Monitoring of erosion and sedimentation should occur during construction after every rainstorm and / flood, and for the operational phase, during maintenance activities to check for accumulation of debris, blockages, instabilities and erosion.	1. After every major rainstorm and / flood.	1. Brief indication of the method of assessment; 2. Assumptions and Limitations must be listed; 3. Photos and GPS point locations taken of existing erosion in the watercourse and buffer zones prior to and post construction and operation must be incorporated into the report. 4. Any erosion observed must be discussed in detail; 5. Map indicating where erosion is present; and 6. Recommended mitigation and remediation actions should be presented.	1.GPS 2. Camera 3. Field Form 4.Measuring Tape
	2. All pipe outlet structures (EWR outlet and the pipeline outlet).				
	3. The Steel bridge pipeine bridge (Geogrphical co-ordinates 33°30'19.79S 19°16'1.51E and 33°30'20.85"S 19°16'1.88"E).		2. Monthly monitoring report compiled by the appointed ECO during the construction phase. Biannually for 3 years during the operational phase.		
	4. Areas where alien trees have been removed from the riparian zone.				
Alien Vegetation Control	1. The entire reach of the Wabooms River associated with the diversion scheme.	1. Monitoring will be done during and after growing season; 2. Regrowth of alien vegetation should be monitored monthly during the construction phase; and 3. Monitoring must be done annually during the operational phase until indigenous basal cover has re-established.	1 Monthly monitoring report must be compiled by the appointed ECO during the construction phase and alien vegetation reported on at least quarterly.	1. Provide a list of species occurring within the subject property; 2. Discuss the density of species; 3. riparian habitat integrity and risk to be discussed; 4. Fixed point photo (Taking photo at specific point within priority area to show effect of alien vegetation control.); and 5. Map indicating where alien vegetation is present.	1. GPS 2. Field Form 3. Camera
	2. All disturbed areas as part of the construction activities.		2. During operational phase an annual report must be developed for three years following the completion of construction or until indigenous basal cover has re-estabished..		
Spillage Events	Roads and areas where vehicles commute, specifically river crossings and while construction equipment are within the Wabooms River as well as all areas	Monitoring of any spillage events should occur monthly during the construction phase, or directly after a spill event; and for the	1. Monthly monitoring report compiled by the appointed ECO during the construction phase.	1. Brief indication of the method of assessment; 2. Discuss type and extent of spill; 3. Photos and GPS point locations taken of the spills in the Wabooms River;	

Aspect	Monitoring Location	Frequency of sampling	Frequency of Reporting	Report Content	Equipment
	where chemical storage containers are located.	operational phase, during maintenance activities.	2. Report should be compiled for three months post rehabilitation.	4. Map indicating where the spills has occurred; and 6. Recommended mitigation should be presented.	
Surface Water Quality					
Pre-construction	1. Upstream of the proposed weir. 2. At the proposed pipeline bridge crossing. 3. Downstream of the pipeline outlet, before the existing abstraction weir. 4. Directly downstream of the existing weir, within the existing pond wherein fish species are noted to breed.	Water must be tested at least once a month for a minimum of three months before construction commences in order to obtain baseline levels. GPS point must be taken so that monitoring takes place consistently at the same point.	Report must be compiled after laboratory analyses was completed.	Results of the following must be discussed in detail: 1. Physico-Chemical Water Quality including pH, EC, TDS and Temperature; and 2. Turbidity using a turbidity meter or clarity tube.	1.GPS 2. Camera 3. Field Form 4. Handheld multi-probe 5. DO Probe (not essential)
Construction	Monitoring must take place at the GPS point localities that was taken for the pre-construction monitoring.	Water monitoring must be assessed on a weekly basis.	Report must be compiled after laboratory analyses was completed.	Compare results to pre-construction assessments and aspects as listed in pre-construction report content.	As listed in Pre-Construction Equipment
Rehabilitation	Monitoring must take place at the GPS point localities that was taken for the pre-construction monitoring.	Water monitoring must be assessed on a monthly basis during rehabilitaticion activities.	Report must be compiled after laboratory analyses was completed.	Compare results to pre-construction assessments and aspects as listed in the construction report content.	
Operation	Monitoring must take place at the GPS points that was taken for the pre-construction monitoring.	Three months after completion of construction.	Report must be compiled quarterly.	Compare results of pre-construction, construction and rehabilitation assessments and aspects as listed in pre-construction report content.	As listed in Pre-Construction Equipment

In accordance with the South African water quality guidelines volume 7, Aquatic ecosystems (DWAF, 1996), the below percentage change guidelines must be followed:

- Electrical Conductivity (EC)/Total Dissolved Solids (TDS) concentrations should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year, and the amplitude and frequency of natural cycles in EC/TDS concentrations should not be changed;
- pH values should not be allowed to vary from the range of the baseline pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 % temporal variation, and should be assessed by whichever estimate is the more conservative.
- Note that EC and pH comparisons refer to temporal comparisons. However, as no guidelines are available for spatial comparisons, the percentage change recommendations will also be applied to spatial comparisons. For the purpose of this monitoring, a temporal or spatial change of 15% will be considered significant with reference to DO.

This monitoring plan must be implemented by a competent person and submit the findings, on an annual basis to the responsible authority for evaluation.

8 CONCLUSION AND RECOMMENDATIONS

This RRMP includes suitable management and monitoring measures in order to effectively manage, maintain and improve the ecological characteristics of watercourses associated with the proposed new instream weir, diversion chamber, pipeline and outlet structure. Rehabilitation impacts are applicable to areas where impact avoidance and minimisation are unavoidable and where an attempt to re-instate impacted areas and return them to conditions which are ecologically similar to the pre-project condition or an agreed post project land use. Rehabilitation cannot, however, be considered as the primary mitigation tool as even with significant resources and effort, rehabilitation usually does not lead to adequate replication of the diversity and complexity of the natural system.

The measures as set out in this report are deemed sufficient to guide the construction and necessary rehabilitation of all areas affected by the proposed water scheme, to a point where the resources can be suitably restored. A separate aquatic and water quantity monitoring plan must be compiled in order to monitor and ensure the EWR are being met and the aquatic health of the system is not detrimentally impacted by the proposed water scheme.

The information gathered through monitoring programs such as this and the proposed aquatic monitoring plan, will assist in better understanding of the ecology of the area and ensuring proactive management of risks to the receiving environment. All measures as stipulated in this report are considered to be in compliance with the conditions and aspects as stipulated in Government Notice 509 of 2016, as it relates to the National Water Act, 1998 (Act No. 36 of 1998) as well as the National Environmental Management Act, 1998 (Act No. 107 of 1998).

9 REFERENCES

Campbell P.J. (2000) *Rehabilitation Recommendations after Alien Plant Control*. Plant Protection Research Institute, Agricultural Research Council, Hilton.

Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, and South African National Biodiversity Institute. 2013. Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector. Pretoria

Department of Environmental Affairs and Tourism (1995). *Urban Open Space: Guidelines for effective management. Discussion document based on Agenda 21 and the RDP*, Technikon Pretoria

Department of Water Affairs and Forestry (2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas,* prepared by M. Rountree, A. L. Batchelor, J. MacKenzie & D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kotze, D.C., Marneweck G.C., Bachelor, A.L., Lyndley, D.S. & Collins, N.B. (2009). Wet-EcoServices. South Africa.

Mucina, L. & Rutherford, M.C. (2006): The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

National Environmental Management: Biodiversity Act (Act No. 10 of 2004) and the associated Alien and Invasive Species Regulations (GN R598 of 2014).

Sarel Bester Ingenieus BK. 2019. Water Use Licence Applicayion for installing weir and pipeline in Waboomsriver on Farms 602/2, 602RE. 706RE. 196/5 and 196/9, Worcester District, Darlingbrug and Wagenboomsriver Irrigation Boards.

Watsan Africa (2018) in collaboration with Sarel Bester Ingenieurs BK and EnviroAfrica. Proposed Water offtake weir on Portion 2 of the Farm Snelrivier 602, Worcester: Preliminary Techncial Report V1.2. Water Use Licence Application: a reguirement of Section 21 of the National Water Act, 1998 (Act NO. 36 of 1998).

ANNEXURE A – PROJECT TEAM

Contact detail of the responsible people who will implement the MMP.

Table A1: Contact details of the responsible person who will implement the RRMP

Engineer	Sarel Bester Engineers	Tel: 023 312 2017 Email: lizbe@sbri.co.za
EAP Practitioner	EnviroAfrica cc	Tel: 021 851 1616 Email: inge@enviroafrica.co.za
ECO	Still to be appointed	Still to be appointed
Contractor	Still to be appointed	Still to be appointed
Consult who compiled RRMP	Scientific Aquatic Services Environmental CC	Phone: 011 616 7893 Email: kim@sasenvgroup.co.za

Scientific Aquatic Services Team
Stephen van Staden
SACNASP Pr. Sci. Nat. Reg No: 400134/05

Stephen van Staden completed an undergraduate degree in Zoology, Geography and Environmental Management. He then undertook an honours course in Aquatic health. In 2002 he began a Master's degree in environmental management, including his dissertation in aquatic resource management. Stephen built a career at a firm specialising in town planning development, after which he moved to a larger firm in late 2002 where he managed the monitoring division and acted as a specialist freshwater resource consultant and other environmental processes and applications. In 2003, Stephen started consulting independently specialising in water resource management. In addition to freshwater assessments, clients enquired about terrestrial ecological assessments. Stephen started working in the wetland consulting arena and has become recognised as a national expert combining science, engineering principles and an in-depth understanding of the legislative framework to provide turnkey advisory services. Stephen launched soil and land capability assessment and visual impact assessment services with other specifically qualified specialists. Stephen is registered by the SA RHP as an accredited biomonitoring specialist and is SACNASP registered in ecology. Stephen is a member of the Gauteng Wetland Forum, SASSO, LARSA and IAIA. Stephen has also attended the DWS training courses on the various Ecostatus models, as well as the implementation of Regulation 509 of 2016 and has attended the course Tools for Wetland Delineation and Assessment by Rhodes University and presented by Prof. F. Ellery, whom was instrumental in the development of the various wetland Ecostatus tools.

Kim Marais
SACNASP Pr. Sci. Nat. Reg No: 117137/17
Kim obtained her undergraduate BSc. at Wits University in Ecology, Environmental Science and Conservation (EEC). During the course of her undergraduate degree she was involved in microbiological and water quality assessments of several urban rivers as well as the Bruma lake in Johannesburg. In 2012 she obtained her BSc. Honours degree, at Wits University in Zoology and published her Honours thesis titled "A Comparative analysis of the diets of *Varanus albigularis* and *Varanus niloticus* in South Africa*"* in African Zoology, April 2014.

Upon graduation Kim worked as a Junior Environmental Assessment Practitioner for 2,5 years, working throughout South Africa and Uganda before joining the SAS team in 2015 as the lead Environmental Scientist and Manager of the Cape Town branch. Kim has extensive knowledge of the environmental legislation as well as faunal and freshwater ecology, undertaking various freshwater and faunal assessments as well as Water Use Licence Applications in the Western Cape and having completed the short course on tools for wetland assessment held by Prof. Fred Ellery at Rhodes University and a wetland and aquatic plant identification course by Dr. G van Grinkel. Kim is registered as a Professional Natural Scientist with SACNASP in the field of Environmental Science, is a member of the South African Wetland Society.

ANNEXURE B – LEGAL REQUIREMENTS

The sections below present each legislative document and the aspects, which are pertinent to water resource management including the rehabilitation of disturbed areas.

The National Environmental Management Act, 1998 (Act No. 107 of 1998)	The National Environmental Management Act, 1998 (Act No. 107 of 1998) and the associated Regulations as amended in 2017, refer specifically to biodiversity management in the following Clause: (4)(a) *Sustainable* development requires the consideration of all relevant factors including, (i) that the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied. This Maintenance and Management Plan has been developed in fulfilment of the requirements as defined in the Environmental Impact Assessments EIA Regulations, 2014 (as amended) (No. R. 327) where a "maintenance management plan" is defined as a management plan maintenance purposes defined or adopted by the competent authority. The following EIA Regulation triggers the need for this MMP: Activity 19, Listing Notice 1: The infilling or depositing of any material of more than 10 cubic meters into, or the dredging, excavation, removal or moving of soil, sand, shell grit, pebbles or rock of more than 10 cubic metres from a watercourse; but excluding where such infilling, depositing, dredging, excavation, removal or moving- (a) will occur behind a development setback; (b) is for maintenance purposes undertaken in accordance with a maintenance management plan; (c) falls within the ambit of activity 21 in this Notice, in which case that activity applies; (N.B. Points (d) and (e) does not apply as these activities fall within the coastal zone).
The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)	The objectives of this act are (within the framework of the National Environmental Management Act) to provide for: ➢ the management and conservation of biological diversity within the Republic of South Africa and of the components of such diversity; ➢ the use of indigenous biological resources in a sustainable manner; ➢ the fair and equitable sharing among stakeholders of benefits arising from bio prospecting involving indigenous biological resources; ➢ to give effect to 'ratified international agreements' relating to biodiversity which are binding to the Republic; ➢ to provide for co-operative governance in biodiversity management and conservation; and ➢ to provide for a South African National Biodiversity Institute to assist in achieving the objectives of this Act. This act alludes to the fact that management of biodiversity must take place to ensure that the biodiversity of surrounding areas is not negatively impacted upon, by any activity being undertaken, in order to ensure the fair and equitable sharing among stakeholders of benefits arising from indigenous biological resources. Furthermore, a person may not carry out a restricted activity involving either: a) a specimen of a listed threatened or protected species; b) specimen of an alien species; or c) a specimen of a listed invasive species without a permit. Permits for the above may only be issued after an assessment of risks and potential impacts on biodiversity is carried out. Before issuing a permit, the issuing authority may in writing require the applicant to furnish it, at the applicant's expense, with such independent risk assessment or expert evidence as the issuing authority may determine. The Minister may also prohibit the carrying out of any activity, which may negatively impact on the survival of a listed threatened or protected species or prohibit the carrying out of such activity without a

	permit. Provision is made for appeals against the decision to issue/refuse/cancel a permit or conditions thereof. ***National Environmental Management: Biodiversity Act (NEMBA) (Alien and Invasive Species Regulations, 2014)*** NEMBA is administered by the Department of Environmental Affairs and aims to provide for the management and conservation of South Africa's biodiversity within the framework of the NEMA. In terms of alien and invasive species. This act in terms of alien and invasive species aim to: ➢ Prevent the unauthorized introduction and spread of alien and invasive species to ecosystems and habitats where they do not naturally occur, ➢ Manage and control alien and invasive species, to prevent or minimize harm to the environment and biodiversity; and ➢ Eradicate alien species and invasive species from ecosystems and habitats where they may harm such ecosystems or habitats. Alien species are defined, in terms of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) as: (a) a species that is not an indigenous species; or (b) an indigenous species translocated or intended to be translocated to a place outside its natural distribution range in nature, but not an indigenous species that has extended its natural distribution range by natural means of migration or dispersal without human intervention. Categories according to NEMBA (Alien and Invasive Species Regulations, 2014): ➢ **Category 1a**: Invasive species that require compulsory control. ➢ **Category 1b**: Invasive species that require control by means of an invasive species management programme. ➢ **Category 2**: Commercially used plants that may be grown in demarcated areas, provided that there is a permit and that steps are taken to prevent their spread. ➢ **Category 3**: Ornamentally used plants that may no longer be planted. See **Appendix C** for further details pertaining to Alien and Invasive Vegetation control.
The Protected Areas Act (Act No. 57 of 2003) (In conjunction with the National Environmental Management: Biodiversity Act of 2004)	To provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; and for matters in connection therewith. This Act, as with the forestry act alludes to the fact that the conservation status of all vegetation types needs to be considered when any development is taking place to ensure that adequate conservation of all vegetation types is ensured.
The Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)	Amendments to regulations under the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) ensures that landowners are legally responsible for the control of invasive alien plants on their properties. The CARA legislation divides alien plants into weeds and invader plants, with *weeds* regarded as alien plants with no known useful economic purpose, while *invader plants* may serve useful purposes as ornamentals, as sources of timber and may provide many other benefits, despite their aggressive nature.
The National Water Act, 1998 (Act No. 36 of 1998)	The purpose of the National Water Act, 1998 (Act 36 of 1998) (NWA) is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled. The NWA, 1998 also provides for water use licenses which an operation will have to apply for, before commencing with any Section 21 water use activity. Various conditions may be attached to these licenses and a breach thereof will result in criminal and civil liability. The conditions attached to water use licenses will function alongside the additional protective

	measures, duty of care and statutory liability provisions provided by the NWA and other legislation to regulate a whole array of water issues. Accordingly, and in terms of the *Guide to the National Water Act*, "water use" refers to doing something that has an impact on the water resource, for example: ➢ The amount of water in the resource; ➢ The quality of water in the resource; and ➢ The environment surrounding the resource. Section 4 governs the entitlement to use water and states that water may only be used if it is a Schedule 1 use, a continuance of an existing lawful use (ELU), or authorised in terms of a general authorisation (GA) or license. A water use may therefore not be implemented unless it is properly authorised through one of these types of authorisations. The National Water Act, 1998 (Act No. 36 of 1998) recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) & (i). A watercourse is defined as: a) A river or spring; b) A natural channel in which water flows regularly or intermittently; c) A wetland, lake or dam into which, or from which water flows; and d) Any collection of water which the minister may, by notice in the Gazette, declare a watercourse.
Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998)	In accordance with Regulation GN509 of 2016, a regulated area of a watercourse for section 21c and 21i of the NWA, 1998 is defined as: ➢ The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; ➢ In the absence of a determined 1 in 100 year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or ➢ A 500 m radius from the delineated boundary (extent) of any wetland or pan. This notice **replaces GN1199** and may be exercised as follows: i) Exercise the water use activities in terms of Section 21(c) and (i) of the Act as set out in the table below, subject to the conditions of this authorisation; ii) Use water in terms of section 21(c) or (i) of the Act if it has a low risk class as determines through the Risk Matrix; iii) Do maintenance with their existing lawful water use in terms of section 21(c) or (i) of the Act that has a LOW risk class as determined through the Risk Matrix; iv) Conduct river and storm water management activities as contained in a river management plan; v) Conduct rehabilitation of wetlands or rivers where such rehabilitation activities have a LOW risk class as determined through the Risk Matrix; and vi) Conduct emergency work arising from an emergency situation or incident associated with the persons' existing lawful water use, provided that all work is executed and reported in the manner prescribed in the Emergency protocol. A General Authorisation (GA) issued as per this notice will require the proponent to adhere with specific conditions, rehabilitation criteria and monitoring and reporting programme. Furthermore, the water user must ensure that there is a sufficient budget to complete, rehabilitate and maintain the water use as set out in this GA.

ANNEXURE C – ALIEN FLORAL SPECIES CONTROL

The dominant alien floral species are predominantly associated with agricultural activities and should be identified by the ECO prior to the commencement of construction. An Alien and Invasive Plant (AIP) species control program should be developed for control of these species. The basic principles of a control program are presented below.

AIP control programs must include the following three phases (Campbell, 2000):

- Initial Control Phase: The existing population must be drastically reduced.
- Follow-up Control Phase: Control of coppice regrowth, root suckers and seedlings.
- Maintenance Phase: Low AIP density and numbers with a low annual control cost. During this phase, AIP are no longer considered a problem. It is important to monitor the situation of infestation during the growing season of the plants as to avoid re-infestation and to keep the control cost at a minimum.

Control Methods

In order to control AIP successfully, one must use a number of control methods. When using herbicides, the recommendations that are stated on the label of the specific product must be adhered to (Campbell, 2000).

Integrated control strategies

A combination of the most suitable and effective methods should be used to control a specific species in a particular situation. The following selection of suitable control methods should take into account the following (Campbell, 2000):

- Species of alien and invasive weeds;
- The type of growth form (i.e. seedling, sapling, shrub or tree);
- The density of infestation;
- Terrain where the infestation is present;
- Rehabilitation requirements
- What resources are available;
- Speed or urgency that the control of the infestation requires – physical removal and biological control will take longer than chemical control.

- **Initial control phase**
  - **Hand pull:** saplings and seedlings must be pulled out by hand and regrowth must be controlled with herbicide (Campbell, 2000). All guidelines for the application of herbicide listed in this Rehabilitation Plan must be adhered to;
  - **Frill:** a cane knife is used to cut frills into the stem. Herbicide must be applied (1-2 mm per frill) and must be done in 30min after frilling;
  - **Soil application:** herbicide is applied to the soil and taken up by the plants roots

Methods for controlling Coppice, saplings and seedlings:

AIP infestation can comprise of different growing forms, and some of the growth forms cannot be utilised. These plants need to be cut with a brush cutter and the stumps treated with herbicide that was mixed with a dye to show where treatment was done (however stumps must not be removed as they significantly contribute to soil stability).

Integrated strategies to control alien shrubs

- **Alien shrubs that are less than 1 m in height**:
  - Foliar application must be used in the general control of alien shrubs that are less than 1 m in height.

- Registered herbicide must be used and where grass is present, selective broadleaf herbicide that will not impact on the grass. When grass is not present, a selective or non-selective registered herbicide must be used.
- For dense seedling growth that are of uniform height a flat fan nozzle with knapsack must be used.
- For seedling growth that are of uneven height, root suckers, short saplings, and coppice growth a cone nozzle must be used.

➢ **Alien shrubs that are taller than 1 m (Campbell, 2000):**

- Shrubs that are taller than 1 m must be reduced cutting using brush cutter or cane knifes.
- When large areas with dense growth are present a tractor mounted gyro-motor must be used.
- For low – medium density infestation a cut stump treatment must be used. Stumps that are must be treated immediately. The best time to treat is during the active growing season.
- Medium – high density infestations must be slashed to knee height so that the plants can coppice. The best time to do this is during the winter months as the plants are dormant and the coppice will come out during the active growing period after good rain. The coppice must be sprayed when enough leaves are present to absorb the herbicide and a dye must also be used to indicate treated areas.
- Pathways must be cut to increase exposed areas so that a foliar spray treatment is more effective without compromising the indigenous vegetation.
- Mechanical uprooting of shrubs is not always a preferred method because the soil is disturbed and this increases the risk of alien vegetation infestation. Erosion is also promoted by this activity, and soil loss will occur. Mechanical uprooting can be done in areas that have a dense grass cover, as the roots of the grass will keep the soil intact. After uprooting the soil must be leveled and if grass seeds are present, some grass seeds must be placed on these areas to promote grass regrowth.

Integrated strategies to control alien herbs (Campbell, 2000)

Chemical Control:

➢ Alien herbs are soft non-woody species.
➢ Some of the alien herbs have registered herbicides to control them and are either pre- or post-emergent herbicides.
➢ When alien herbs are associated with woody alien plant, herbicides that are registered to control woody alien species are often used to control alien herbs. Alternatively, glyphosate can be used as it is often registered for both alien herb and alien woody species.

Follow up control (Campbell, 2000)

Introduction

Follow-up control is essential to control alien saplings, seedlings and coppice regrowth to achieve and sustain the progress that was made with the initial control work in the initial phase. If the follow up control phase is neglected, the alien infestation will become worse and denser than before the eradication process started. It is essential to sustain the follow up phase because it will prevent the suppression of alien seedlings on planted grasses.

Follow up treatment control must use the following methods:

➢ Chemical control methods: Only use registered herbicides to control any alien species. Instruction on the herbicide labels must be followed carefully.
➢ Mechanical control methods
➢ Biological control methods that are available.

Control methods for dense regrowth

After initial control operations dense regrowth may arise as new regrowth will sprout in the form of stump coppice, seedlings and root suckers.

- **Chemical control / foliar application:**
  - Plants that are less than 1 m in height must be controlled by foliar application.
  - Dense seedling growth must be controlled with knapsack sprayers with a flat fan nozzle.
  - If grass is present, the use of a registered selective herbicide must be used so as to not harm the grass, and if grass is not present a registered non-selective or selective herbicide can be used.
  - Suitable dye must be used at all times to limit over- or under spray of areas.
- **Mechanical control:**
  - Areas with dense seedlings should not be uprooted or hoed out, as these areas will result in soil disturbance and will in return promote flushes and germination of alien seedling growth.
  - When stump density is high, plants should not be cut. This is impractical and there will be many untreated stumps. Instead cut the stumps in dense areas with brush cutters and remove the top growth. Stumps will start to coppice and foliar spay must be used to control the coppice regrowth.

Control methods for low-medium density regrowth

Neglecting to control low-medium density regrowth will result in densification and spreading as well as additional control costs.

- **Chemical control:**
  - Cut stump method must be used and stumps must be cut up to a height of 15 cm and must be sprayed within an hour of cutting the plant with a registered herbicide. Herbicide must be applied with knapsack sprayers set to a low pressure, using cone nozzles e.g. TG1 or CE1. Hand sprayers can also be used to apply herbicide. A suitable dye must be used to ensure all stumps are treated. Only the cut surface must be treated with herbicide and the side of the stumps must not be treated.
  - Foliar spray can be applied to regrowth that is up to the height of 1m. Herbicide must be applied using knapsacks with solid cone nozzle and must be mixed with a suitable dye to prevent over- or under spraying of treated areas.
- **Mechanical control:**
  - Seedlings can be removed from wet soil by hand pulling. Gloves can be used for hand protection during the operation.