Specialist Aquatic Biodiversity Assessment – TR75/1 Road Upgrade, Oudtshoorn, Western Cape.

DRAFT FINAL REPORT

For:

Sharples Environmental Services

By:

Dr. J.M. Dabrowski (james@confluent.co.za)

Confluent Environmental

March 2023

EXECUTIVE SUMMARY

The Western Cape Government: Department of Public Works – Roads Branch (the applicant) is planning to undertake rehabilitation of the road TR75/1 (N12 Highway), near Oudtshoorn within the Oudtshoorn Local Municipality, which forms part of the Garden Route District Municipality, Western Cape. The road crosses numerous watercourses and the nature of the proposed rehabilitation activities trigger activities listed under the National Environmental Management Act (NEMA) and the National Water Act (NWA). The scope of work for this report is therefore defined by the legislative requirements of these respective acts and includes the following:

- A desktop review of freshwater features and provincial and national freshwater conservation plans relevant to the site;
- Undertake a site visit to the study area to verify the sensitivity of aquatic biodiversity affected by maintenance activities; and
- Compile an aquatic biodiversity assessment report that meets the requirements of the both the NEMA and the NWA.

The road crosses twenty-eight (28) watercourses. Without exception, all watercourses can be classified as non-perennial rivers, with clearly discernible bed and banks, that are characterised by a highly intermittent hydroperiod (i.e. flowing for a short period – hours to a few days - only after heavy rainfall events in the catchment area). The size of these watercourses varied from minor, first order drainage lines (approximately one meter in width) to broader second and third order streams (up to 5 m in width). All watercourses cross the TR75/1 road via formalised culverts and ultimately flow into the Klip River which runs adjacent to the TR75/1 road alignment. The Klip River is a large fifth order perennial river which eventually becomes a floodplain wetland prior to its confluence with the Olifants River. Given the relatively undeveloped catchment area, the Present Ecological State of each affected watercourse is B, Largely Natural. The watercourses are important in terms of connecting large areas of undisturbed terrestrial CBA areas to the lowland perennial Klip River system. For these reasons it is important that rehabilitation of the road is undertaken in a sensitive manner and that all mitigation measures are implemented.

Rehabilitation activities will include widening of the road and associated extension of culverts as well as maintenance of existing culverts. At the time of compiling this report no information was available as to which specific watercourses would be affected by a specific rehabilitation activity (i.e. extension of a culvert). Impacts described and assessed in this report are therefore generic to all watercourse crossings. The approach is however considered justified considering the similarity of all affected watercourses.

Given the existing presence of the road and railway and the impacts already present, it is unlikely that the rehabilitation activities will result in any further deterioration to the PES of the watercourses or the receiving Klip River. It is therefore recommended that environmental authorisation for the activities associated with the road rehabilitation should be granted. In terms of the NWA, considering the Low risk associated with all construction and operational phase activities the rehabilitation plan qualifies for a General Authorisation.

Declaration of Specialist Independence

- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;
- I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;
- I do not have any influence over decisions made by the governing authorities;
- I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;
- I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;
- This document and all information contained herein is and will remain the intellectual property of Confluent Environmental. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.
- All the particulars furnished by me in this document are true and correct.

Dr. James Dabrowski (Ph.D., Pr.Sci.Nat. Water Resources; SACNASP Reg. No: 114084)

March 2023

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Project Background

The Western Cape Government: Department of Public Works – Roads Branch (the applicant) is planning to undertake rehabilitation of the road TR75/1 (N12 Highway), near Oudtshoorn within the Oudtshoorn Local Municipality, which forms part of the Garden Route District Municipality, Western Cape. The road crosses numerous watercourses and the nature of the proposed rehabilitation activities trigger activities listed under the National Environmental Management Act (NEMA) and the National Water Act (NWA). The scope of work for this report is therefore defined by the legislative requirements of these respective acts.

1.2 Key Legislative Requirements

1.2.1 National Environmental Management Act (NEMA, 1998)

According to the protocols specified in GN 320 (Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(A) and (H) and 44 of the National Environmental Management Act, 1998, when Applying for Environmental Authorisation), assessment and reporting requirements for aquatic biodiversity are associated with a level of environmental sensitivity identified by the national web-based environmental screening tool (screening tool). An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of:

- **Very High** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Specialist Assessment; or
- **Low** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Compliance Statement.

According to the protocol, prior to commencing with a specialist assessment a site sensitivity verification must be undertaken to confirm the sensitivity of the site as indicated by the screening tool:

- Where the information gathered from the site sensitivity verification differs from the screening tool designation of **Very High** aquatic biodiversity sensitivity, and it is found to be of a **Low** sensitivity, an Aquatic Biodiversity Compliance Statement must be submitted.
- Similarly, where the information gathered from the site sensitivity verification differs from the screening tool designation of **Low** aquatic biodiversity sensitivity, and it is found to be of a **Very High** sensitivity, an Aquatic Biodiversity Specialist Assessment must be submitted.

The screening tool identified the road alignment as being of **Very High** aquatic biodiversity due to its close proximity to a mapped wetland and aquatic Critical Biodiversity Area (CBA).

1.2.2 National Water Act (NWA, 1998)

The Department of Water & Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (NWA) (Act No. 36 of 1998) aims to protect water resources, through:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means:

- 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 Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

No activity may take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). According to Section 21 (c) and (i) of the National Water Act, a Water Use License (WUL) is required for any activities that impede or divert the flow of water in a watercourse or alter the bed, banks, course or characteristics of a watercourse. The regulated area of a watercourse for section 21(c) or (i) of the Act water uses means:

a) 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;
b) In the absence of a determined 1 in 100-year flood line or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or
c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.

Rehabilitation activities along the road will require work to be undertaken at numerous river crossings all of which fall within the regulated area of a watercourse. Any water use activities that do occur within the regulated area of a watercourse must be assessed using the DWS Risk Assessment Matrix (GN 509) to determine whether activities may be generally authorised (Low Risk according to the Risk Assessment Matrix) or require a WUL (Medium or High Risk according to the Risk Assessment Matrix).

1.3 Scope of Work

Based on the key legislative requirements listed above, the scope of work for this report includes the following:

- A desktop review of freshwater features and provincial and national freshwater conservation plans relevant to the site;
- Undertake a site visit to the study area to verify the sensitivity of aquatic biodiversity affected by maintenance activities; and
- Compile an aquatic biodiversity assessment report that meets the requirements of the both the NEMA and the NWA.

2 METHODS

2.1 Watercourse Assessment

A desktop assessment was conducted to contextualize the affected watercourses in terms of their local and regional setting, and conservation planning. An understanding of the biophysical attributes and conservation and water resource management plans of the area assists in the assessment of the importance and sensitivity of the watercourses, the setting of management objectives and the assessment of the significance of anticipated impacts. The following data sources and GIS spatial information were consulted to inform the desktop assessment:

- National Freshwater Ecosystem Priority Area (NFEPA) atlas (Nel at al., 2011);
- National Wetland Map 5 and Confidence Map (CSIR, 2018);
- Western Cape Biodiversity Spatial Plan (CapeNature, 2017); and
- DWS hydrological spatial layers.

A site visit was conducted on the 9th of March 2023, with the objective of identifying and classifying watercourses affected by maintenance activities, determining their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS), and assessing the impacts of the maintenance activities on these watercourses.

2.1.1 Watercourse Classification

Watercourses were classified based on their hydrological and geomorphological characteristics which provides a fundamental understanding of the drivers that characterize each watercourse and therefore assists in the interpretation of impacts to the watercourse. The classification of the watercourse also determines which PES and EIS assessment methodologies can be applied. Each watercourse was categorised into discrete hydrogeomorphic units (HGMs) based on its geomorphic characteristics, source of water and pattern of water flow through the watercourse. These HGMs were then classified according to Ollis et al. (2013). Each watercourse was delineated according to the outer extent of its riparian zone using methods described in DWAF (2005) as well as various desktop methods including the use of topographic maps, historical and current digital satellite imagery, and historical aerial photographs.

2.1.2 Present Ecological State

An important factor that influences the diversity and abundance of aquatic communities is the condition of the surrounding physico-chemical habitat. Habitat loss, alteration, or degradation generally results in a decline in species diversity. The PES of affected watercourses was assessed using the Index of Habitat Integrity (IHI) (see Appendix 1).

2.1.3 Ecological Importance and Sensitivity

The ecological importance of a watercourse is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Resh et al. 1988; Milner 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity. The EIS of affected watercourses was assessed using methods described in Appendix 2.

2.2 Impact Assessment

The impact assessment methodology is described in the appendix to this report (Appendix 3). Development activities typically impact on the following important drivers of natural and artificial watercourses:

- *Hydrology:* Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes and base flows and modifications to general flow characteristics, including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river etc.);
- *Geomorphology:* This refers to the alteration of hydrological and geomorphological processes and drivers, and associated impacts to aquatic habitat and ecosystem goods and services primarily driven by changes to the sediment regime of the aquatic ecosystem and its broader catchment;
- *Modification of water quality:* This refers to the alteration or deterioration in the physical, chemical and biological characteristics of water within streams, rivers and wetlands, and associated impacts to aquatic habitat and ecosystem goods and services (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication etc.);
- *Fragmentation:* Loss of lateral and/or longitudinal ecological connectivity due to structures crossing or bordering watercourses (e.g. road or pipeline crossing a wetland);
- *Modification of aquatic habitat:* This refers to the physical disturbance of in-stream and riparian aquatic habitat and associated ecosystem goods and services including the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.)*;* and
- *Aquatic biodiversity:* Impacts on community composition (numbers and density of species) and integrity (condition, viability, predator prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site.

Rehabilitation activities were therefore assessed with respect to their impact on these drivers (if applicable).

3 DESKTOP ASSESSMENT

The TR75/1 road connects the Oudtshoorn to the N9 highway. The section of road that will be rehabilitated runs through quaternary catchment J35B and for the majority of its alignment runs immediately adjacent to the Klip River, which flows in a northerly direction before joining up with the Olifants River (Figure 1). The southern half of the section of road to be rehabilitated falls within level 19.01 of the Level 1 Southern Folded Mountains ecoregion and is characterized by parallel hills and low mountains (altitude ranging from 100 to 1300 m.a.m.s.l) which drain towards lowland areas. The northern half of the road falls within level 19.10 of the Level 1 Southern Folded Mountains ecoregion and is characterized by irregular plains. The majority of the road alignment runs along the lower elevation of these hills, low mountains and irregular plains and as such crosses numerous watercourses that drain into the lowland area (i.e. Klip River valley). Rainfall for the ecoregion is low (0 – 400 mm per annum) and all watercourses draining into the Klip River are indicated as non-perennial watercourses. The Klip River itself is a perennial system, the source of which originates from the Outeniqua Mountains, which receives considerably higher rainfall and has been designated as a Strategic Water Source Area (SWSA).

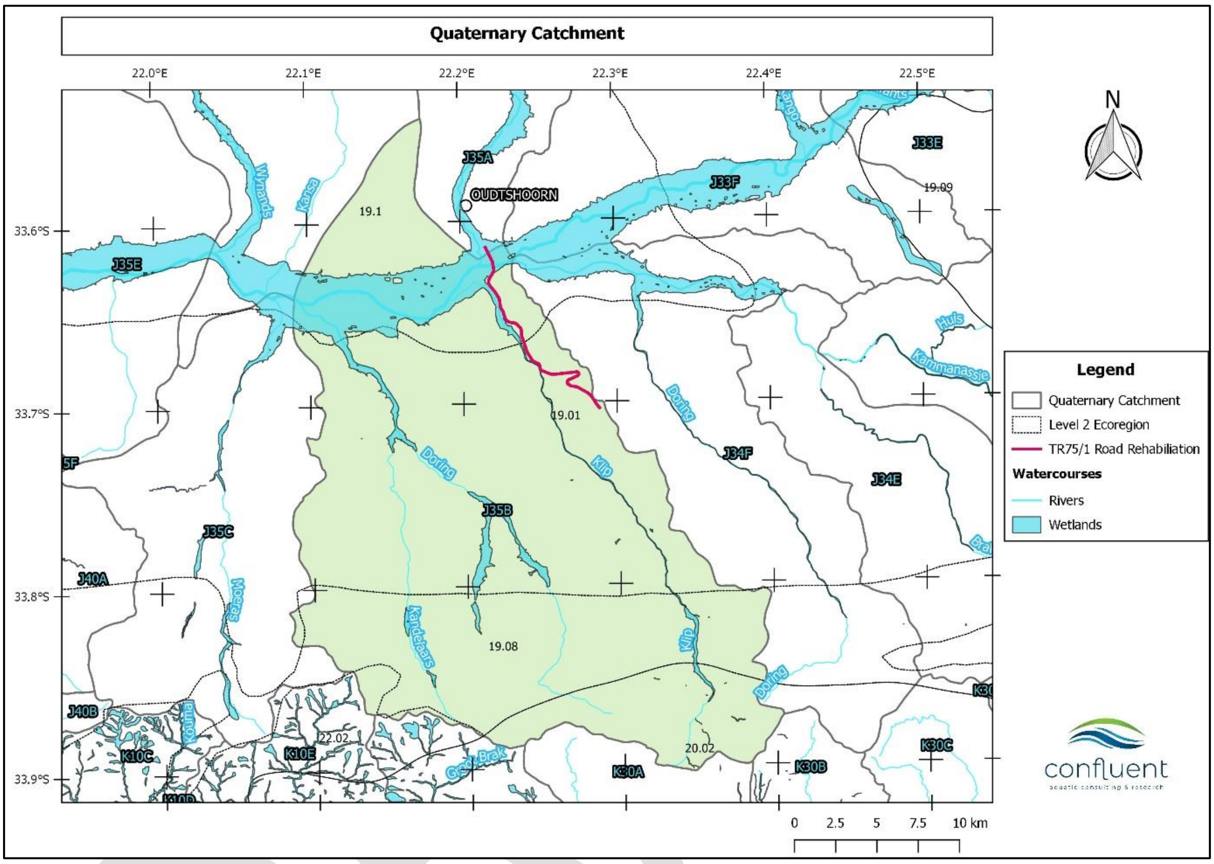


Figure 1: Location of the road relative to quaternary catchment J35B and mapped watercourses.

3.1 Freshwater Conservation & Management

3.1.1 National Freshwater Ecosystem Priority Atlas (NFEPA)

The road is located within sub-quaternary catchment (SQC) 8861 (Figure 2), which, according to the National Freshwater Ecosystem Priority Atlas (NFEPA, Nel et al., 2011), has been classified as an Upstream Management Area. These areas need to be managed to prevent degradation of downstream Freshwater Ecosystem Priority Areas (FEPAs) – which in this case includes several quinary catchments located along the Olifants River which have been designated as important fish corridors and are categorised as Fish Support Areas. Fish Support Areas are SQCs that are not necessarily in a good ecological condition but are still essential for protecting threatened or near-threatened freshwater fish species that are indigenous to South Africa. The management goal of Fish Support Areas is to prevent additional fish species from becoming threatened or to prevent threatened or near-threatened species from becoming extinct. In order to achieve these objectives, there should be no further deterioration in river condition.

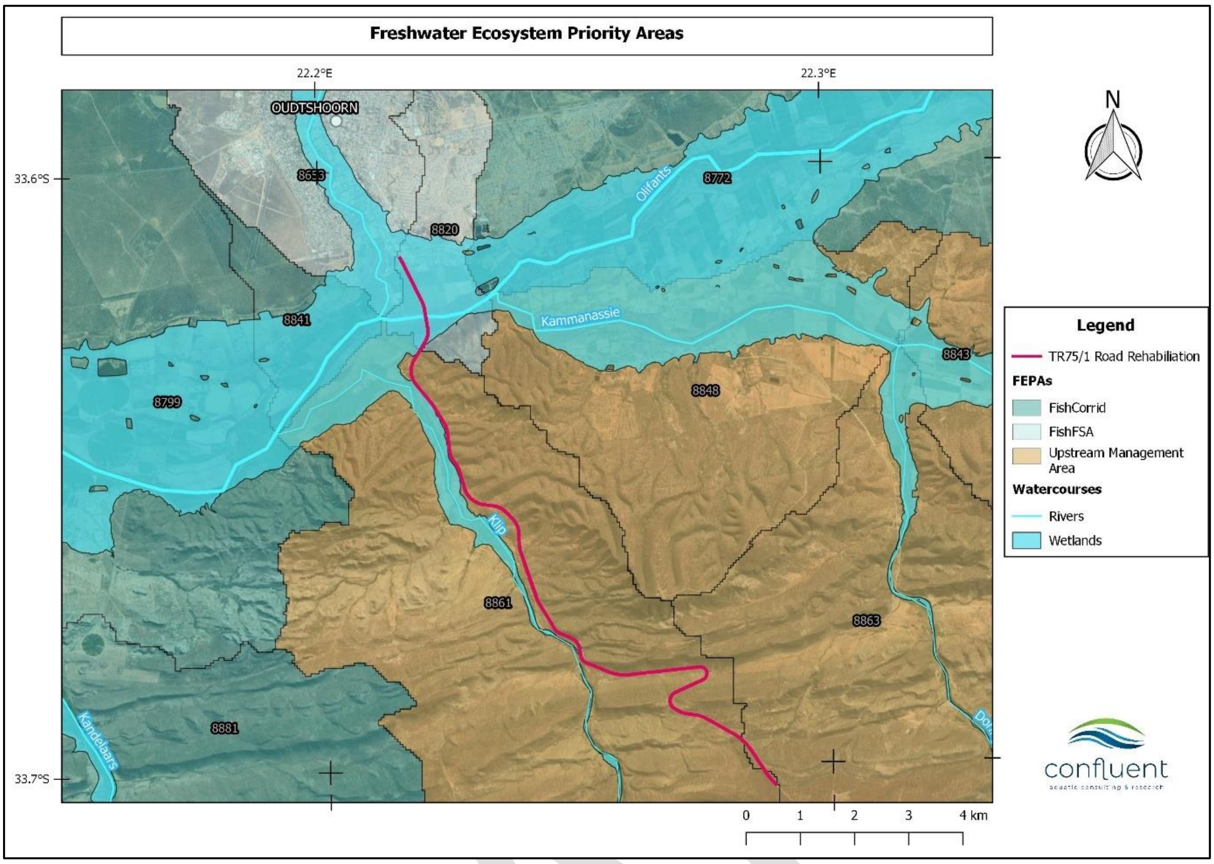


Figure 2: Map indicating the location the TR75 road in relation to mapped FEPAs and watercourses.

3.2 Western Cape Biodiversity Spatial Plan

According to the Oudtshoorn WCBSP many of the mapped watercourses have been categorized as aquatic Ecological Support Areas (ESAs) (Figure 3). The definitions and associated management objectives of these biodiversity features are described in Table 1. The management objectives allow for some habitat loss provided that the ecological function of these watercourses is not compromised. Maintenance of existing road infrastructure (including maintenance or extension of culverts) can therefore be considered as an acceptable activity within the context of these objectives. Several mapped watercourses have not been categorized as aquatic biodiversity area but are indicated to occur in terrestrial Critical Biodiversity Areas (CBAs).

Table 1: Descriptions and management objectives of mapped biodiversity planning units.

Biodiversity Unit	Description	Management Objective
Aquatic ESA1	Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of PAs or CBAs, and are often vital for delivering ecosystem services.	Maintain in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised.
Terrestrial CBA1	Areas in a natural condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure.	Maintain in a natural or near-natural state, with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.

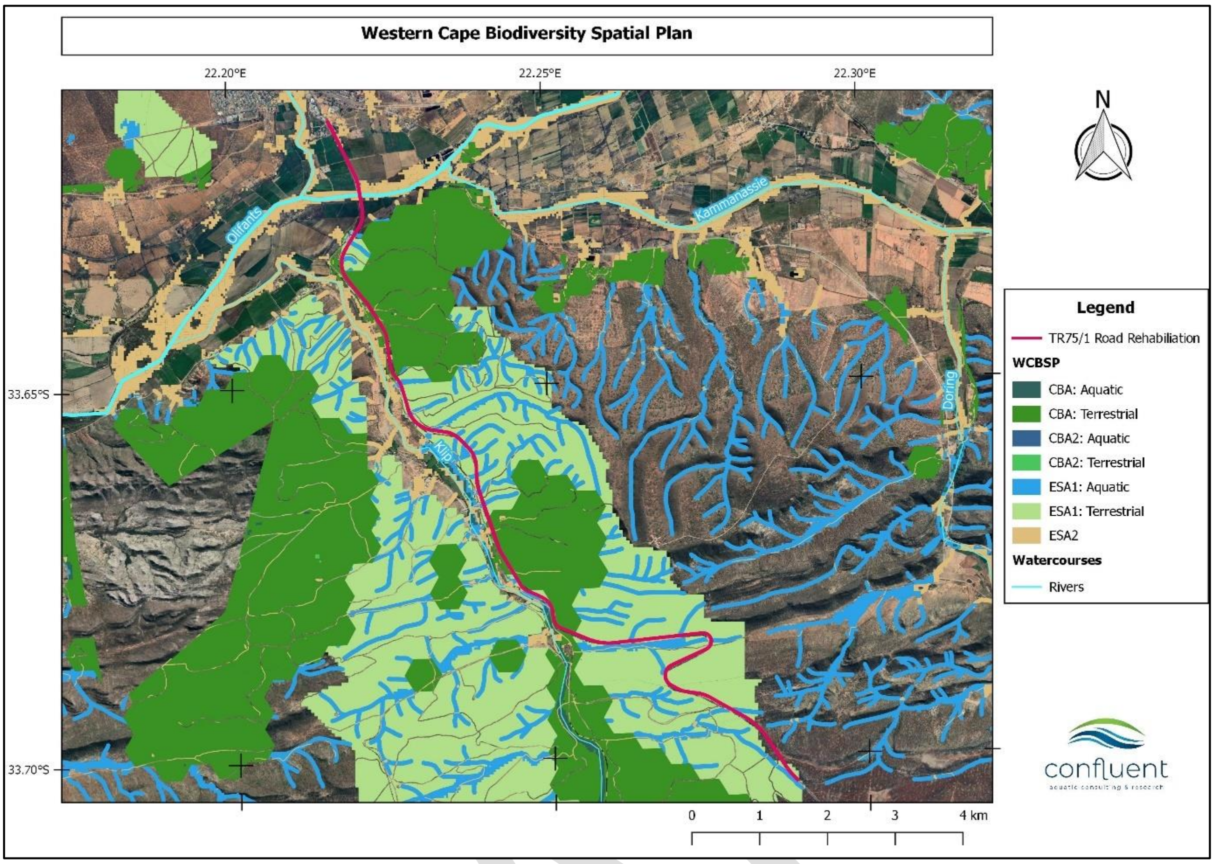


Figure 3: Map of the section of the TR75 road that will be rehabilitated in relation to the Western Cape Biodiversity Spatial Plan (WCBSP).

4 WATERCOURSE ASSESSMENT

4.1 Watercourse Classification

Travelling in the direction of Oudtshoorn (northerly direction) the road descends from a higher elevation down to the lower slopes of the hills and mountains as it follows the course of the Klip River. The road crosses twenty-nine (29) watercourses before crossing the large Olifants River system. Without exception, all of these 29 watercourses can be classified as non-perennial rivers, with clearly discernible bed and banks, that are characterised by a highly intermittent hydroperiod (i.e. flowing for a short period – hours to a few days - only after heavy rainfall events in the catchment area). The size of these watercourses varied from minor, first order drainage lines (approximately one meter in width) to broader second and third order streams (up to 5 m in width). All watercourses cross the TR75/1 road via formalised culverts and ultimately flow into the Klip River. The Klip River is a large fifth order perennial river which eventually becomes a floodplain wetland prior to its confluence with the Olifants River. The section of the TR75 that will be rehabilitated also crosses the Olifants River, which is a large floodplain wetland system. Large areas of its former extent have been converted to irrigated agriculture. Photographs of each watercourse crossing are presented in Appendix 4 of this report. Non-perennial watercourses and the delineated extent of affected wetland systems are illustrated in (Figure 4).

Given the road crosses numerous watercourses the sensitivity of the road alignment with respect to aquatic biodiversity is confirmed as **Very High**.

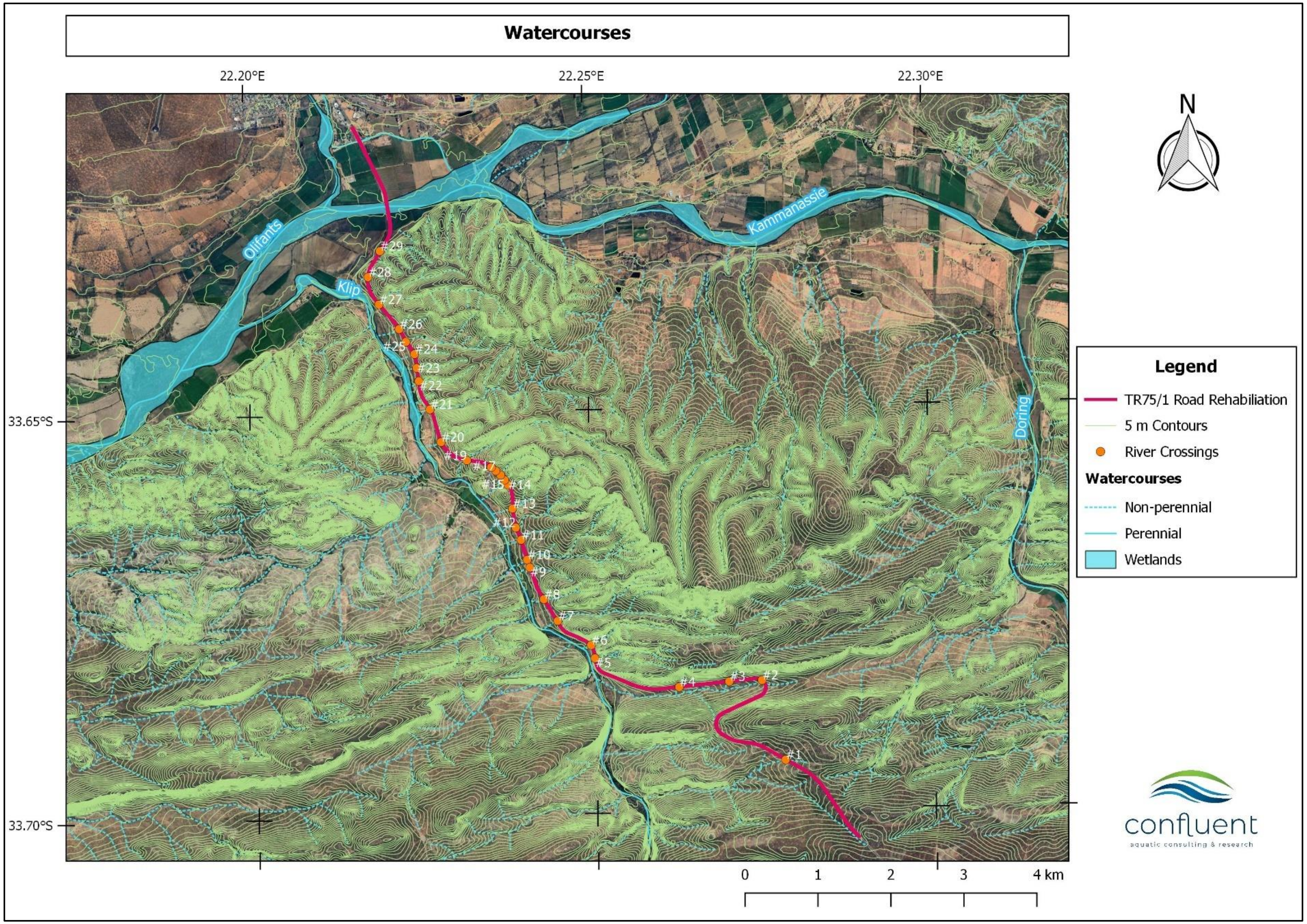


Figure 4: Map indicating delineated watercourses crossed by the TR75/1 road connecting the N9 to Oudtshoorn.

4.2 Present Ecological State (PES)

All watercourses originate from areas that have been described as terrestrial CBA1 and CBA2 areas. The catchment areas are therefore in a relatively natural condition with no commercial crop production taking place. While some grazing of livestock is likely, the upper reaches of each watercourse are relatively undisturbed. The greatest disturbance is associated with the existing TR75/1 road where infilling of the watercourse has occurred at road crossings and intermittent flows are directed through culverts at each road crossing. Particularly at the larger watercourses the culverts have the effect of constricting flows which leads to acceleration and increased energy of flow which leads to erosion of the bed and banks of the section of the river reaches downstream of the road. In all instances this impact is confined to the lower reach of each watercourse. The watercourses are also crossed by a railway line immediately to the west of the road which has similar impacts to the road. Establishment of agricultural fields within the floodplain of the Klip River has also impacted on the lower most reaches of watercourses which generally results in disturbance and removal of riparian habitat and modifications the bed and channel of the watercourse.

Given the large number of affected watercourses as well as their similarity in terms of flow dynamics, ecological function and existing impacts, the PES of the watercourses has been assessed collectively and is described in Table 2. While some modification to natural habitat has occurred in the lower most reaches, the ecosystem functions are essentially unchanged and the PES is **B, Largely Natural**.

Table 2: Present Ecological State (PES) of the non-perennial watercourses crossing the TR75 road.

Modification	Drainage Line
Water abstraction	**5 –** Non-perennial watercourses with unreliable supply of water. Minor abstraction in the lower reaches during periods of flow.
Flow modification	**0 –** No dams in watercourses – no modification to flow.
Bed modification	**5 –** Minor levels of increased sediment due to increased rates of erosion from the cathchemt
Channel modification	**10 –** Incised channels in lower most reaches due to modifications in flow dynamics caused by culverts on the TR75 road and railway line
Physico-chemical modification	**0 -** None
Inundation	**0 –** None
Alien macrophytes	**0 -** None
Alien aquatic fauna	0 - None
Rubbish dumping	**5 –** Minor levels in lower reaches
Instream IHI score	**86 (B – Largely Natural)**
Vegetation removal	**5 –** Minor removal associated with agricultural fields
Invasive vegetation	**5 –** Minor in lower reaches
Bank erosion	**10 –** Bank erosion confined to lower most reaches of watercourses

Modification	Drainage Line
Channel modification	**10 -** Incised channels in lower most reaches due to modifications in flow dynamics caused by culverts on the TR75 road and railway line
Water abstraction	**0 –** None
Inundation	**0 –** None
Flow modification	**0 –** None
Physico-chemical modification	**0 –** None
Riparian IHI Score	**85 (B – Largely Natural)**
Combined Score	**86 (B – Largely Natural)**

According to DWS (2014), the PES of the Olifants River is **D, Largely Modified**. This is mainly due conversion of floodplain wetland habitat to agriculture, resulting in highly disturbed banks, removal of riparian vegetation, invasion of exotic tress, infilling and high rates of abstraction for irrigation. Modification of streamflow caused by the Stompdrift Dam (on the Olifants River) and the Kamanassie Dam (on the Kamanassie River) has reduced the intensity and frequency of flood events which has resulted in the channel becoming clogged with *Phragmites australis.*

4.3 Ecological Importance & Sensitivity (EIS).

Given the non-perennial and highly intermittent flow characteristics of all watercourses draining towards the Klip River, these watercourses are not important with respect to hosting a diverse aquatic assemblage that is dependent on permanently flowing water. The main function of these watercourses is to supply flows to downstream areas (i.e. the Klip River) as opposed to hosting instream aquatic fauna and flora. Similarly, the intermittent flows and geomorphological characteristics limits the diversity of aquatic habitat features and refuge and migration options for aquatic biota. They are however relatively important in terms of connecting terrestrial CBAs to the Klip River system. Overall, the EIS of theses watercourses is considered to be **Low** (Table 3).

Table 3: Ecological Importance and Sensitivity (EIS) of the non-perennial watercourses crossing the TR75 road.

Determinant	Drainage Line
Presence of Rare & Endangered Species	**0 –** No rare or endangered taxa.
Populations of Unique Species	**0 –** No unique species.
Intolerant Biota	**1 -** Very low proportion of biota is expected to be dependent on flowing water for the completion of their life cycle.
Species/Taxon Richness	**1 -** Low diversity of fauna and flora expected on a local scale.
Diversity of Habitat Types or Features	**1 –** Non-perennial, with little geomorphological variation
Refuge value of habitat types	**2** – Important at a local scale particularly considering that they run through terrestrial CBAs
Sensitivity of habitat to flow changes	**1 –** A non-perennial river which is unlikely to be sensitive to changes in flow.

Determinant	Drainage Line
Sensitivity to flow related water quality changes	**1 –** A non-perennial river sensitive to modifications in water quality.
Migration route for instream and riparian biota	**2** – Important at a local scale – connects terrestrial CBA areas to the larger Klip River system.
Protection Status	**1** – ESAs
EIS Score	**1 (Low)**

The EIS of the Olifants River is **High** (DWS, 2014), largely due its large size and diverse habitat types and because of its importance in terms of providing an important migration corridor for aquatic biota and for protecting threatened or near-threatened freshwater fish species that are indigenous to South Africa.

5 PROPOSED MAINTENANCE ACTIVITIES

Proposed maintenance activities that will be undertaken on the road that could potentially impact on watercourses include the following:

- Extension of existing minor culverts.
- Maintenance of existing minor culvert inlet and outlet structures.
- Widening or raising head and wing walls at major culverts if required due to cross-section rehabilitation or introduction of auxiliary lanes.
- Maintenance to major culverts including:
  - Concrete crack repair.
  - Scour repair.
- Maintenance to B4691 over the Olifants River including:
  - Repair of honeycombing in concrete.
  - Replacement of bridge joints.

6 IMPACT ASSESSMENT

6.1 Planning and Layout Phase

Impact 1: Impact of stormwater management structures (i.e. extended culverts and drains) on flow dynamics. Poor planning of construction of stormwater management structures could lead to increased erosion of watercourses.		
	Without Mitigation	**With Mitigation**
Intensity	High	Low
Duration	Ongoing	Ongoing
Extent	Limited	Very limited
Probability	Almost certain	Unlikely
Significance	**-78: Moderate**	**-30: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- No drop in height should occur between the downstream invert of a culvert and the watercourse bed to avoid erosion caused by high flows.
- Methods to disperse flows and reduce flow velocities on culvert outflows must be implemented.
- Erosion protection (e.g. stone pitching) must be implemented in channels that convey stormwater off the road and into watercourses.

6.2 Construction Phase

Impact 2: Impact of storage and management of construction materials on instream habitat

Poor management of construction camps and laydown areas can lead to unnecessary physical disturbance and/or pollution of aquatic habitats.

	Without Mitigation	With Mitigation
Intensity	Moderate	Low
Duration	Short term	Brief
Extent	Limited	Very limited
Probability	Almost certain	Unlikely
Significance	**-54: Minor**	**-18: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Construction camps, equipment and material lay down areas must be located at least 30 m from any watercourse.
- Concrete or cement mixing is not permitted at or in the vicinity of the watercourse. Any cement mixing cannot take place on bare ground. An impermeable or bunded area must be established in a way that cement slurry will not run off into the surrounding environment.
- Any soil or material stockpiles must be covered with a geotextile or plastic and bunded (e.g. with sand bags) to prevent erosion of the material down slopes into the watercourse.
- Excess cement or other materials must be left to dry out before being removed and disposed of at an appropriate facility.
- Construction should be planned to avoid seasonal rainfall peaks

Impact 3: Impact of the operation of heavy machinery and vehicles on water quality and instream habitat

Operation of vehicles and machinery within and in close proximity to watercourses can lead disturbance of aquatic habitat (riparian vegetation and the bed and banks of the watercourse) and/or to spills and leaks of hydrocarbons which can pollute water resources.

	Without Mitigation	With Mitigation
Intensity	High	Low
Duration	Medium term	Brief
Extent	Limited	Very limited
Probability	Likely	Unlikely
Significance	**-55: Minor**	**-18: Negligible**

Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Vehicle access roads to construction areas must not cross watercourses. Vehicles must be diverted back to the existing road at these points (i.e. watercourses must not become traffic thoroughfares).
- Access to the watercourse can only be for work specifically being conducted to enlarge the crossings and culvert areas. In these areas, access must be limited to essential equipment only.
- Fuel storage and vehicle refuelling areas must be located at least 50 m from any watercourse.
- Discontinue construction during periods of high rainfall.
- Vehicles and machinery must be inspected for leaking fuel before accessing the site, and leaking vehicles must not be permitted to work at the site.

Impact 4: Impact of increased numbers of labourers in and around watercourses on water quality and instream habitat

Increased human activity in and around watercourses can lead to unnecessary disturbance and/or pollution of watercourses.

	Without Mitigation	With Mitigation
Intensity	Moderate	Low
Duration	Short term	Brief
Extent	Limited	Very limited
Probability	Likely	Unlikely
Significance	**-45: Minor**	**-18: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Provide bins or rubbish bags for rubbish and place them in an area designated for break-time. Ensure bins are cleaned out on a regular basis.
- Provide portable chemical toilets on-site (1 toilet per 10 workers). Waste from toilets is to be disposed of regularly, at least weekly, in a responsible manner by a registered waste contractor. Toilets must be located more than 30 m away from watercourses.
- All workers must be briefed that no waste is to be disposed of in the environment.
- All workers must be briefed that no access to watercourses is permitted for the duration of construction works unless this is related to maintenance or construction of road infrastructure.

Impact 5: Impact of soil disturbance on erosion Maintenance and rehabilitation activities will most likely lead to localised disturbance of soil which can lead to increased erosion and sedimentation of watercourses and/or modifications to the bed and banks of watercourses (bank erosion and destabilisation).		
	Without Mitigation	**With Mitigation**
Intensity	High	Low
Duration	Long term	Brief
Extent	Limited	Very limited
Probability	Almost certain	Unlikely
Significance	**-72: Minor**	**-18: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

Following the completion of construction, disturbed areas must be:

- Cleared of construction debris and any blockages.
- Cleared of alien invasive vegetation.
- Reshaped to free-draining and non-erosive contours where possible.
- Re-vegetated with indigenous vegetation suitable to the area.

Impact 6: Loss of instream habitat due to widening of the road. Widening of the road and the associated extension of culverts will result in loss of instream habitat at affected watercourses. This loss of habitat represents very small proportion of the length of each watercourse and the overall impact is therefore considered to be minor.	
	Without Mitigation
Intensity	Very low
Duration	Permanent
Extent	Very limited
Probability	Certain
Significance	**-70: Minor**
Reversibility	High
Irreplaceability	Low
Confidence	High

Mitigation:

Cannot be mitigated

6.3 Operational Phase

Impact 7: Impact of culverts on erosion of the bed and banks of watercourses

Directing flows through watercourses can lead to minor to major modifications in localised flow dynamics which can potentially result in erosion and scour of the bed and banks downstream of the culvert. This impact can be largely avoided by adequate planning during the Planning and Layout Phase (see Section 6.1). Nevertheless, it is still likely that erosion could occur during the operational phase.

	Without Mitigation	With Mitigation
Intensity	Moderate	Low
Duration	Ongoing	Ongoing
Extent	Limited	Very limited
Probability	Likely	Unlikely
Significance	**-60: Minor**	**-30: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Inspect road crossings following rainfall events to ensure there is no erosion or sediment deposition along watercourses associated with the culverts.
- Where erosion has occurred determine an appropriate method of rehabilitation such as revegetation with indigenous plants to stabilise soil or silt fences on slopes. Identify areas of channelled flow or high flow velocities. Methods to spread water and reduce flows should be investigated.
- Ensure pipes and culverts under roads are free of debris following rainfall events.

Impact 8: Impact of disturbance of the bed and banks on the establishment of alien invasive plant species

All culverts are currently free of alien invasive plant species. Disturbance of bed and banks during construction activities could lead to the establishment of alien invasive plant species during the operational phase.

	Without Mitigation	With Mitigation
Intensity	Low	Very low
Duration	Ongoing	Brief
Extent	Very limited	Very limited
Probability	Probably	Unlikely
Significance	**-40: Minor**	**-15: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Inspect culverts bi-annually to ensure that road crossings following rainfall events to ensure there is no erosion or sediment deposition along watercourses associated with the culverts.
- Bi-annual inspections should be sufficient to allow invasive plants to be removed by hand-pulling. Alternatively, plants must be controlled using the cut-stump method:
    - The tree must be felled as close to the ground as possible;

○ The freshly cut stump must be painted with a herbicide registered for the control of the plant species in question; and ○ The herbicide must be mixed with a dye to identify stumps that have already been treated.

7 DWS RISK ASSESMENT

The risk assessment matrix (Based on DWS 2015 publication: Section 21 (c) and (i) water use Risk Assessment Protocol) was implemented to assess risks of management and maintenance activities on the watercourses. The first stage of the risk assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change.

Risks were assessed assuming full implementation of mitigation measures described for the operational and construction phase. All ratings fall within a Low Risk class (Table 4 and Table 5). It is important to note that while the Klip River floodplain does occur within 500 m of the road alignment, no activities will be undertaken within the delineated area of the wetland. The only potential impact to the floodplain wetland could be related to increased sediment inputs due to erosion of the bed and banks of the non-perennial watercourses feeding the wetland. This impact is however expected to be Low and is unlikely to increase more than the present-day situation. The hydrology and vegetation of the floodplain wetland will therefore remain unchanged. Maintenance of the bridge crossing the Olifants River will be restricted to repairing concrete and replacing bridge joints on the road surface and no activities will therefore take place within the bed and banks of the river.

Given the low impact associated with all activities highlighted in this report, and according to Government Notice 509 of August 2016 (RSA, 2016) of the National Water Act, the proposed rehabilitation and maintenance activities are Generally Authorised and do not require a Water Use License. While the rehabilitation is generally authorised, it is important to note that the water use activity should still be registered with the DWS. In this respect the following steps, as highlighted in the General Authorisation for Section 21 (c) and (i) water uses, are relevant:

1. Subject to the provisions of the General Authorisation, the applicant must submit the relevant registration forms to the responsible authority;
2. Upon completion of registration, the responsible authority will provide a certificate of registration to the water user within 30 working days of the submission;
3. On written receipt of a registration certificate from the Department, the applicant will be regarded as a registered water user and can only then commence with the water use as contemplated in the General Authorisation; and
4. The registration forms can be obtained from DWS Regional Offices or Catchment Management Agency office of the Department or from the Departmental website: http://www.dwa.gov.za/Projects/WARMS/Licensing/licensing1.aspx

Table 4: DWS Risk Assessment matrix for operational phase impacts associated with the rehabilitation of the TR75 road.

				Severity																	
Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**PES AND EIS OF WATERCOURSE**
Construction Phase	Design of stormwater infrastructure	Alteration of flow dynamics	Erosion of bed and banks	**1**	**1**	**3**	**1**	**2**	**1**	**1**	**4**	**1**	**3**	**5**	**1**	**10**	**35**	**Low**	**95**	See Impact 1	PES: B EIS: Low
	Extension and maintenance of culverts	Storage and management of construction materials	Physical disturbance to aquatic habitat	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**4**	**1**	**3**	**5**	**1**	**10**	**35**	**Low**	**95**	See Impact 2	
		Operation of heavy machinery and vehicles	Disturbance of aquatic habitat and water quality	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**4**	**1**	**3**	**5**	**1**	**10**	**35**	**Low**	**95**	See Impact 3	
		Increased human activity	Physical disturbance to aquatic habitat	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**3**	**5**	**1**	**10**	**30**	**Low**	**95**	See Impact 4	
		Disturbance of bed and banks	Erosion of bed and banks	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**4**	**1**	**3**	**5**	**1**	**10**	**35**	**Low**	**95**	See Impact 5	
	Widening the road	Widened road may extend into watercourses	Loss of aquatic habitat	**1**	**1**	**5**	**2**	**2**	**1**	**1**	**4**	**1**	**2**	**5**	**1**	**13**	**55**	**Low**	**95**	Cannot be mitigated	
	Repair to bridge crossing Olifants River	Storage and management of construction materials	Physical disturbance to aquatic habitat	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**5**	**1**	**8**	**24**	**Low**	**95**	See Impact 2	PES: D EIS: High (DWS, 2014)

Table 5: DWS Risk Assessment matrix for operational phase impacts associated with the rehabilitation of the TR75 road.

				Severity																	
Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**PES AND EIS OF WATERCOURSE**
Operational Phase	Operation of Culverts	Alteration of flow dynamics	Scour and erosion of bed and banks of watercourses	**1**	**1**	**3**	**1**	**2**	**1**	**1**	**4**	**1**	**3**	**5**	**1**	**10**	**35**	**Low**	**95**	See Impact 7	PES: B EIS: Low
			Increased sediment delivery to Klip River	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**3**	**5**	**2**	**11**	**33**	**Low**	**95**		
	Disturbed soil following construction activities	Establishment of alien invasive plant species	Disturbance of aquatic habitat	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**3**	**5**	**1**	**10**	**30**	**Low**	**95**	See Impact 8	

8 CONCLUSION

Rehabilitation of TR75/1 road will involve several activities that will affect watercourses. These include widening of the road and associated extension of culverts as well as maintenance of existing culverts. At the time of compiling this report no information was available as to which specific watercourses would be affected by a specific rehabilitation activity (i.e. extension of a culvert). Impacts described and assessed in this report are therefore generic to all watercourse crossings. The approach is however considered justified considering the similarity of all affected watercourses.

Given the relatively undeveloped catchment area the PES of each affected watercourse is B, Largely Natural. The watercourses are important in terms of connecting large areas of undisturbed terrestrial CBA areas to the lowland perennial Klip River system which runs along most of the length of the road alignment. For these reasons it is important that rehabilitation of the road is undertaken in a sensitive manner and that all mitigation measures are implemented. Given the existing presence of the road and railway and the impacts already present, it is unlikely that the rehabilitation activities will result in any further deterioration to the PES of the watercourses or the receiving Klip River and will also not contradict the management objectives associated with the provincial and national biodiversity and conservation plans for watercourses in the catchment. It is therefore recommended that environmental authorisation for the activities associated with the road rehabilitation should be granted. In terms of the NWA, considering the Low risk associated with all construction and operational phase activities the rehabilitation plan qualifies for a General Authorisation.

9 REFERENCES

CapeNature (2017). *2017 WCBSP Oudsthoorn [Vector] 2017*. Available from the Biodiversity GIS website, downloaded on 26 March 2019.

CSIR (2018). National Wetland Map 5 and Confidence Map [Vector] 2018. Available from the Biodiversity GIS website, downloaded on 15 February 202.

Department of Water and Sanitation (DWS). (2014). A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: [J3]. Compiled by RQIS-RDM: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx accessed on [2 April 2023].

DWAF (2005). *Final Draft: A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas*.

Milner, A.M. (1994). System recovery. In: Calow P and Petts GE (eds.): The rivers handbook. Vol. 2. Blackwell Scientific Publications. London.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (2011). *Technical Report for the National Freshwater Ecosystem Priority Areas project.* WRC Report No. 1801/2/11. Water Research Commission, Pretoria, South Africa.

Ollis, D.J., Snaddon, C.D., Job, N.M. and Mbona, N. (2013). *Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems.* SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria

Resh, V.H., Brown, A.P., Covich, M.E., Gurtz, H.W., Li, G.W., Minshall, S.R., Reice, A.L., Sheldon, J.B., Wallace and Wissmar, R.C. (1988). The role of disturbance theory in stream ecology. Journal of the North American Benthological Society. 7: 433-455.

10 APPENDICES

Appendix 1 – Index of Habitat Integrity

Index of Habitat Integrity (IHI; Kleynhans, 1996). The IHI was regarded as the most appropriate method for assessing riverine habitats as it is not dependent on flow in the watercourse and, therefore, produces results that are directly comparable across perennial and non-perennial systems. The IHI was developed as a rapid assessment of the severity of impacts on criteria affecting habitat integrity within a river reach. Instream (water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; rubbish dumping) and riparian (vegetation removal, invasive vegetation, bank erosion, channel modification, water abstraction, inundation, flow modification, physico-chemistry) criteria are assessed as part of the index. Each of the criteria are given a score (from 0 to 25, corresponding to no and very high impact, respectively – Table 6) based on their degree of modification, along with a confidence rating based on the level of confidence in the score.

Weighting scores are used to assess the extent of modification for each criterion (x):

$$Weighted\ Score = \frac{IHI_x}{25} \times Weight_x$$

Where;

- IHI = rating score for the criteria (Table 6);
- 25 = maximum possible score for a criterion; and
- Weight = Weighting score for the criteria (Table 7).

Table 6: Descriptive classes for the assessment of habitat modifications (Kleynhans, 1996)

Impact Class	Description	Score
None	No discernible impact, or the modification is located in a way that has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not affected.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Table 7: Criteria and weights used for the assessment of instream and riparian zone habitat integrity

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**		**100**

The estimated impacts of all criteria calculated this way are summed, expressed as a percentage and subtracted from 100 to arrive at an assessment of habitat integrity for the instream and riparian components, respectively. An IHI class indicating the present ecological state of the river reach is then determined based on the resulting score (ranging from Natural to Critically Modified – Table 8).

Table 8: Index of habitat integrity (IHI) classes and descriptions

Integrity Class	Description	IHI Score (%)
A	Unmodified, natural.	> 90
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.	80 – 90
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60 – 79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40 – 59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20 – 39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 – 19

Reference:

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

Appendix 2 – Ecological Importance & Sensitivity (River)

The ecological importance and sensitivity (EIS) of the watercourse was assessed using a method developed by Kleynhans (1999). In summary, several biological and aquatic habitat determinants are assigned a score ranging from 1 (low importance or sensitivity) to 4 (high importance or sensitivity). These determinants include the following:

- **Biodiversity support:**
    - Presence of Red Data species;
    - Presence of unique instream and riparian biota;
    - Use of the ecosystem for migration, breeding or feeding.
- **Importance in the larger landscape:**
    - Protection status of the watercourse;
    - Protection status of the vegetation type;
    - Regional context regarding ecological integrity;
    - Size and rarity of the wetland types present;
    - Diversity of habitat types within the wetland.
- **Sensitivity of the watercourse:**
    - Sensitivity of watercourse to changes in flooding regime;
    - Sensitivity of watercourse to changes in low flow regime, and
    - Sensitivity to water quality changes.

The median value of the scores for all determinants is used to assign an EIS category according to Table 9.

Table 9: Ecological importance and sensitivity categories. Interpretation of average scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3 and <=4	A
High: Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.	>2 and <=3	B
Moderate: Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use	>1 and <=2	C
Low/marginal: Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.	>0 and <=1	D

Reference:

Duthie, A. (1999). IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). Resource Directed Measures for Protection of Water Resources: Wetland Ecosystems. Department of Water Affairs and Forestry.

Appendix 3: Impact Assessment Methodology

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

Consequence = *type x (intensity + duration + extent)*

Where type is either negative (i.e. -1) or positive (i.e. 1). The significance of the impact was then calculated by applying the probability of occurrence to the consequence as follows:

Significance = *consequence x probability*

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

Table 10: Categorical descriptions for impacts and their associated ratings

Rating	Intensity	Duration	Extent	Probability
1	Negligible	Immediate	Very limited	Highly unlikely
2	Very low	Brief	Limited	Rare
3	Low	Short term	Local	Unlikely
4	Moderate	Medium term	Municipal area	Probably
5	High	Long term	Regional	Likely
6	Very high	Ongoing	National	Almost certain
7	Extremely high	Permanent	International	Certain

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

Table 11: Value ranges for significance ratings, where (-) indicates a negative impact and (+) indicates a positive impact

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

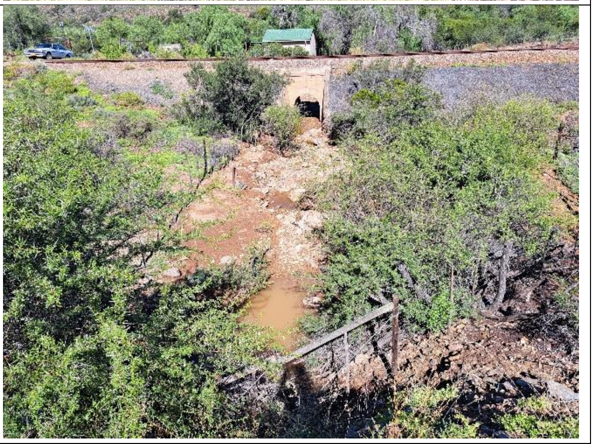
Each impact was considered from the perspective of whether losses or gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence was also determined and rated as low, medium or high (Table 12).

Table 12: Definition of reversibility, irreplaceability and confidence ratings.

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

Appendix 4 – Site Photographs

Upstream	Downstream
	
	
	
	

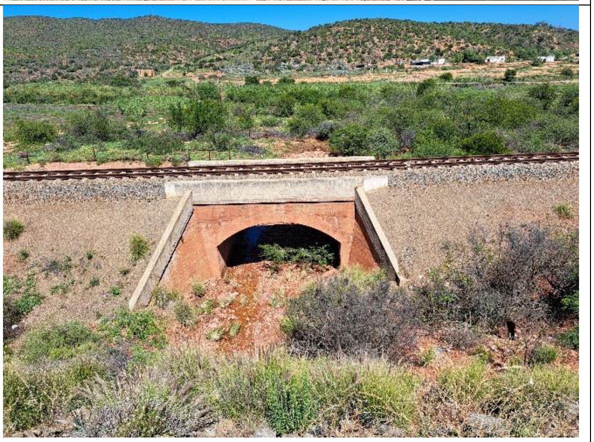
Upstream	Downstream
	
	
	
	

Upstream	Downstream
	
	
	
	

Upstream	Downstream
	
	
	
	

Upstream	Downstream
	
	
	
	

Upstream	Downstream
	
	
	
	

Upstream	Downstream
	
	
	
	


Olifants River