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Environmental Regulatory Process Comprising of an Amendment and Consolidation of the Environmental Management Programme (EMPr) and Integrated Water Use License (IWUL) associated with the Dorstfontein East Coal Mine, Mpumalanga Province

Aquatic Biodiversity & Impact Assessment

Prepared for:
Exxaro Central Coal (Pty) Ltd

Project Number:
EXX5725

April 2021

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Report Type:	Aquatic Biodiversity & Impact Assessment
Project Name:	Environmental Regulatory Process Comprising of an Amendment and Consolidation of the Environmental Management Programme (EMPr) and Integrated Water Use License (IWUL) associated with the Dorstfontein East Coal Mine, Mpumalanga Province
Project Code:	EXX5725

Name	**Responsibility**	**Signature**	**Date**
Tebogo Khoza *Cand.Sci.Nat.*	Data collation and report writer		September 2021
Byron Bester *Pr.Sci.Nat.*	Field survey, and technical review		April 2021

DETAILS AND DECLARATION OF THE SPECIALIST

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Qualification(s):	MSc. Biodiversity & Conservation
Experience (years):	2
Registration(s):	South African Council for Natural Scientific Professionals: *Candidate Natural Scientist* (Reg. No. 119651)

I, Tebogo Khoza, declare that: –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
  - I declare that there are no circumstances that may compromise my objectivity in performing such work;
  - I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority 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 the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and

- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

	30 September 2021
Signature of the Specialist	*Date*

Findings, recommendations and conclusions provided in this report are based on the best available scientific methods and the author's professional knowledge and information at the time of compilation. Digby Wells employees involved in the compilation of this report, however, accepts no liability for any actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, and by the use of the information contained in this document.

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Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) was appointed by Exxaro Central Coal (Pty) Ltd (ECC Mining) to undertake an Aquatic Biodiversity Assessment for the amendment and consolidation of the Environmental Management Programme (EMPr) and Integrated Water Use License (IWUL) associated with the Dorstfontein East Mine located near Kriel, in Mpumalanga.

The goal of the Aquatic Study is to describe the baseline conditions within the aquatic ecosystems associated with the proposed underground mine extension (hereafter the Proposed Project) prior to the commencement of construction activities. As part of the assessment, foreseeable aquatic-related impacts are also identified and appropriate mitigation measures provided for the preservation of the associated watercourses.

The Proposed Project lies within the Emalahleni Local Municipality of the Mpumalanga Province adjacent to the town of Kriel. The project area falls within primary drainage region B of the Olifants Water Management Area (WMA) and the B11B and B11D quaternary catchments, namely Sub-Quaternary Reaches (SQR) B11B-01327 (Olifants River) and B11D-01366 (Steenkoolspruit).

The timing of the baseline aquatic survey coincided with the late dry season for the Study Area. At the time of the survey, instream channels along some of the assessed sites were dry or non-flowing and as such, this may have negatively affected the adequacy of the utilised indices, which are primarily designed to be used exclusively in flowing/riverine systems.

Baseline Ecological Conditions

Systems of the Steenkoolspruit, as well as the Western Tributary of the Olifants River were dry at the time of the survey, as such, only the Eastern Tributary of the Olifants and the Olifants River were sampled. Amongst the water quality results, temperature values were recorded within typical summer season temperatures in South Africa. The pH values recorded exhibited close to neutral to slightly alkaline conditions, with all assessed sites partially exceeding the recommended guideline. Similarly, conductivity levels were elevated above the recommended guideline at all the sites. It is less likely that these findings can be attributed to the existing Dorstfontein East mining activities since sites upstream of the mines (i.e. Site ETO2 and Site O1) show similar water quality conditions to those downstream of the mine. It is therefore suspected that agricultural influences (i.e. nutrient runoff from crops and livestock) might be altering the pH and conductivity in the aquatic ecosystems. This was evidenced by the observed substantial algae within the watercourses. Furthermore, farmlands and livestock were observed throughout the survey in proximity to most of the monitoring sites.

The findings from the Index for Habitat Integrity (IHI) assessments conducted during the current survey indicate that the habitat integrity along the assessed Eastern Tributary of the Olifants and the Olifants River ranged from *Largely Modified* (Ecological Category D) to *Moderately Modified* (Ecological Category C). The main modifications to the instream component of the assessed reaches were those of agricultural and mining origin including

water abstraction, flow modification, water quality and inundation. Major modifications of the riparian habitat component include the removal of indigenous vegetation, consequently resulting in exotic vegetation encroachment. Also, damming of the systems has resulted in inundation.

The availability and integrity of aquatic macroinvertebrate biotopes were *Poor* across all sampled river reaches. The sites were dominated by shallow standing water with limited marginal vegetation. Sand and mud were the most prevalent biotopes within the watercourses. Consequently, the results of the South African Scoring System version 5 (SASS5) and Macroinvertebrate Response Assessment Index (MIRAI) indicate that conditions at the sampled reaches ranged between *Largely Modified* (Ecological Category D) and *Seriously Modified* (Ecological Category E) with macroinvertebrate community assemblages largely composed of taxa that have "*Low"* water quality requirements.

A total of 4 fish species were collected (or observed), of which one was regarded as alien invasive species (*Gambussia affinis*). A single species was sampled at the Eastern Tributary of the Olifants River (*Enteromius anoplus*) whilst 3 were sampled at the Olifants River. In general, the collected species are known to have a high preference/tolerance for slow-shallow water, modified water quality as well as no-flow conditions. Consequently, the sampled fish assemblages ranged from *Largely Modified* conditions to *Seriously-Critically Modified* conditions (Ecological Category E/F). This may have been attributed to: the timing of the survey; the migratory behaviour of some species; the modified water quality or low dissolved oxygen levels (which could not be determined at the time of the survey) and or the inefficiency of the sampling technique.

Following integration of the defined ecological conditions obtained for the instream biological integrity and the riparian component, it was determined that all assessed sites represented an integrated EcoStatus of *Largely Modified* (Ecological Category D).

Impact Assessment and Mitigation Measures

The potential surface related impacts associated with the Proposed Project were determined to be *Minor* for the associated Riverine systems and *Negligible* upon adequate implementation of mitigation measures. With gentle slopes for the associated watercourses, the Eastern Tributary of the Olifants River is approximately 400 m away from the closest point of the proposed infrastructure, whilst the Olifants River is approximately 2 km away.

An aquatic biomonitoring programme has been provided for the monitoring and preservation of the aquatic ecosystems associated with the Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might significantly affect aquatic biota.

Reasoned Opinion Whether Project Should Proceed

In light of the distances, gentle slope and existing impacts between the Proposed Project boundary and the aquatic ecosystems under study, highlighted foreseeable negative impacts are likely to occur following rainfall events. Furthermore, impacts of the Proposed Project onto the associated water courses are predicted to be *Negligible* upon implementation of mitigation measures.

No notable fatal flaws were identified during the current study, thus the Proposed Project may proceed with an immediate implementation of the mitigation measures and the aquatic biomonitoring programme must be adhered to throughout the operation and decommissioning phases to ensure no deterioration of the associated watercourses occur.

Recommendations

Based on the results of the current study, the following actions have been recommended to allow for commencement of the proposed Project:

- The non-perennial nature of the associated watercourses presents challenges in limiting the adequacy of the indices utilised for the River Ecostatus Monitoring Programme (REMP), therefore toxicity testing (screening-level) should be implemented for a minimum of three biological groups (i.e. algae, invertebrates, and fish) during the wet season periods and soil samples should be collected for invertebrate hatching through incubation during dry season. These should be coupled with the SASS5 technique and visual assessment of the watercourses.

The developed Aquatic Biomonitoring Programme must be adopted on an annual basis after commencement of the Construction Phase of the Project. This programme should continue for the life of the Project and for at least three years post the Decommissioning Phase.

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ACRONYMS, ABBREVIATIONS AND DEFINITION

ASPT	Average Score Per Taxa
CSIR	Council for Scientific and Industrial Research
DO	Dissolved Oxygen
DWS	Department of Water and Sanitation
EC	Ecological Category
EMPr	Environmental Management Programme
FRAI	Fish Response Assessment Index
IHAS	Invertebrate Habitat Assessment System
IHI	Index for Habitat Integrity
MIRAI	Macro-Invertebrate Response Assessment Index
MRA	Mining Rights Area
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Areas
PES	Present Ecological State
PCD	Pollution Control Dam
REMP	River EcoStatus Monitoring Programme
SAIAB	South African Institute of Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SASS5	South African Scoring System version 5
SQR	Sub-Quaternary Reach
TWQR	Target Water Quality Range
WMA	Water Management Area
WRC	Water Research Commission
WUL	Water Use Licenses
WWF	Worldwide Fund for Nature

Legal Requirement		Section in Report
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	iii
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	iii-iv
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	6
cA	And indication of the quality and age of the base data used for the specialist report;	N/A
cB	A description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	45
(d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	26
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of the equipment and modelling used;	21
(f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives;	1
(g)	an identification of any areas to be avoided, including buffers;	N/A
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	7
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	37
(k)	any mitigation measures for inclusion in the EMPr;	46
(l)	any conditions/aspects for inclusion in the environmental authorisation;	53
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	50
(n)	a reasoned opinion (Environmental Impact Statement) -	53

Legal Requirement		Section in Report
	whether the proposed activity, activities or portions thereof should be authorised; and	
	if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	8
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
(q)	any other information requested by the competent authority.	N/A

1. Introduction

Freshwater ecosystems provide habitat for a significant number of animal and plant species which constitute a valuable natural resource, in economic, cultural, aesthetic, scientific and educational terms (Schmeller *et al*., 2018). In most parts of the world, these systems are experiencing declines in biodiversity and some of the well documented threats include: overexploitation; water pollution; flow modification; destruction or degradation of habitat; and invasion by exotic species (Dudgeon *et al.*, 2006; Skowno *et al.*, 2019). Mining is one of the major industrial sectors, which alter and negatively impact the water quality of natural aquatic ecosystems (Dallas & Day, 2004). The conservation and management of these systems is thus essential for ensuring that the ecosystem diversity, functionality, and connectivity are maintained.

This aquatic ecology assessment entailed identifying the potential impact(s) of the proposed expansion of the underground mining area in surrounding water bodies associated with the Dorstfontein East Coal Mine operations.

Digby Wells Environmental (hereafter Digby Wells) was appointed by Katlego Coal (Pty) Ltd (ECC Mining) to undertake an Aquatic Biodiversity Assessment for the amendment and consolidation of the Environmental Management Plan standard River EcoStatus Monitoring Programme (REMP, previously referred to as the River Health Programme) techniques were used to ensure compliance with the conditions of the Environmental Management Programme (EMPr) and Integrated Water Use License (IWUL) associated with the Dorstfontein East Mine located near Kriel, in Mpumalanga.

Exxaro Central Coal (Pty) Ltd holds an approved Mining Right with reference number **MP 30/5/1/2/3/2/1 (51) MR** for opencast and underground mining at the Dorstfontein East Coal Mine (DECM) situated in the Mpumalanga Province. The current proposal aims to extend the existing approved underground mining area (approved under the ownership of Total Coal South Africa (Pty) Ltd) and introduce supporting infrastructure. ECC aims to extend the underground mining area of the 2 Seam and 4 Seam associated with the Mining Right.

The required infrastructure/activities proposed for the extension include (refer to Figure 1-2):

- Portal ventilation fan;
- Sewage Treatment Plant;
- Water Treatment Plant;
- Potable Water storage tank;
- Erikson Pond;
- A new 22 kV overhead powerline from the existing substation to a new 22kV substation;
- Run of Mine (ROM) Stockpile conveyor at portal;
- Change house;

- Lamp room;
- Office;
- Clinic;
- Stores;
- Workshop area;
- Stone dust silo; and
- Coal discard processing plant.

An environmental regulatory process comprising of an amendment and consolidation of the EMPr and Integrated Water Use License (IWUL) is required for the new proposals.

1.1 Project Description

This application pertains to the expansion of underground mining activities, as well as additional surface infrastructure. These activities are explained in more detail below.

1.1.1 Underground Mining

The project aims to expand the DECM's underground mining area within the existing Mining Right Areas MP30/5/1/2/51MR. DECM was previously owned by Total Coal South Africa (Pty) Ltd (Total) and was ceded to ECC on 20 August 2015, which has an approved Environmental Management Programme (EMPr), dated October 2017. ECC is now applying to expand the underground mining areas as approved under Total. Subsequently, additional coal reserves have been identified for mining, which are not covered under the existing approval. ECC is also approved to undertake underground mining of deeper coal reserves at DECM. The underground mining operations will be accessed from the existing Pit 2 open cast and Dorstfontein West operations (Figure 1-1 and Figure 1-2). DECM therefore intends to further extend the Life-Of-Mine (LOM) through the exploitation of these identified additional coal reserves between 2021 until 2034 (14 years).

In addition, a portion of Pit 3, which is approved for opencast mining, will now be included into the underground mining extension. The Pit 3 coal reserves are contained in Seam 4.

1.1.2 Additional Surface infrastructure

For the proposed expansion, DECM will require a new Sewage Treatment Plant, a new Water Treatment Plant, a water storage tank, and a coal discard processing plant (Figure 1-2).

1.1.2.1 Sewage Treatment Plant

DECM has an approved Sewage Treatment Plant (STP) on site, however, with the extension of underground operations additional sewage capacity is required. The plant will be in a "dirty water area" in the main workshop and office area and will service up to 220 people per day. The treatment plant will require 45 m^3 of water per day to process 16.2 kg of organic load. The plant is 3 m high, with a 2.3 m diameter, with a $10m^3$ volume. The STP will discharge into the existing Pollution Control Dams (PCDs).

1.1.2.2 Water Treatment Plant

The proposed Water Treatment Plant is located north of the main workshop and office area, also within a previously disturbed area. The plant will treat domestic wastewater only, therefore, no gypsum or brine by-products will result from the treatment process. The effluent emanating from the plant will be collected by the existing PCDs.

1.1.2.3 Water Storage tank

Water from the PCDs will be stored in a raw water tank with a capacity of $300m^3$. This dirty water will be fed into the sewage treatment plant.

1.1.2.4 Discard Processing Plant

A coal discard processing plant has been proposed to treat 100 kilotons per month (ktpm) of re-mined coal discard. The plant will process discard from both the existing discard dump and the Coal Handling and Preparation Plant (CHPP). The plant will also accommodate all future DECM discard production. The product will be transported to the plant feed stockpile area by means of truck haul and from there, fed into the plant through a conveyor.

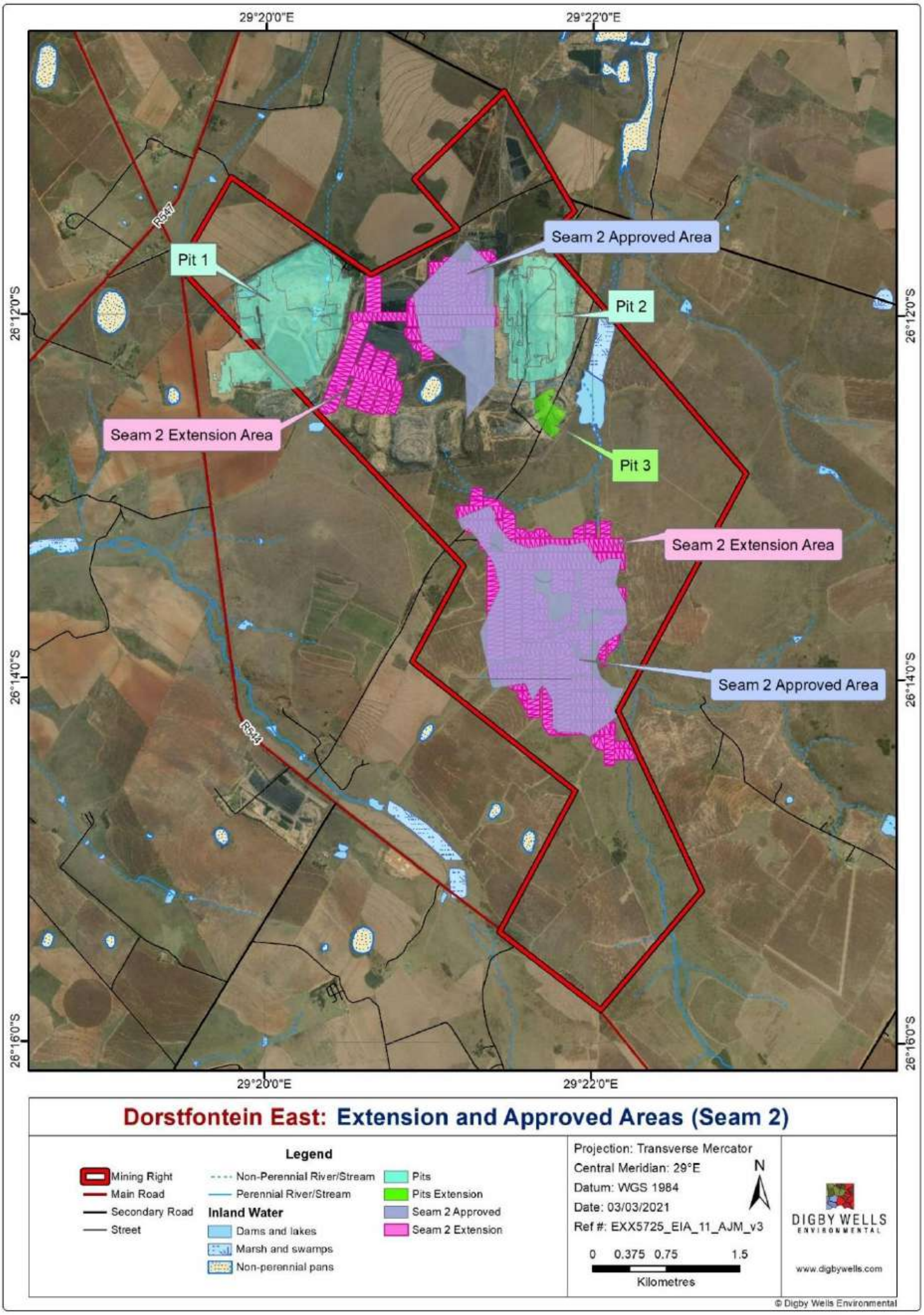

Figure 1-1: Approved and proposed underground areas (Seam 2)

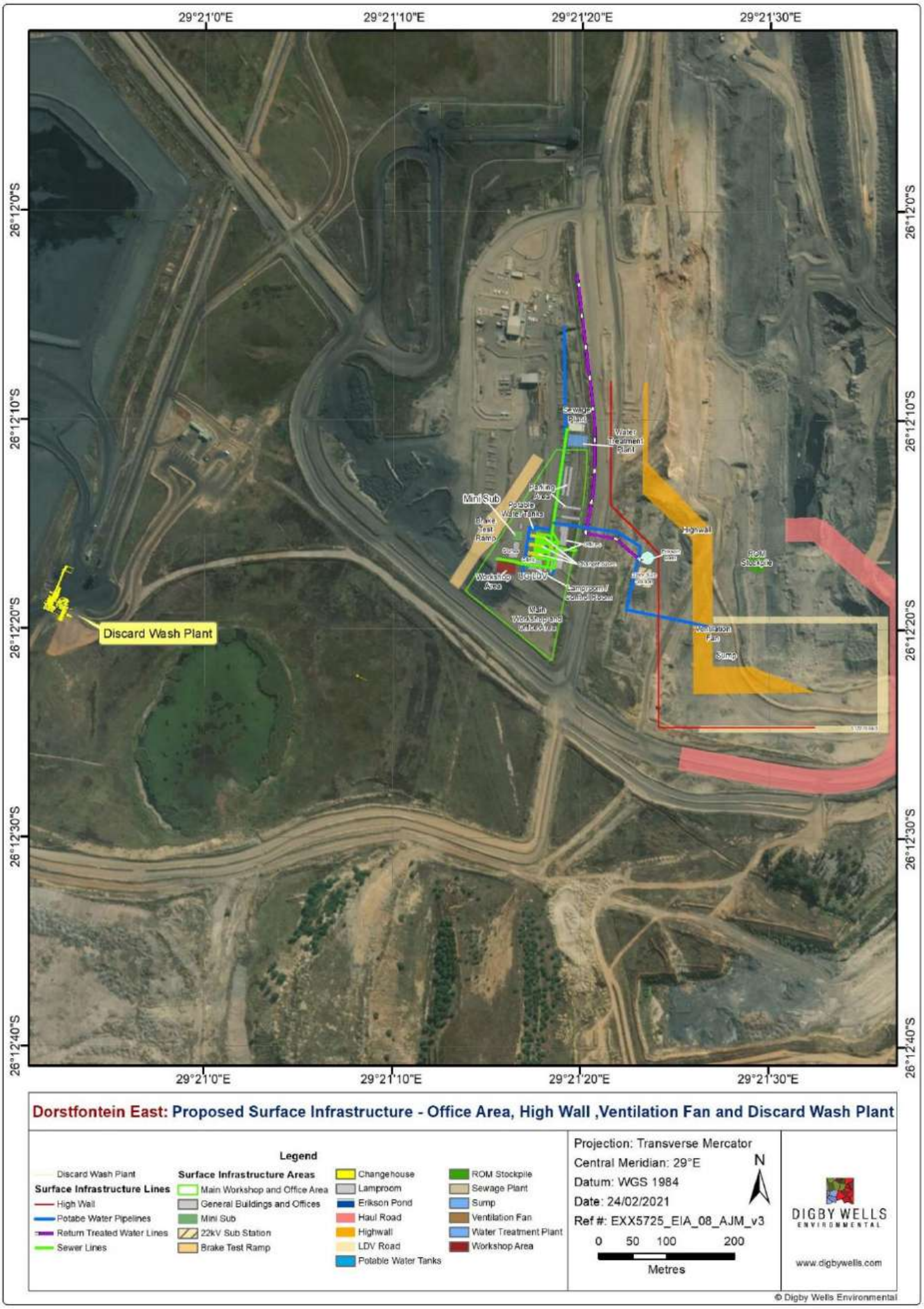

Figure 1-2: Surface Infrastructure Layout

1.2 Terms of Reference and Purpose of this Report

The terms of reference for the current study are as follows:

- Determine the baseline aquatic biodiversity assessment within the receiving watercourses associated with the proposed Project:
  - Determine the Present Ecological State (PES; or Ecological Category) of the associated watercourses, where possible.
- Assess the potential impacts upon the associated watercourses likely to originate from the proposed activity and associated infrastructure:
  - Identify potential impacts (incl. direct, indirect and cumulative) upon the associated watercourses implicated by the proposed infrastructure and mining operations to be undertaken within the study area;
  - Provide a professional opinion and assessment of the potential impacts (including assessment of duration, extent, magnitude, nature, etc.) of each of the identified potential impacts; and
  - Recommend appropriate mitigation measures, management objectives and interventions, as well as identify any potential fatal flaws associated with the proposed activities, if and when applicable.

1.3 Details of the Specialist/s

The following specialists were involved in the compilation of this report (CVs of the Project Team will be provided upon request):

Responsibility	**Data Collation and Report Compilation**
Full Name of Specialist	Tebogo Khoza
Highest Qualification	MSc. Biodiversity & Conservation
Years of experience in specialist field	2
Registration(s):	South African Council for Natural Scientific Professionals: *Candidate Natural Scientist* (Reg. No.119651)
Responsibility	**Field Survey, Data Collation, Report Compilation and Technical Review**
Full Name of Specialist	Byron Bester
Highest Qualification	MSc (Aquatic Health)
Years of experience in specialist field	10
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400662/15)

Responsibility	Senior Review
Full Name of Specialist	Danie Otto
Highest Qualification	MSc (Geography & Environmental Management)
Years of experience in specialist field	20
Registration(s):	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400096/02)

1.4 Assumptions, Exclusions and Limitations

The following limitations were made by the author at the time of writing:

- To obtain a comprehensive understanding of the dynamics of the biota present within a watercourse (e.g. migratory pathways, seasonal prevalence, etc.), studies should include investigations conducted during different seasons, over a number of years and through extensive sampling efforts. However, it should be noted that considering the short timeframes associated with the Environmental Authorisation process, only a single field survey has been undertaken and as such, the conclusions were based on data collected, a literature review, and professional experience.
- Some of the constraints observed during the field assessment include: a malfunction of the dissolved oxygen meter; systems which lacked connectivity wherein sampling was undertaken in isolated pools; some of the sites were dry; and most of the freshwater systems in the area were representative of non-perennial systems. Undertaking an aquatic biodiversity assessment in non-flowing systems may have limited the adequacy of the indices utilised due to their dependency on flowing water. Findings presented in this report should be reviewed in collaboration with the surface water and wetland reports.
- At the time of the impact assessment survey, the Dorstfontein West Operations were not part of the Proposed Project, thus did not form part of the current assessment.
- The Western Tributary of the Olifants and the Steenkoolspruit tributary are not expected to be impacted by the proposed activities as the watershed appears to drain towards the north-east and as such, were not included in the assessment.

2 Relevant Legislation, Standards and Guidelines

Aquatic-related legislation, standards, and guidelines applicable to the Project are listed and briefly discussed below (Table 2-1).

Table 2-1: Applicable legislation, regulations, and guidelines

Legislation, Regulation, Guideline or By-Law	Applicability
National Environmental Management Act (Act No. 107 of 1998) (NEMA): NEMA (as amended) was set in place under Section 24 of the Constitution. Certain environmental principles under NEMA must be adhered to, to inform decision making for issues affecting the environment. Section 24 (1)(a) and (b) of NEMA state that: *The potential impact on the environment and socio-economic conditions of activities that require authorisation or permission by law and which may significantly affect the environment must be considered, investigated and assessed before their implementation and reported to the organ of state charged by law with authorizing, permitting, or otherwise allowing the implementation of an activity.* The NEMA requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimised and treated.	• The listed activities of the Project have the potential to impact on the environment, specifically the associated aquatic ecology. Therefore, requiring environmental authorisation before commencement.
National Environmental Management Biodiversity Act (Act No. 10 of 2004) (NEM:BA) The NEM:BA regulates the management and conservation of the biodiversity of South Africa within the framework provided under NEMA. This Act regulates the protection of species and ecosystems that require national protection and considers the management of alien and invasive species. The following regulations which have been promulgated in terms of the NEM:BA are also of relevance.	• An Aquatic Impact Assessment has been undertaken to identify species protected under this Act as well as the impacts posed to biodiversity; and • Required mitigation measures will be included in the Environmental Management Plan (EMP) as part of Environmental Authorisation process.
National Water Act (Act No. 27 of 2014) (NWA): The NWA aims to protect, use, develop, conserve, manage and control water resources including rivers, dams, wetlands, the surrounding land, groundwater, as well as human activities that influence them. The NWA intends to protect these water resources against over exploitation and to ensure that there is water for social and economic development and water for the future.	• An Aquatic Impact Assessment has been undertaken to identify water resources (particularly riverine ecosystems) associated with the proposed Project and the impacts thereof.

Legislation, Regulation, Guideline or By-Law	Applicability
Mpumalanga Nature Conservation Act (Act No. 10 of 1998): This Act provides for the protection of wildlife, hunting, fisheries, protection of endangered fauna and flora as listed in the Convention on international Trade in Endangered Species of Wild Fauna and Flora, the control of harmful animals, freshwater pollution and enforcement within the Mpumalanga Province.	• An Aquatic Impact Assessment has been undertaken to identify potential occurrence of endangered aquatic species associated with the proposed Project.
The Mineral and Petroleum Resources Development Act (Act No.28 of 2002) (MPRDA) intends: • to make provision for equitable access to and sustainable development of the nation's mineral and petroleum resources; and • to provide for matters connected therewith.	• An aquatic ecology Impact Assessment was undertaken as part of the EIA Phase for the mining of Resources; • Environmental Management Plan and Monitoring Program is included in the EIA Phase; and • Recommendations to prevent, avoid, and rehabilitate possible impacts were assessed.
Protocol for the specialist assessment and minimum report content requirements for environmental impacts on terrestrial animal species This protocol provides the criteria for the specialist assessment and minimum report content requirements for impacts on terrestrial animal species for activities requiring environmental authorisation.	• The protocol was used in this Aquatic Study to comply with the minimum assessment and reporting requirements as set out by the Department of Environment, Forestry and Fisheries (2020).

3 Description of the Environment

The following sections briefly describe the biophysical attributes and provide a regional context for the proposed expansion area.

3.1 Project Locality

The proposed Project lies within the Emalahleni Local Municipality, situated in the southern part of the Nkangala District Municipality and within the Emalahleni Local Municipality in the northern part of the Gert Sibande District Municipality of the Mpumalanga Province adjacent to the town of Kriel. Other closest towns include Ogies, Emalahleni and Bethal (Figure 3-1).

3.2 Associated Watercourses

The water resources of South Africa are divided into quaternary catchments, which are regarded as the principal water management units in the country (DWA, 2011). These catchments represent the fourth order of the hierarchical classification system, in which the primary catchments are the major units. The primary drainages are further grouped into or fall under Water Management Areas (WMA) and Catchment Management Agencies (CMA). The Department of Water and Sanitation (DWS) has established nine WMAs and nine CMAs as contained in the National Water Resource Strategy 2 (2013) in terms of Section 5 subsection 5(1) of the National Water Act, 1998 (Act No. 36 of 1998). The establishment of these WMAs and CMAs is to improve water governance in different regions of the country, to ensure a fair and equal distribution of the Nations freshwater resources, while making sure that the resource quality is sustained.

The proposed project area falls within primary drainage region B of the Olifants WMA and the B11B and B11D quaternary catchments, namely Sub-Quaternary Reaches (SQR) B11B-01327 (Olifants River) and B11D-01366 (Steenkoolspruit, Figure 3-1 and Figure 3-2). The Olifants River is a third order stream, approximately 36 km in length, which drains from south-east along the north-eastern boundary of the project Area. The Steenkoolspruit is a third order stream, approximately 16 km in length, which drains from south along the western boundary of the project area.

The project area also includes numerous non-perennial drainage lines that each report to the Olifants River. Both SQR's drain into the Olifants River, a major river, which flows in a north-easterly direction into Mozambique and then joins the Limpopo River and drains into the Indian Ocean.

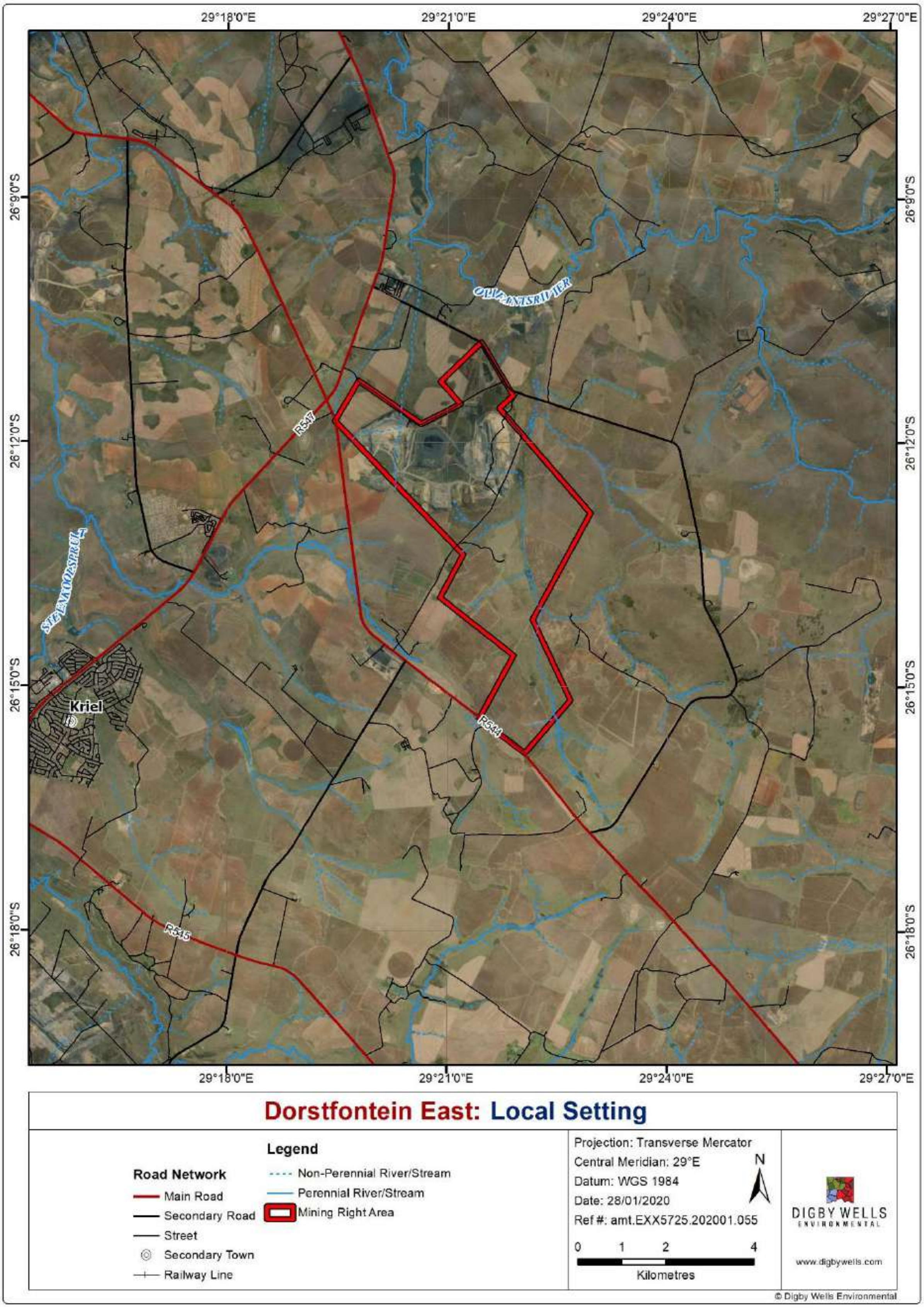

Figure 3-1: Map showing the regional setting of the Dorstfontein East Coal Mine

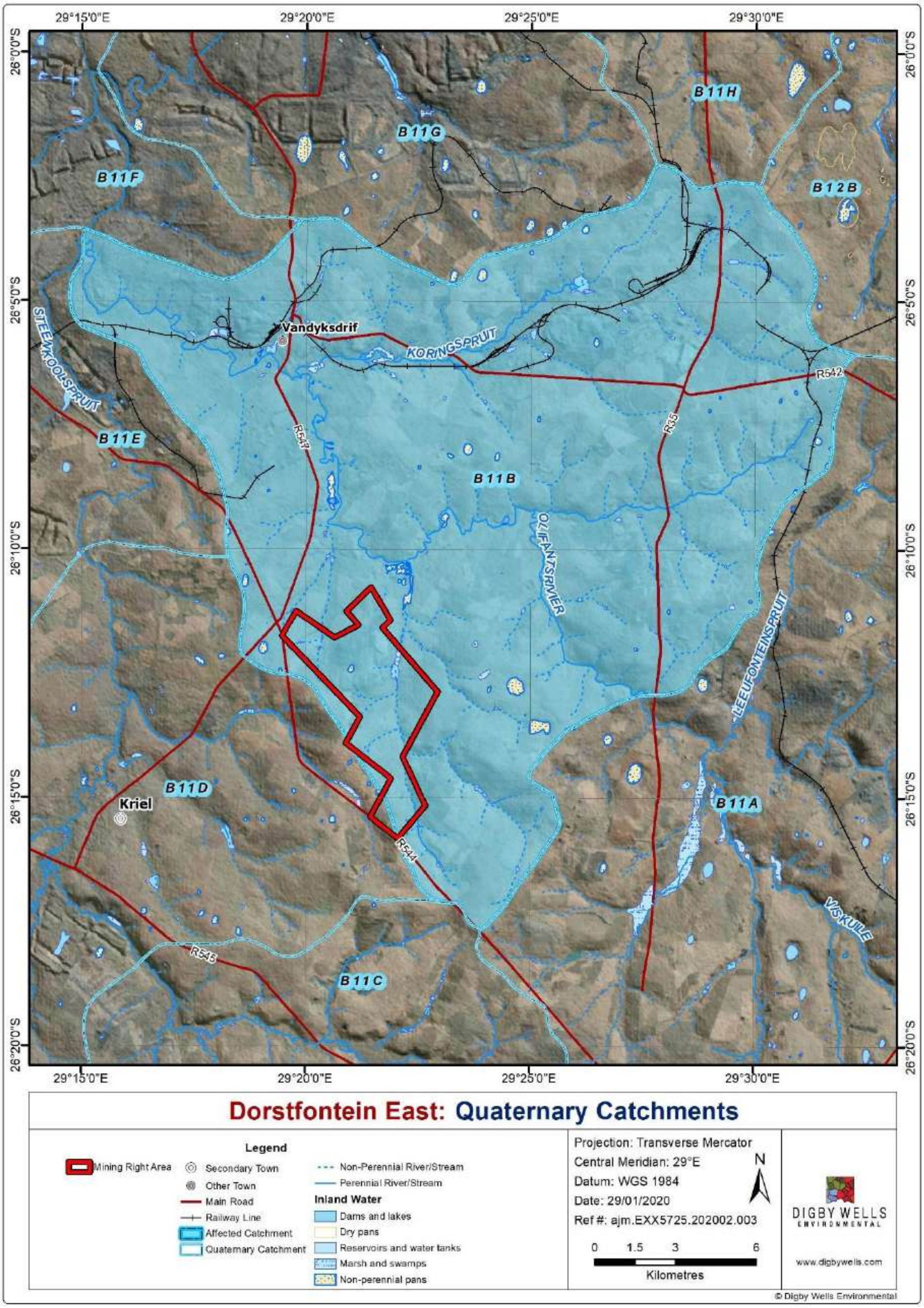

Figure 3-2: Quaternary Catchments and Regional Drainage associated with the Study Area

3.3 Regional Biodiversity Importance

3.3.1 Bioregional Context

The Southern Temperate Highveld global freshwater ecoregion is delimited by the South African interior plateaux sub-region of the Highveld aquatic ecoregion, of which the main habitat type (in terms of watercourse) is Savannah-Dry Forest Rivers (Darwall et al., 2009). Aquatic biota within this bio-region have mixed tropical and temperate affinities, sharing many species between the Limpopo and Zambezi systems (Skelton, 1990); Skelton *et al*., 1995; Darwall *et al*., 2009).

It should be noted that the level of biological and ecological investigation within this ecoregion was noted to be **high**, while the threats to this ecosystem integrity are also relatively well known, which have broadly been attributed to surface water abstraction and impacts associated with the human development and/or ‘footprint’ (Scott, 2015). Consequently, this global freshwater ecoregion has been defined largely by the temperate upland rivers and seasonal pans present throughout the area and is bio-regionally outstanding with a conservation status of Endangered (Nel *et al*., 2004; Darwall *et al*., 2009).

3.3.2 National Freshwater Ecosystem Priority Areas (NFEPA)

The National Freshwater Ecosystem Priority Areas (hereinafter NFEPA) project represents a multi-partnership between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). NFEPA specifically aims to:

- Identify Freshwater Ecosystem Priority Areas (hereinafter FEPAs) to meet national biodiversity goals for freshwater ecosystems; and
  - This aim is to accomplish systematic biodiversity planning to identify priorities for conserving South Africa’s freshwater biodiversity within the context of equitable social and economic development.
- Develop a basis for effective implementation of measures to protect FEPAs, including free-flowing rivers. This aim comprises of two separate components:
  - National component aimed to align DWA (or currently the DWS) and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems, while the
  - Sub-national component is aimed to use three case studies to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes.

- Maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver *et al*., 2011).

The project further aimed to maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation (Driver et al., 2011).

Based on the current outputs of the NFEPA project (Nel et al., 2011), none of the sub-quaternary catchments associated with the proposed project were identified as areas of potential concern. Upstream Water Management Areas occur south of the project area, however these areas occur to the south of the watershed, which drains in the opposite direction to the proposed project area (Figure 3-3).

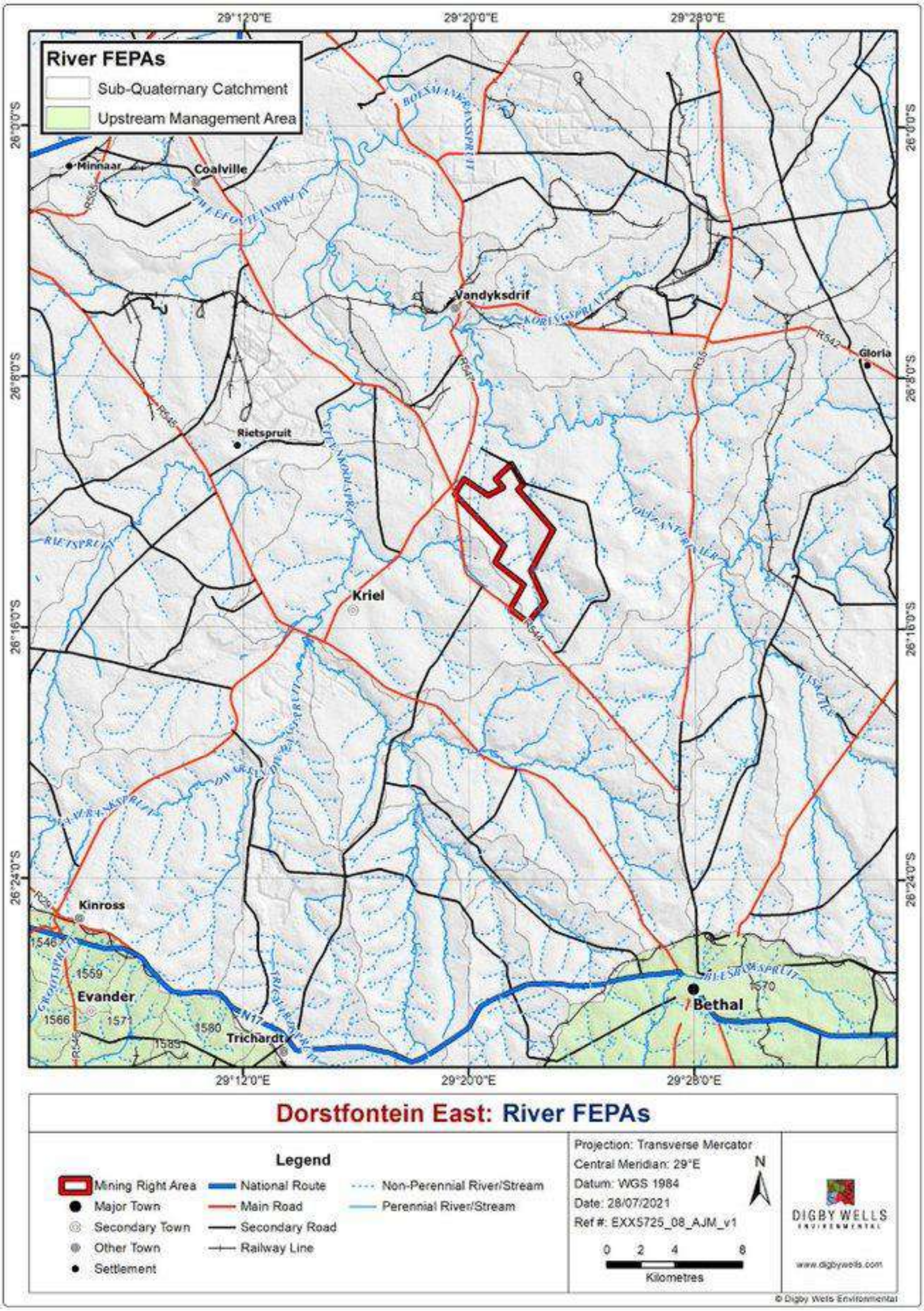

Figure 3-3 River FEPA's

3.3.3 Mining and Biodiversity Guideline

The Mining and Biodiversity Guideline was developed collaboratively by South African National Biodiversity Institute (SANBI), the Department of Environmental Affairs (DEA), the Department of Mineral Resources (DMR), the Chamber of Mines and the South African Mining and Biodiversity Forum (2013). The purpose of the guideline was to provide the mining sector with a manual to integrate biodiversity into the planning process, thereby encouraging informed decision-making around mining development and environmental authorizations. The aim of the guideline is to explain the value for mining companies to consider biodiversity management throughout the planning process.

The guideline highlights the importance of biodiversity in managing the social, economic and environmental risk of the proposed mining Project. The country has been mapped into biodiversity priority areas including the four categories each with associated risks and implications (Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, & South African National Biodiversity Institute, 2013, Table 3-1).

Table 3-1: Mining and Biodiversity Guideline Categories (DEA et al., 2013)

Category	Risk and Implications for Mining
Legally Protected	Mining prohibited; unless authorised by ministers of both the DEA and DMR.
Highest Biodiversity Importance	Highest Risk for Mining: the Environmental Impact Assessment (EIA) process must confirm significance of the biodiversity features that may be a fatal flaw to the proposed Project. Specialists must provide site-specific recommendations for the application of the mitigation hierarchy that informs the decision-making processes of mining licences, water use licences and environmental authorisations. If granted, authorisations should set limits on allowed activities and specify biodiversity related management outcomes.
High Biodiversity Importance	High Risk for Mining: the EIA process must confirm the significance of the biodiversity features for the conservation of biodiversity priority areas. Significance of impacts must be discussed as mining options are possible but must be limited. Authorisations may set limits and specify biodiversity related management outcomes.
Moderate Biodiversity Importance	Moderate Risk for Mining: the EIA process must confirm the significance of the biodiversity features and the potential impacts as mining options must be limited but are possible. Authorisations may set limits and specify biodiversity related management outcomes.

Two of the categories occur at the proposed project area i.e. **Highest Biodiversity Importance – Highest Risk for Mining** and **Moderate Biodiversity Importance – Moderate Risk for Mining** (Figure 3-4). However, the Proposed Project includes an underground mine extension and not open-cast, thus not expected to impact on the existing surface-related biodiversity features, if any. Furthermore, the Proposed Project lies in an area impacted by extensive mining and agriculture. The anticipated risks and mitigations for the proposed project are further discussed in section 7.

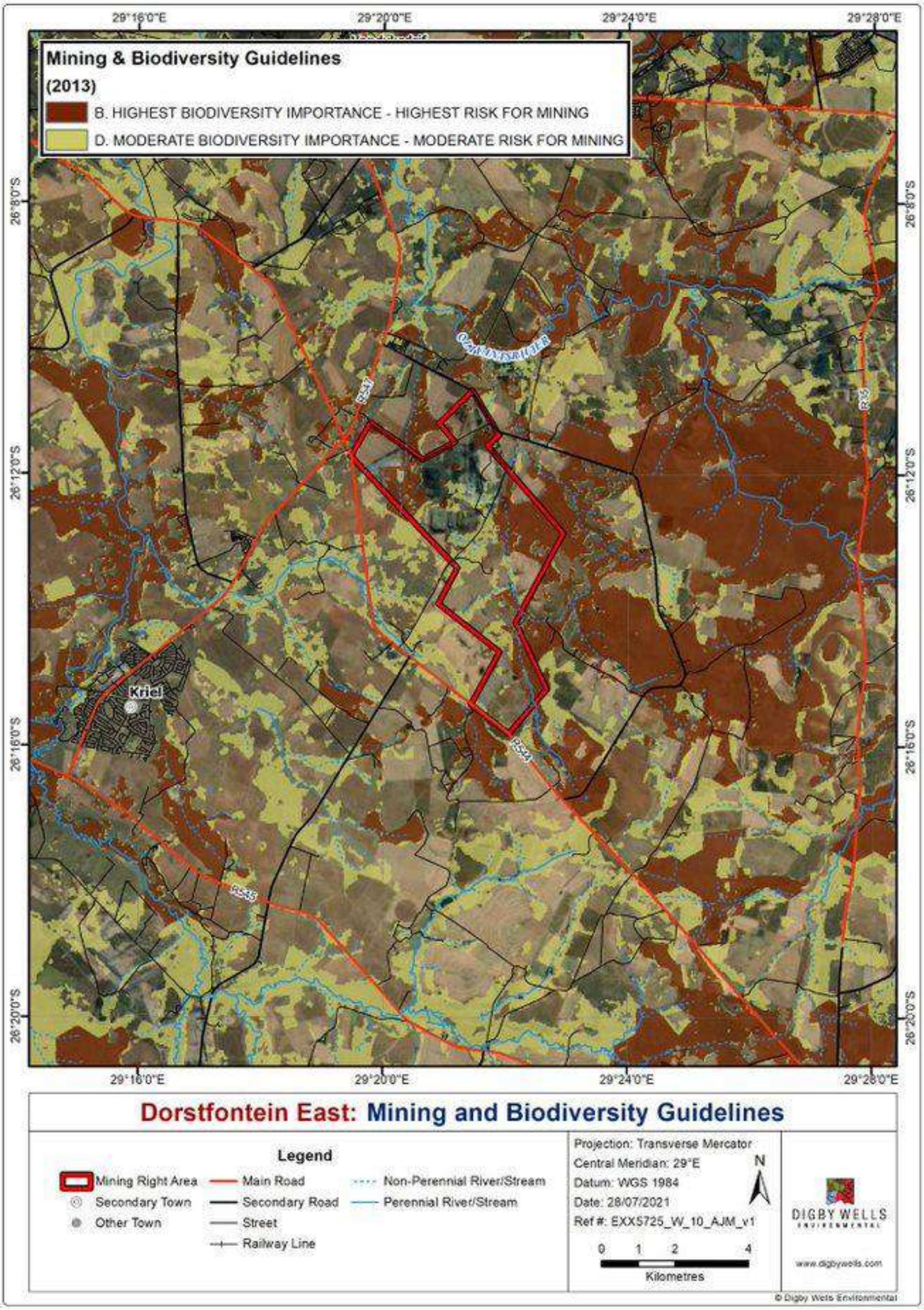

Figure 3-4: Mining and Biodiversity Guideline associated with the proposed Project Area

3.4 Mpumalanga Biodiversity Sector Plan

The Mpumalanga Biodiversity Sector Plan (MBSP) is a spatial tool that forms part of the national biodiversity planning tools and initiatives that are provided for national legislation and policy. The MBSP was published in 2014 by the Mpumalanga Tourism and Parks Agency (MTPA) and comprises a set of maps of biodiversity priority areas accompanied by contextual information and land-use guidelines for use in land-use and development planning, environmental assessment and regulation, and natural resource management. Strategically the MBSP enables the province to:

- Implement the NEM:BA, 2004 provincially, and comply with requirements of the National Biodiversity Framework, 2009 (NBF) and certain international conventions;
- Identify those areas of highest biodiversity that need to be considered in provincial planning initiatives; and
- Address threat of climate change (ecosystem-based adaptation).

The publication includes terrestrial and freshwater biodiversity areas that are mapped and classified in Protected Areas (PAs), Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs) or Other Natural Areas (ONAs).

Critical Biodiversity Areas (CBAs) with a bioregion are the portfolio of areas (i.e. map of CBAs for Mpumalanga Province), which if maintained in the appropriate respective condition (i.e. Land-use Guidelines) would meet the pattern targets for all biodiversity features, as well as ensure that areas necessary for supporting critical ecological processes remain functional. Based on these primary outputs (Figure 3-5), **CBA Irreplaceable**, **CBA Optimal**, and **ONAs**, areas occur at the east, south and west portions of the proposed project area (Table 3-2).

Table 3-2: Mpumalanga Biodiversity Sector Plan Categories Associated with the proposed Project, as well as recommended Land Management Objectives

Category	Description	Land Management Objective
CBA Irreplaceable and CBA Optimal	Areas of high biodiversity value, but are often also at risk of being lost through biodiversity-incompatible land-use practices.	They should remain in a natural state that is maintained in good ecological condition. CBAs are areas of high biodiversity value.
ONAs	Areas that have not been identified as a priority in the current systematic biodiversity plan but retain most of their natural character and perform a range of biodiversity and ecological infrastructural functions. Although they have not been prioritized for biodiversity, they are still an important part of the natural ecosystem.	An overall management objective should be to minimise habitat and species loss and ensure ecosystem functionality through strategic landscape planning. These areas offer the greatest flexibility in terms of management objectives and permissible land-uses, but some authorisation may still be required for high-impact land-uses.

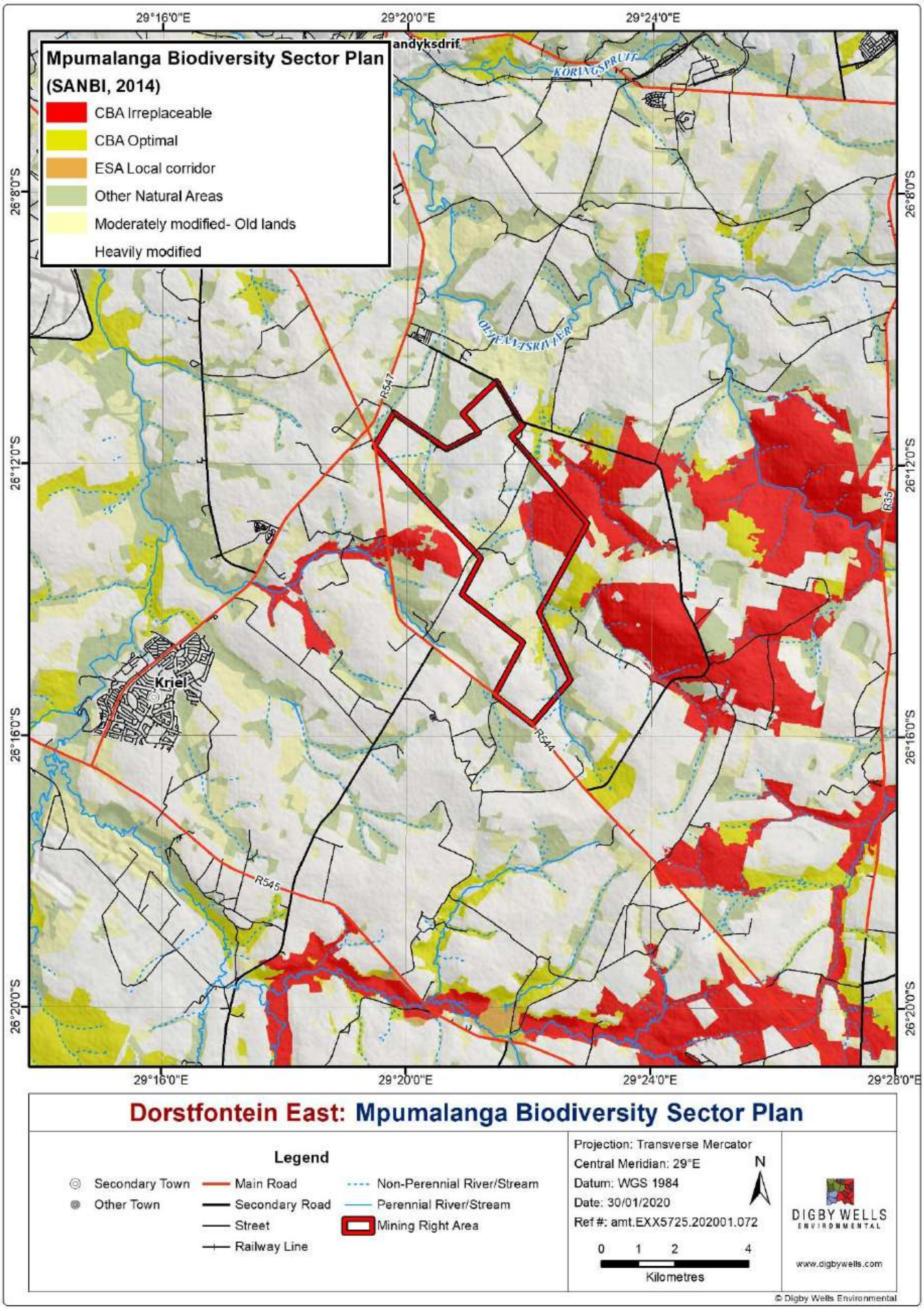

Figure 3-5: Mpumalanga Biodiversity Sector Plan features associated with the proposed Project

4 Study Directive

This section provides a brief description of field observations at the time of the field survey, a summary of the approach to the study, including each of the respective bioassessment indices utilised, as well as each of the selected monitoring sites.

4.1 Field Survey

This report presents the aquatic biodiversity observed within the aquatic ecosystems associated with the Mining Right Area (MREA), the field survey for which was conducted on the 10th September 2019 (i.e. late dry season survey).

4.2 Approach to Study

To enable an adequate description of the aquatic environment and the determination of the present ecological state, the following stressor, habitat, and response indicators were evaluated:

- **Stressor indicators:**
  - *In situ* water quality assessment (Temperature, pH, Electrical Conductivity, and Dissolved Oxygen), including comparison to applicable guideline values (if any) and identification of parameters of potential concern; and
- **Habitat indicator:**
  - Instream and riparian habitat conditions, utilising the Index for Habitat Integrity (IHI, version 2); and
  - Aquatic macroinvertebrate biotope evaluation through the Adapted Invertebrate Habitat Assessment System (IHAS, Version 2.2).
- **Response indicators:**
  - Aquatic macroinvertebrate assessment, including the determination of ecological condition through Version 5 of the South African Scoring System (SASS5) and the Macro-Invertebrate Response Assessment Index (MIRAI);
  - Ichthyological assessment, including the evaluation of reference conditions and determination ecological condition through the Fish Response Assessment Index (FRAI); and
  - Determination of the integrated EcoStatus (EcoStatus 4, Version 1.02).

A detailed description of each index/approach utilised in the baseline determination has been outlined in Appendix A.

4.3 Selection of sampling sites

To identify trends regarding the occurrence of species present within the watercourses associated with the study area, as well as provide a comparative basis for which future impacts can be evaluated, a number of sampling sites were strategically selected based on accessibility, availability of sampling habitat and relative proximity to associated potential impacts originating from the study area.

Co-ordinates of the sampling sites utilised during this investigation (Table 4-1) were determined using a Garmin global positioning device (GPS) and presented graphically in Figure 4-1. Photographs of the sites sampled are provided in Appendix B.

Table 4-1: Location and description of the selected sampling sites

Site	Co-Ordinates	Description
Unnamed tributary of the Olifants River, east of the mining right area		
ETO1	26°14'0.56"S 29°22'13.42"E	Located along an unnamed non-perennial drainage line on the eastern boundary of the mining right area
ETO2	26°11'28.50"S 29°22'12.84"E	Located at a river crossing downstream of Site ETO1 near the eastern boundary of the mining right area
Olifants River		
O1	26°10'4.90"S 29°22'28.62"E	Most upstream site on the Olifants River. Occurs at a river crossing upstream of the confluence with the unnamed non-perennial drainage line
O2 previously DES-5	26°10'9.48"S 29°21'24.49"E	Located at a river crossing downstream of Site O1 along the Olifants
O3 previously DES-3	26° 8'10.82"S 29°20'42.19"E	Most downstream site on the Olifants River. Occurs at a river crossing downstream of Site O2
Unnamed tributaries of the Olifants River, north of the mining right area		
WTO1 previously DES-1	26°10'17.37"S 29°20'24.37"E	Located along an unnamed non-perennial drainage line near the northern boundary of the mining right area at a road crossing
WTO2 previously DES-2	26°10'22.05"S 29°20'34.10"E	Located along an unnamed non-perennial drainage line adjacent to Site WTO1 at a road crossing

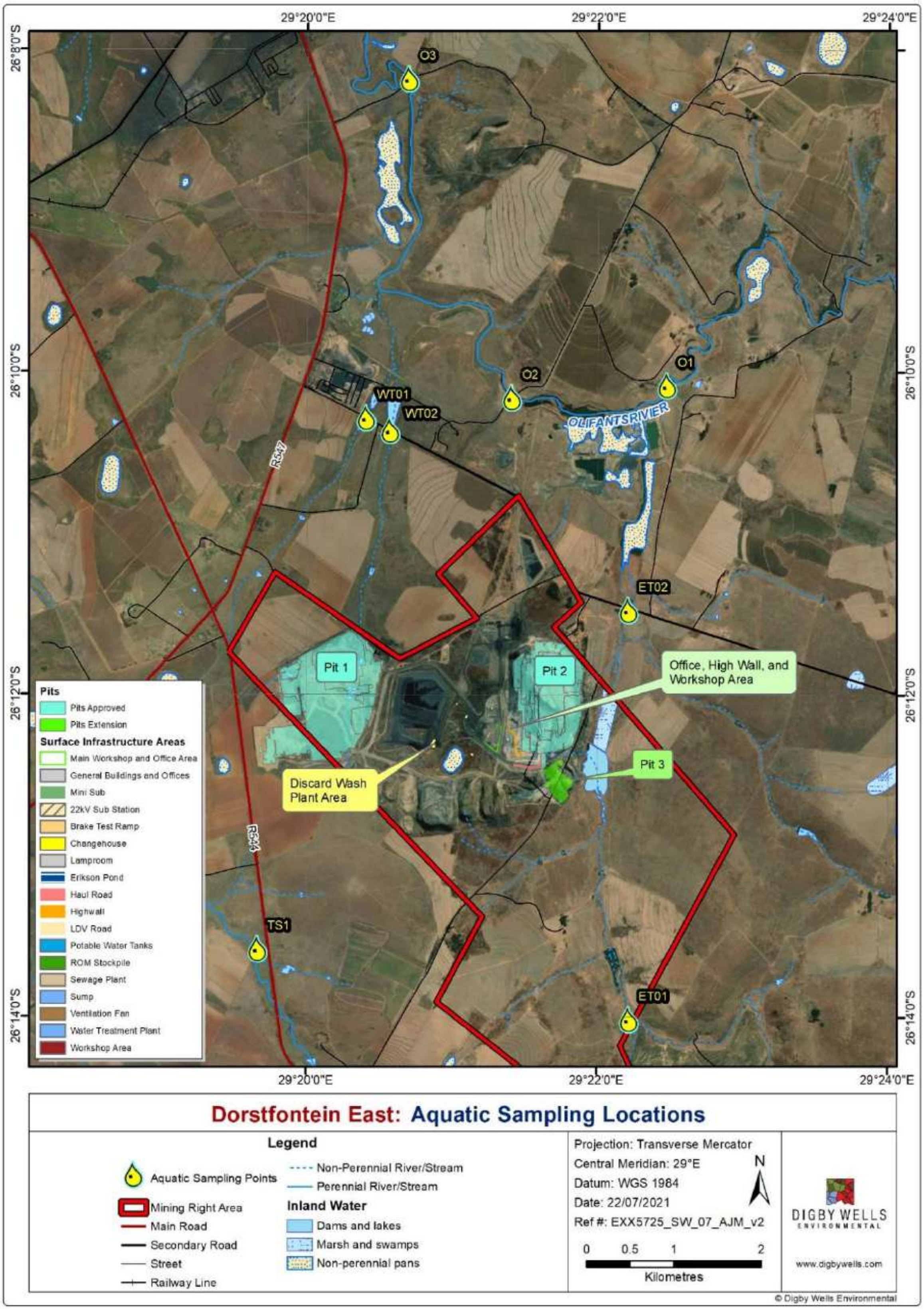

Figure 4-1: Aquatic Biomonitoring sites

5 Desktop Information

The Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) information available for the considered aquatic ecosystems in the Department of Water and Sanitation 1:500 000 river layer (DWS, 2014) is discussed below.

5.1 Desktop Present Ecological State, Importance and Sensitivity

Table 5-1 outlines the desktop aquatic-related data obtained for the Olifants B11B-01327 Sub-Quaternary Reach (SQR) and the Steenkoolspruit B11D-01366 SQR (DWS, 2014). Figure 3-2 displays the potentially affected watercourses and Olifants.

According to the desktop data obtained for the Olifants, the reach appears to be in a Moderately Modified state (i.e. Ecological Category C), while the Steenkoolspruit is in a Largely Modified state (i.e. Ecological Category D; DWS, 2014). Agricultural and mining land uses appear to be present in the upper reaches of the Olifants associated with the project area.

According to the DWS (2014), impacts associated with agricultural activities such as water abstraction; exotic vegetation; small dams; cattle trampling; vegetation removal; and those associated with mining activities, such as effluent run-off appear to be affecting the current aquatic ecology associated with the Olifants SQR. Within regards to the Steenkoolspruit SQR, a high urban density area occurs upstream, within the proximity of the project area. Agricultural and mining activities are also prevalent around the SQR with impacts such as water abstraction; road-crossings; erosion; exotic vegetation; increased sedimentation; small dams; cattle trampling; and effluent run-off (DWS, 2014).

Table 5-1: Desktop Aquatic data pertaining to the Olifants River and Steenkoolspruit

Aquatic Component	Olifants River	Steenkoolspruit
SQR Code	**B11B-01327**	**B11D-01366**
Ecological Category	**C**	**D**
Category Description	Moderately Modified	Largely Modified
Ecological Importance (EI)	High	Moderate
Ecological Sensitivity (ES)	High	High

The Ecological Importance of the Olifants River SQR has been classified as "*High*" with good pool-channel habitats and shrubs on the banks. A total of 45 macroinvertebrate taxa, as well as a total of 7 indigenous fish species are expected to occur at the Olifants SQR. The Ecological Importance of the Steenkoolspruit SQR has been classified as "Moderate" and expected to contain a total of 45 macroinvertebrate taxa, as well as a total of 5 indigenous fish species. Two macroinvertebrate taxa are known to occur at the Olifants SQR and not at the Steenkoolspruit SQR (i.e. Elmidae and Tabanidae) and two macroinvertebrate taxa are known to occur at the Steenkoolspruit SQR and not at the Olifants SQR (i.e. Haliplidae and Muscidae) (see Table 5-2).The latter SQR consists of all fish species found at the Olifants River, excluding *Labeobarbus polylepis* (Smallscale Yellowfish) and *Enteromius* cf. *neefi* (Sidespot

Barb). The Sidespot Barb is however, currently under assessment within South Africa as the population is distinct to the true *E. neefi* population existing in Angola, Zambia and the Democratic Republic of Congo (Moelants and Tweddle, 2018). This species has therefore been removed from the list of expected fish in the project area for the current assessment. In terms of their conservation status, all the expected fish species are listed as Least Concern (Table 5-3).

The Ecological Sensitivity for the SQR's has been classified as "*High*". This, from an instream perspective, is mainly due to the macroinvertebrates' and fish sensitivity towards physicochemical and flow velocity modifications.

5.1.1 Expected Aquatic Macroinvertebrates

The expected aquatic macroinvertebrate taxa for the project area of concern are presented in Table 5-2.

Table 5-2: Expected Macroinvertebrate taxa in the Project Area

Family names		
Turbellaria	Gerridae	Hydraenidae
Oligochaeta	Hydrometridae	Hydrophilidae
Hirudinea	Naucoridae	Ceratopogonidae
Potamonautidae	Nepidae	Chironomidae
Atyidae	Notonectidae	Culicidae
Hydracarina	Pleidae	Muscidae
Baetidae 2 sp	Veliidae/Mesoveliidae	Tabanidae
Caenidae	Ecnomidae	Simuliidae
Leptophlebiidae	Hydropsychidae 1 sp	Ancylidae
Tricorythidae	Hydropsychidae 2 sp	Bulininae
Coenagrionidae	Hydroptilidae	Lymnaeidae
Aeshnidae	Leptoceridae	Physidae
Gomphidae	Dytiscidae	Planorbinae
Libellulidae	Elmidae/Dryopidae	Corbiculidae
Belostomatidae	Gyrinidae	Sphaeriidae
Corixidae	Haliplidae	Unionidae
Green = high physio-chemical sensitivity; Blue = high-velocity dependence; Orange = both high physio-chemical sensitivity and velocity dependence		

Based on the prevalence of mining and agricultural land use in the adjacent land areas associated with the project area, the water in the associated aquatic ecosystems is expected to be of modified quality (DWS, 2014).

5.1.2 Expected Fish Species

The fish species expected in the reaches associated with the project area have been provided for in Table 5-3 (DWS, 2014). Additionally, each species sensitivity ratings towards physio-chemical and no-flow conditions have been provided for, together with their conservation statuses according to DWS (2014) and the IUCN Red List of Threatened Species (2018).

Within the reaches associated with the project area, a total of six fish species are expected. All six species are expected to occur within the Olifants River (SQR B11B-01327) and five are expected to occur at the Steenkoolspruit (SQR B11D-01366). Two of the six species are regarded as moderately intolerant towards water quality changes and no-flow conditions, namely *Enteromius paludinosus* and *Labeobarbus polylepis*. *E.paludinosus* prefers quiet, well-vegetated waters and slow-flowing streams, while *L. polylepis* prefers deep pools and flowing waters of permanent rivers and dams (Skelton, 2001). Such habitat was observed to be present along the Olifants. However, *E.paludinosus* is considered sensitive to changes in flow conditions, while *L. polylepis* is considered sensitive to changes in water quality. Therefore, it is of low confidence that these species are present in the reaches given the Present Ecological States (see Table 5-3).

Table 5-3: Expected Fish Species in the Reaches associated with the Project Area

SQR		Fish Species	Common Name	Tolerance/ Sensitivity		Status
				Physio-chemical	No-flow	
Olifants River		*Labeobarbus polylepis*	Smallscale Yellowfish	2.9	3.3	LC
Olifants River	Steenkoolspruit	*Enteromius anoplus*	Chubbyhead Barb	2.6	2.3	LC
Olifants River	Steenkoolspruit	*Enteromius paludinosus*	Straightfin Barb	3.3	2.8	LC
Olifants River	Steenkoolspruit	*Clarias gariepinus*	Sharptooth Catfish	1.0	1.7	LC
Olifants River	Steenkoolspruit	*Pseudocrenilabrus philander*	Southern Mouthbrooder	1.4	1.0	LC
Olifants River	Steenkoolspruit	*Tilapia sparrmanii*	Banded Tilapia	1.4	0.9	LC

Tolerance: 1-2 = tolerant, 4-5 = sensitive, **Conservation Status:** LC=Least Concern

6 Results and Discussion

The findings for the September 2019 survey have been detailed in the respective subsections below. It should be noted that the Western Tributary of the Olifants and the Steenkoolspruit tributary are not expected to be impacted by the proposed activities as the watershed appears to drain towards the north-east and as such, were not included in the following sections.

6.1 *In situ* Water Quality

Due to the highly dynamic nature of lotic (or flowing) systems, water quality conditions have been known to vary substantially on a temporal scale (e.g. seasonality) and along the longitudinal profile of the watercourse (Dallas & Day, 2004). Despite these variations, the assessment of selected water quality parameters is important for the interpretation of results obtained during biological investigations, as aquatic organisms are directly influenced by the environment in which they live. Accordingly, selected *in situ* water quality parameters were measured at each of the identified monitoring sites prior to sampling. The results of the *in situ* water quality assessment are provided in Table 6-1 for the Olifants River and the Eastern Tributary of the Olifants.

Table 6-1: *In situ* water quality parameters recorded within the Olifants River and associated tributary

Site	Eastern tributary of the Olifants		Olifants River			Guideline Values
	ETO1	ETO2	O1	O2	O3	
Temperature (˚C)	18.7	DRY	17.2	22.2	20.6	5-30
pH	**8.80**		**9.68**	**9.31**	**9.17**	6-8
Conductivity (µS/cm)	**882**		**505**	**703**	**844**	<500
Red values indicate constituents exceeding recommended guidelines for aquatic life						

For the purposes of the current assessment, each of the values recorded at the time of the survey were compared against various water quality guidelines originating from the following sources:

- Temperature and pH guidelines obtained from Department of Water Affairs and Forestry (1996); and
- Conductivity guideline value of 500 µS/cm stipulated in U.S. Environmental Protection Agency (2010).

For the ease of interpreting the water quality data gathered for the various assessed ecosystems, the results have been separated for each considered reach for the relevant assessments where applicable.

6.1.1 Eastern Tributary of the Olifants

It should be noted that Site ETO2 was dry at the time of sampling, thus *in situ* findings for Site ETO1 only are discussed. Water temperature was recorded within the normal temperature range for rivers in South Africa (Department Of Water Affairs And Forestry, 1996), therefore aquatic biota was not expected to be deterred due to temperature. Recorded pH and conductivity levels were however above the recommended guidelines (Department Of Water Affairs And Forestry, 1996; U.S.EPA 2010).

The recorded pH level was slightly alkaline (pH 8.8), this was likely as a result of the natural process of photosynthesis, wherein the removal of CO_2 alters with the carbonate/bicarbonate equilibrium resulting in elevated levels of pH. This was also evidenced by the observed presence of algae along the river reach (Figure 6-1). The algae was also an indication of mild eutrophication possibly facilitated by agricultural runoff from the adjacent crop cultivation, which could also be linked to the recorded elevated conductivity level (882 µS/cm)

(Department Of Water Affairs And Forestry, 1996). Furthermore, the system was observed to be incised and eroded.

Figure 6-1: Algae along the Eastern Tributary of the Olifants at the time of the survey

6.1.2 Olifants River

Along the Olifants River, pH levels were alkaline (ranging from pH 9.17 at Site O3 to pH 9.68 at Site O1), thus the pH was recorded above the recommended guideline (Department Of Water Affairs And Forestry, 1996). Similarly, conductivity levels were elevated and recorded above the recommended guideline at all the sites (Department Of Water Affairs And Forestry, 1996). Conductivity values ranged from 505 µS/cm at Site O1 to 844 µS/cm at Site O3.

Similar to the Eastern Tributary of the Olifants, the assessed main stem Olifants River reaches appeared to be impacted by nutrient enrichment, which was evidenced by the presence of excessive algae at the time of the survey (Department Of Water Affairs And Forestry, 1996; Divya, 2012). Both systems are suspected to be impacted by the surrounding agricultural activities through surface run-off of nutrients/fertilizers.

Nonetheless, the pH levels recorded during the current survey were not expected to notably deter the presence of sensitive aquatic biota (Department of Water Affairs and Forestry, 2009).

6.2 Aquatic and Riparian Habitat

Assessment of aquatic habitat was based largely on the application of recognised assessment indices at each of the selected sampling points within the assessed watercourses, namely the Index for Habitat Integrity (IHI). The IHI is a rapid, field-based, visual assessment of modifications to a number of pre-selected biophysical drivers (i.e. semi-quantitative) used to determine the Present Ecological State (PES, or Ecological Category) of associated instream and riparian habitats.

6.2.1 Index for Habitat Integrity

The IHI was completed on a desktop level for each aquatic ecosystem considered in the Study and populated with observations recorded during the field survey (Table 6-2).

Table 6-2: Index for Habitat Integrity for the Dorstfontein East study area

Assessed Reach	Habitat Component	IHI Score	Ecological Category
Olifants Eastern Tributary	Instream	54.9	D
	Riparian	61.2	C
Olifants River	Instream	67.3	C
	Riparian	65.2	C

The findings from the IHI assessments conducted indicate that the habitat components ranged from *Largely Modified* (Ecological Category D) to *Moderately Modified* (Ecological Category C) within the Study Area. In general, the main modifications to the assessed reaches of the Olifants River are of agricultural and mining origin. Water abstraction, flow modification, water quality and inundation as a result of the farming practices and mining activities.

The riparian habitat was categorised as *Moderately Modified* (Ecological Category C) at the assessed reaches largely due to activities of agricultural origin. Farmlands have replaced and encroached on pre-existing habitat, resulting in a loss of riparian species. Additionally, damming of the system has resulted in inundation of mainly the upper reaches. It appears that this has also resulted in a replacement of typical woody riparian plant species to more wetland suited grass species (DWS, 2014).

6.3 Aquatic Macroinvertebrate Assessment

The following sections provides insights into the available habitat that was sampled at each respective monitoring sites at the time of the current survey, as well as the South African Scoring System (SASS, Version 5) metrics obtained and the subsequent determination of the ecological condition of the observed assemblages in relation to reference conditions.

6.3.1 Invertebrate Habitat Assessment System

The Invertebrate Habitat Assessment System (IHAS, Version 2.2), developed by McMillan (1998), has routinely been used in conjunction with the South African Scoring System (SASS) as a measure of variability in the quantity and quality of representative aquatic macroinvertebrate biotopes available during sampling. However, according to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores with regards to the suitability of habitat for aquatic macroinvertebrates at assessed sampling sites, as its performance appears to vary between geomorphologic zones and biotope groups (Ollis *et al*., 2006). While no final conclusion can be made regarding the accuracy of the index until further testing has been conducted, these potential limitations and/or shortfalls should be noted.

Nevertheless, due to the value of basic habitat assessment data and its suitability for comparison of available macroinvertebrate habitats between various sampling sites, an adapted IHAS approach (exclusion of the surrounding physical stream condition) was maintained during the interim period (Table 6-3).

Table 6-3: Invertebrate Habitat Assessment System findings for the Aquatic Study

Sampling Site	IHAS Score (%)	Interpretation
Eastern Tributary of the Olifants		
ETO1	40	Poor
ETO2	DRY	
Olifants		
O1	40	Poor
O2	35	Poor
O3	29	Poor

All of the results for the IHAS conducted for the sampling sites classified the available macroinvertebrate habitat as ‘Poor’. Sites at the Olifants River reach as well as the Eastern Tributary of the Olifants were mostly dry with sections of pooled water (Figure 6-2). The sampled sites were dominated by shallow, still and/or slow-flowing water and a lack of the stones biotope was a common feature throughout the sites.

Figure 6-2: Pooled water observed along the unnamed eastern tributary of the Olifants River

6.3.2 Benthic Communities and Composition

Due to their differential sensitivities, the composition of aquatic macroinvertebrates can provide an indication of changes in water quality and other conditions within a watercourse. The use of the South African Scoring System (SASS) has undergone numerous advances, culminating in Version 5 presently being utilised in river health studies along with the application of the Macroinvertebrate Response Assessment Index (MIRAI). However, it should be noted that the application of these indices within non-flowing/wetland systems should be used with caution, as these assessment indices were primarily designed to be used exclusively within riverine systems. Nevertheless, these methods were deemed to be sufficient for monitoring purposes within the associated channelled systems despite their potential limitations, as the primary intention was to standardise the monitoring approach. SASS5 data collected within the study area is presented in Table 6-4.

Within the Olifants river reach, the highest SASS5 score was obtained at the most upstream Site O1, followed by Site O3, then Site O2 with the least SASS5 score. However, the Average Score Per Taxon (ASPT) at Site O3 was the lowest of all, indicating that the sampled assemblage predominantly consisted of less sensitive taxa compared to Site O2. The lower SASS score obtained at the site immediately below mining areas suggests impacts associated with mining activities in addition to agricultural activities.

The aquatic macroinvertebrate community assemblages were predominantly composed of taxa that have "Low" water quality requirements. Of the collected invert families, only 8 families with a "Moderate" water quality requirement (i.e. SASS sensitivity score of 7-11), thirteen with a “Low” requirement and fourteen with a “Very Low” requirement were collected throughout the sampled sites. The highest scoring taxa, Polymitarcyidae and Dixidae (SASS score of 10) were both collected at the Olifants Site O1.

Table 6-4: SASS5 scores recorded during the September 2019 survey

Sampling Site	SASS5 Score	No. of Taxa*	ASPT**
Eastern Tributary of the Olifants			
ETO1	107	25	4.28
ETO2	DRY		
Olifants			
O1	137	28	4.89
O2	57	12	4.75
O3	75	17	4.41
*Number of individual macroinvertebrate families sampled; **Average Score per Taxon			

6.3.3 Ecological Condition of the Aquatic Macroinvertebrate Assemblages

Although Chutter (1998) originally developed the SASS protocol as an indicator of water quality, it has since become clear that the SASS approach gives an indication of more than mere water quality, but also a general indication of the current state of the macroinvertebrate community. While SASS does not have a particularly strong cause-effect basis for interpretation, the aim of the MIRAI is to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic macroinvertebrate community (assemblage) from the reference condition (C. Thirion, 2008). This does not preclude the calculation of SASS scores, but encourages the application of MIRAI assessment, even for the River EcoStatus Monitoring Programme (REMP) purposes, as the preferred approach.

It is preferred to apply the MIRAI on a reach-based level by incorporating macroinvertebrate findings at several sites which have similar aquatic conditions along the same watercourse. The lack of connectivity along the Eastern Tributary and the Olifants River systems at the time of the survey did not suit a reach based MIRAI approach. Therefore, a site-based approach has been adopted for both river reaches.

Before interpreting the MIRAI findings for sites sampled within the Olifants River reach, it should be noted that the determined scores were based solely on the presence or absence of macroinvertebrate families within the site. Not all families are expected to be frequent within the entirety of the reach. Therefore, the overall Ecological Category could be negatively skewed as “missed” taxa may be present within additional sites along the watercourse. Nonetheless, the MIRAI scores for the relevant metric groups categorised the macroinvertebrate assemblage at sites O1 and O2 as *Largely Modified* (Ecological Category D) and *Seriously Modified* (Ecological Category E) at Site O3 (Table 6-5).

At the Eastern Tributary Site ETO1, MIRAI findings indicate that the macroinvertebrate assemblage within the assessed reach was in a *Largely Modified* state (Ecological Category D).

Table 6-5: MIRAI findings for the assessed sites

Site	MIRAI Value	Ecological Category	Description
Eastern Tributary of the Olifants			
ETO1	52.9	D	Largely Modified
ETO2	DRY		
Olifants			
O1	54.1	D	Largely Modified
O2	41.4	D	Largely Modified
O3	35.4	E	Seriously Modified

In general, flow modifications metrics appear to be largely responsible for the determined scores, resulting in a loss of flow dependent taxa from the reaches. The non-perennial nature of these systems coupled with the farm dams appear to be altering with the flow. Additionally, modifications to water quality and habitat also appear to be greatly driving the macroinvertebrate assemblage in the lower reaches of the Olifants River. This was also seen in the IHAS scores wherein the lower Olifants reaches scored the lowered (see section 6.3.1).

6.4 Ichthyofaunal Assessment

The use of fish as a means to determine ecological disturbance has many advantages (Zhou et al., 2009). Fish are long living, respond to environmental modification, continuously exposed to aquatic conditions, often migratory and fulfil higher niches in the aquatic food web. Therefore, fish can effectively give an indication into the degree of modification of the aquatic environment. The electro-narcosis technique was applied to sample the available fish species within the Olifants River system associated with the Proposed Project.

Six indigenous fish species were expected to occur within the study area. The fish species collected during the present study are presented in Table 6-6 and discussed in the below sub-sections. It should be noted that the low and standing water within the Olifants River and the associated tributaries hindered the sampling of fish.

Table 6-6: Fish Collected (or Observed) within the Study Area

Fish Species	Tributary of the Olifants		Olifants River		
	ETO1	ETO2	O1	O2	O3
Labeobarbus polylepis	-	DRY	-	-	-
Enteromius anoplus	153		-	-	-
Enteromius paludinosus	-		-	-	-
Clarias gariepinus	-		-	-	-

Fish Species	Tributary of the Olifants		Olifants River		
	ETO1	ETO2	O1	O2	O3
Pseudocrenilabrus philander	-		3	-	-
Tilapia sparrmanii	-		11	-	-
*Gambusia affinis**			18	-	-
Number of Species	**1**		**3**	-	-
Total Catch	**153**		**32**	-	-
* Alien species					

A total of 4 fish species were collected (or observed), of which one was regarded as alien invasive species (*Gambussia affinis,* or Mosquitofish). A single species (*Enteromius anoplus,* Chubbyhead Barb) was sampled at Site ETO1, whilst three were sampled at Site O1. All the species collected (or observed) at the Olifants River Site O1 have a high preference/tolerance for slow-shallow water, modified water quality, as well as no-flow conditions. The Chubbyhead Barb (only collected at Site ETO1), has a high preference for slow-shallow water and a moderate tolerance for no-flow conditions and water quality modifications (DWS, 2014).

The alien Mosquitofish was introduced in South Africa as a mosquito control agent and forage for bass, but has proved to be an aggressive invader species capable of restricting other fish populations by preying on fish larvae (Skelton, 2001). Its occurrence and dominance at Site O1 can be attributed to its habitat requirements, which were suited at the time of the survey (i.e. standing or slow-flowing water with plant cover).

6.4.1 Ecological Condition of the Fish Assemblages

The REMP uses the FRAI, which is based on the preferences of various fish species, as well as the frequency of occurrence. FRAI results for the sampled river reaches are shown in Table 6-7 and discussed below.

Table 6-7: FRAI Results for the Assessed Olifants River systems

Sampling Site	FRAI Score (%)	Ecological Category	Description
Eastern Tributary of the Olifants			
ETO1	43.7	**D**	Largely Modified
ETO2	DRY		
Olifants River			
O1	38.6	**D/E**	Largely to Seriously Modified
O2	20.0	**E/F**	Seriously to Critically Modified
O3	20.0	**E/F**	Seriously to Critically Modified

Despite collecting (or observing) more fish species at the Olifants River upper reaches, the sampled fish assemblage at the Eastern Tributary of the Olifants upper reaches was representative of *Largely Modified* (Ecological Category D) whilst that of the upper reaches of the Olifants River was representative of *Largely to Seriously Modified* (Ecological Category

D/E). This finding was likely attributed to several factors including the dominance of the alien Mosquito fish at the upper of the Olifants.

At the middle and lower reaches of the Olifants River, none of the expected fish species were collected. Consequently, each of the reaches were representative of *Seriously* to *Critically Modified* states (Ecological Category E/F). These findings may be attributed to the following:

- The timing of the survey;
- Substrate and/or habitat heavily smothered with algae;
- Migratory behaviour of some species; and
- Inefficiency of the sampling technique.

The survey was undertaken in late dry season (i.e. September 2019) and this may have influenced the fish assemblages by reducing the population size (Tejerina-Garro & de Mérona, 2010). Also, all the sampled sites had no flow and lacked connectivity. Three of the expected species are known to migrate locally (i.e. 8 to >10 km) and a single species migrates long distances (DWS, 2014).

6.5 Integrated EcoStatus Determination

The EcoStatus is defined as: "*The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services*" (Iversen *et al*., 2000). In essence, the EcoStatus represents an integrated ecological state representing the drivers (hydrology, geomorphology, physico-chemical) and responses (fish, aquatic invertebrates and riparian vegetation; Kleynhans & Louw, 2008).

The Instream Biological Integrity, as well as the integrated EcoStatus, for the sampled river reaches within the project area were determined below Table 6-8.

Table 6-8: The PES of the reaches sampled in September 2019 through the use of the ECOSTATUS4 (Version 1.02; Kleynhans & Louw, 2008)

Site	Response Indices				EcoStatus	
	MIRAI EC	FRAI EC	Instream EC*	Riparian Vegetation EC (IHI)	Score	Category
ETO1	52.9	43.7	49.1	61.2	56.0	D
ETO2	DRY					
O1	54.1	38.6	42.5	65.2	56.4	D
O2	41.4	20.0	34.1	65.2	48.5	D
O3	35.4	20.0	30.2	65.2	46.4	D
*confidence rated data						

Following integration of the defined ecological conditions obtained for the instream biological integrity (i.e. MIRAI from aquatic invertebrates) and the riparian component (i.e. IHI from riparian vegetation assessment), it was determined that the sampled river reaches along the

Eastern Tributary of the Olifants and the Olifants River represented an integrated EcoStatus of *Largely Modified* (Ecological Category D). Despite all sites falling within the same Ecological Category of *Largely Modified*, the EcoStatus score for Site ETO1 was the highest, this was mainly due to the relatively high Instream EC score, which was greatly influenced by the FRAI score. Along the Olifants River, the EcoStatus' appeared to deteriorate along the longitudinal profile of the river system. This suggests that an accumulation of existing impacts, mainly stemming from mining (particularly the 2 Seam Coal Operation) and to some extent agricultural activities, occurs in the downstream direction, as seen with the recorded conductivity levels (see section 6.1.2). This in also indicated by the deteriorating MIRAI scores (I.e. Macroinvertebrate assemblages).

In relation to the Recommended Ecological Category (REC), the assessed sections of the Eastern Tributary of the Olifants and Olifants River were observed to attain to the stipulated Ecological Category of a **"D"**, as gazetted in April 2016 (*Proposed Classes and Resource Quality Objectives of Water Resources of the Olifants Catchment in Terms of Section 13(1)(a) and (b) of the National Water Act, 1998 (Act No.36 of 1998)*, 2016).

7 Impact Assessment

Any development in a natural (or modified) system will impact on the surrounding environment, potentially in a negative way. The purpose of this section of the report is to identify and assess the significance of the impacts likely to arise during the proposed activity and provide a short description of the mitigation required to limit the magnitude of the potential impact of the proposed activity on the natural environment.

Focus of the impact assessment has been solely on the proposed underground mine and associated activities (see section 1). The identified potential impacts that will negatively affect aquatic ecology, particularly the riverine systems (Olifants River and Steenkoolspruit associated tributaries) are discussed below for the various phases of the Project (i.e. Construction Phase, Operational Phase, as well as Closure and Decommissioning Phase).

For a detailed description of the Impact Assessment Criteria and Calculations used during the assessment below, the reader is referred to Appendix A.

7.1 Impact Activities

Table 7-1 below provides the project activities to be considered as part of the impact assessment:

Table 7-1: Project phases and associated activities

Project Phase	Project Activity
Construction Phase	Vegetation and/or soil clearance
	Access and haul road construction
	Infrastructure construction

Project Phase	Project Activity
	Diesel storage and explosives magazine
Operational Phase	Blasting (only when dykes and other geological features are encountered)
	In-pit ROM stockpiling
	Diesel storage and explosives magazine
	Water use and storage on-site – during the operation, water will be required for various domestic and industrial uses. Existing Water Management infrastructure (i.e. PCDs) will be utilised
	Coal transportation through trucking and conveyer belts
	Washing of mine vehicles
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.
	Maintenance activities – through the operations maintenance will need to be undertaken to ensure that all infrastructure is operating optimally and does not pose a threat to human or environmental health. Maintenance will include haul roads, crushing and washing plant, machinery, water and stormwater management infrastructure, stockpile areas, dumps, etc.
Closure and Decommissioning Phase	Demolition and removal of infrastructure – once mining activities have been concluded infrastructure will be demolished in preparation of the disturbed land rehabilitated
	Rehabilitation – rehabilitation mainly consists of spreading of the preserved subsoil and topsoil, profiling of the land and re-vegetation
	Post-closure monitoring and rehabilitation

7.2 Construction Phase

Land manipulation and vegetation clearing associated with the proposed surface infrastructure is the main foreseeable aquatic-related impact associated with the Construction Phase of the Project. There is also a risk of contaminants associated with construction activities and machinery entering the aquatic systems from the Project workings and storage sites.

7.2.1 Impact Description: Water and Habitat Quality Deterioration Associated with Vegetation Manipulation/Clearing

Land manipulation and vegetation clearance for infrastructure will most likely increase surface runoff, erosion and subsequently the amount of suspended and dissolved solids as well as pollutants (i.e. hazardous substances from the actual construction areas such as hydrocarbons, organic waste from lack of ablutions and domestic litter) entering the associated watercourses. This has the potential to negatively affect the water and habitat quality within the associated watercourses.

Erosion of land in association with natural aquatic ecosystems will not only modify the morphology of the systems (e.g. channel and bank modifications), but also has the potential to impact on aquatic-related habitat which, in turn, has the potential to alter biological community structure. Erosion and runoff into the associated aquatic ecosystems can result in the sedimentation of habitat and overall increase in suspended solids content. This can directly alter aquatic habitats after deposition (Wood & Armitage, 1997), which in turn will negatively impact biotic community structure by displacing biota that favour the affected habitat. Suspended solids can also directly impact aquatic biota through the accumulation of silt on respiratory organs (i.e. gills) and by decreasing visibility (i.e. increasing turbidity) which will affect feeding habits of specific taxa.

Erosion and runoff from cleared land can also alter water quality by increasing turbidity, as aforementioned, and by increasing the number of contaminants entering the watercourses from the surrounding landscapes, such as fertilisers/nutrients and unearthed metals. This is expected to alter the physio-chemistry of water and deter water quality sensitive biota.

7.2.1.1 Management Objectives

The main objective for mitigation would be to limit the areas proposed for disturbance/vegetation clearance combined with keeping as far as possible from the banks of associated watercourses. Construction activities should be restricted to the immediate footprint associated with the proposed infrastructure.

7.2.1.2 Management Actions

General mitigation actions provided in the wetlands and surface water studies conducted by Digby Wells should be used to guide the effective management of aquatic resources potentially affected by the proposed Project. However, more specific management actions for the Construction Phase are listed below:

- Limit vegetation removal to the infrastructure footprint area only. Where removed or damaged, vegetation areas (riparian or aquatic related) should be revegetated as soon as possible;
- Bare land surfaces downstream of construction activities must be vegetated, where practically possible, to limit erosion from the expected increase in surface runoff from infrastructure;
- Environmentally friendly barrier systems, such as silt nets or, in severe cases, use trenches downstream from construction sites to limit erosion and possibly trap contaminated runoff from construction;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow;
- Water used at construction sites should be utilised in such a manner that it is kept on site and not allowed to run freely into nearby watercourses (i.e. use of a PCD);

- Construction chemicals, such as paints and hydrocarbons, should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions;
- All vehicles must be frequently inspected for leaks;
- No material may be dumped or stockpiled within any rivers, drainage lines in the vicinity of the proposed project;
- All waste must be removed and transported to appropriate waste facilities; and
- High rainfall periods (usually November to March) should be avoided during construction to possibly avoid increased surface runoff in attempt to limit erosion and the entering of external material (i.e. contaminants and/or dissolved solids) into associated aquatic systems.

7.2.1.3 Impact Ratings

Table 7-2 presents the impact ratings associated with land and vegetation clearing impacts predicted for the Construction Phase of the proposed project. It must be noted that the ratings have been determined based on the observations during the survey.

Table 7-2: Impact assessment ratings for the Construction Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearance and construction of proposed infrastructure			
Impact Description: Land and vegetation manipulation/clearing in proximity to the watercourses.			
Prior to Mitigation/Management			
Duration	Project life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until project closure.	Minor (negative) – 60
Extent	Local (3)	Based on the proximity of the proposed infrastructure to the Olifants River Tributary (~500 m), and largely disconnected nature of the watercourse, the extent of runoff is expected to be localised to within the tributaries directly affected and the receiving Olifants River.	
Intensity x type of impact	Moderately high - Negative (-4)	Effects to biological or physical resources expected to occur within immediate proximity and potentially impact on downstream reaches.	

Dimension	Rating	Motivation	Significance
Probability	Probable (5)	Due to the dry nature of the area, the impact is likely to be significant during high-flow season only. However, direct modifications to the watercourses during the dry periods will have a negative impact	
Nature	Negative		
Post-Mitigation			
Duration	Project Life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until the closure phase of the Project or removal of the infrastructure.	Negligible (negative) – 27
Extent	Limited (2)	Following mitigation actions and if high rainfall periods are avoided for construction, impacts will be limited to immediate surroundings.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the Construction Phase, the intensity of the impact should be low.	
Probability	Unlikely (3)	The likelihood of the impact occurring at the surrounding watercourses is reduced by the mitigation actions and should only result in extreme cases or unexpected rainfall events.	
Nature	Negative		

7.3 Operational Phase

A major foreseeable impact associated with the Operational Phase of the Project is increased runoff seepage possibly resulting in erosion and sedimentation because of constructed impermeable surfaces. Seepage and leaks stemming from the Sewage Treatment Plant (STP) and Water Treatment Plant (WTP) potentially contaminating the nearby watercourses.

7.3.1 Impact Description: Water Quality and Habitat Deterioration Associated with Runoff, Seepage and Leaks from the Operational Areas of the Project

Like the impacts described for the Construction Phase, runoff from the actively mined areas and seepage/leaks has the potential to increase flow rates, sediment input, erosion and contaminants in the associated watercourses. These influences will directly impact on water quality and aquatic habitat which in turn will negatively affect the aquatic biota.

Stormwater and water used on site (e.g. dirty water treatment and process water) has the potential to directly alter habitat and the morphology of the receiving aquatic ecosystems if allowed to flow freely from the MRA (e.g. through sedimentation). Uncontrolled runoff also has the potential to alter water chemistry and degrade water quality of the affected systems by collecting contaminants as it drains across the associated landscapes. This will consequently affect the aquatic ecology and water quality.

7.3.1.1 Management Objectives

Water should not be allowed to flow freely from the operational areas. As proposed, dirty water or water runoff from mine related infrastructure should be stored in PCD's and utilised as storage facilities.

Additionally, the proposed plan is to use mine-affected water for dust suppression on dirt roads.

7.3.1.2 Management Actions

The following management actions are recommended to guide the effective management of stormwater and water generated on site:

- Runoff from dirty areas should be directed to the storm water management infrastructure (drains and PCDs) and should not be allowed to flow into the nearby watercourses, unless DWS discharge authorisation and compliance with relevant discharge standards as stipulated in the NWA is obtained;
- Channelled water should not be dispersed in a concentrated manner. Baffles should be incorporated into artificial drainage lines/channels around the surface infrastructure to decrease the kinetic energy of water as it flows into the natural environment;
- Bare surfaces downstream from the developments where silt traps are not an option should be vegetated in order to attempt to limit erosion and runoff that might be carrying contaminants;
- Careful monitoring of the areas where dust suppression is proposed should be undertaken regularly. Areas concentrating water runoff should be addressed and not allowed to flow freely into associated watercourses; and
- Monitoring of the associated water courses should be done by an aquatic specialist in order to determine potential impacts where after new mitigation actions should be implemented as per the specialist's recommendations.

7.3.1.3 Impact Ratings

Table 7-3 presents the impact ratings determined for the potential runoff, seepage and leaks from the proposed infrastructure and associated activities.

Table 7-3: Impact Assessment Ratings for the Operational Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Uncontrolled runoff of stormwater or process water from or through the surface infrastructure			
Impact Description: Water quality and habitat deterioration of watercourses receiving unnatural/contaminated runoff			
Prior to Mitigation/Management			
Duration	Project Life (5)	It is predicted that contaminant input will continue throughout the life of the Project whenever rainfall events occur.	Minor (negative) – 65
Extent	Local (3)	Based on the proximity of the proposed infrastructure to watercourses, and largely disconnected nature of the watercourses, the extent of runoff is expected to be localised to within the respective catchment.	
Intensity x type of impact	High - Negative (-5)	Runoff, seepage and or leakage into watercourses is expected to impact functioning of the aquatic ecosystems.	
Probability	Likely (5)	The impact is likely to occur throughout the life of the Project but limited due to periodic rainfall events.	
Nature	Negative		
Post-Mitigation			
Duration	Project Life (5)	Runoff will continue throughout the Project life.	Negligible (negative) – 21
Extent	Very limited (1)	Runoff will most likely be largely restricted and captured after mitigation.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Minimal to no loss - Negative (-1)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease. However, contaminants are more difficult to manage compared to solid particles and may enter associated aquatic systems resulting in water quality deterioration.	
Probability	Unlikely (3)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

7.4 Post Closure Phase

This phase entails removal of mine related infrastructure as well as rehabilitation of potentially affected areas and aquatic ecosystems.

7.4.1 Impact Description: Post-closure water quality deterioration as a result of seepage resulting in Acid Mine Drainage

The demolition and removal of infrastructure is not expected to impact on the aquatic ecosystems due to the distance between the watercourse (tributary of the Olifants) and the proposed site for the infrastructure. Thus, none of the listed Post Closure activities are expected to impact on the associated aquatic ecology. However, contamination of aquatic ecosystems through seepage and runoff resulting in Acid Mine Drainage (AMD) is expected. This will consequently affect the aquatic ecology and aquatic biota.

7.4.1.1 Management Objectives

The main objective during the Post Closure Phase should be focused on preventing contaminated water from entering the associated aquatic environment.

7.4.1.2 Management Actions

The goal of mitigation should be to prevent and or limit the seepage and runoff of contaminated water into associated aquatic ecosystems. The following measures may be utilised in attempt to reduce the Post Closure impacts:

- Best practise rehabilitation should be utilised to trap and contain the deep sediments that contain the acid forming rock responsible for acid water formation.

- Financial provision is made annually for a Reverse Osmosis Water Treatment Plant post-closure to prevent AMD water from decanting to release the treated water into the clean environment

Aquatic biomonitoring is also recommended to monitor any changes in the aquatic ecosystems and to provide solutions for identified, additional/unforeseen impacts for at least three years after rehabilitation.

7.4.1.3 Impact Ratings

The impact ratings associated with the Post Closure Phase on associated aquatic ecosystems are predicted in Table 7-4 below.

Table 7-4: Impact assessment ratings for the Post Closure Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Seepage and runoff of contaminated water entering aquatic ecosystems			
Impact Description: Water quality deterioration of watercourses in contact with contaminated water resulting in AMD			
Prior to Mitigation/Management			
Duration	Permanent (7)	AMD will continue to contaminate the Olifants Tributary beyond the life of Project.	Minor (negative) – 108
Extent	Regional (5)	The Olifants River may be able to dilute the contamination. However, as there is largescale mining within the catchment, it is likely that the effect could be compounded.	
Intensity x type of impact	Very High – Negative (-6)	High significant impact on the environment. With potential loss of aquatic biota.	
Probability	Highly probable (6)	AMD is a problem related to coal mining. Groundwater modelling (see Groundwater specialist report) has indicated high likelihood of this occurring.	
Nature	Negative		
Post-Mitigation			
Duration	Medium Term (3)	Impacts will persist throughout the Decommissioning Phase until rehabilitation activities are complete.	Negligible (negative) – 15

Dimension	Rating	Motivation	Significance
Extent	Very limited (1)	If mitigation measures are adhered to, especially working in the dry season, runoff is expected to be restricted to the mitigation structures.	
Intensity x type of impact	Minimal to no loss - Negative (-1)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease notably especially after rehabilitation.	
Probability	Unlikely (3)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

7.5 Cumulative Impacts

Presently, the main cumulative impact identified for the aquatic ecosystems within the project area appears to be the influence of mining and farming areas. Associated activities potentially impact on the biotic and abiotic environment through seepage and runoff, which contaminate the watercourses and result in modified water quality.

7.6 Unplanned and Low Risk Events

There is a risk that watercourses associated with the proposed Project and infrastructure throughout the Project life might be affected by the entry of hazardous substances, such as hydrocarbons, in the event of a spillage or unseen seepage from storage facilities, as well as accidents or deterioration of structures along the roadways, might affect the habitat and water quality of associated aquatic ecosystems.

Therefore, Table 7-5 outlines mitigation measures that must be adopted in the event of unplanned impacts throughout the life of the Project.

Table 7-5: Unplanned events and Associated Mitigation Measures

Unplanned Risk	Mitigation Measures
Chemical and (or) contaminant spills through pipe leaks and bursts from the proposed Project, infrastructure and associated activities.	Ensure correct storage of all chemicals at operations as per each chemical's specific storage requirements (e.g. sealed containers for hydrocarbons);

Unplanned Risk	Mitigation Measures
	Conduct routine inspections for potential leaks and spills Ensure staff involved at the proposed developments have been trained to correctly work with chemicals at the sites; and Ensure spill kits (e.g. Drizit) are readily available at areas where chemicals are known to be used. Staff must also receive appropriate training in the event of a spill, especially near watercourses/drainage lines.

8 Environmental Management Programme

Table 8-1 provides a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMPr.

Table 8-1: Environmental Management Plan

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Site clearing and infrastructure construction.	• Erosion and sedimentation • Altered hydrology.	Aquatic Biodiversity	Construction	• Limit the footprint area of the construction activities to what is essential in order to minimise impacts as a result of vegetation clearing and potential erosion areas; • If possible, construction activities must be prioritised to the dry months of the year to limit mobilisation of sediments, dust generation and hazardous substances from construction vehicles used during site clearing; • Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation; and • An efficient drainage system (e.g. diversion trenches > settling area (or sump) > baffled discharge outlets) should be implemented prior to construction.	*Modify* through construction site planning *Control* through stormwater management and sediment containment infrastructure.	Prior to construction activities are initiated
Construction activities, including vehicular activities and maintenance of access roads	• Water quality impairment	Aquatic Biodiversity	Construction	• Spillage management kits or controls should be taken seriously and put in place in order to reduce oil or fuel run offs to enter nearby river systems. • All vehicles must be frequently inspected for leaks; and • All waste must be removed and transported to appropriate waste facilities.	*Control* through driving access permits and permit areas and ongoing maintenance.	Ongoing throughout the Construction and Operational phases

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Operational aspects of proposed Project	• Erosion and sedimentation • Water quality improvement/impairment	Aquatic Biodiversity	Operational	• Runoff from dirty areas should be directed to the storm water management infrastructure (drains and PCDs); • The aquatic biomonitoring program provided in this report should be adhered to for monitoring water resources within and in close proximity to the project area to allow detection of any contamination arising from operational activities; • The overall housekeeping and storm water system management (including the maintenance of berms, de-silting of dams and conveyance channels and clean-up of leaks) must be maintained throughout the life of mine; and • The hydrocarbon and chemical storage areas and facilities must be located on hard-standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilisation of leaked hazardous substances; • Training of mine personnel and contractors in proper hydrocarbon and chemical waste handling procedures is recommended; • Vehicles must only be serviced within designated service bays; • Wash bay and workshop runoff should flow through an oil separator as indicated on the infrastructure plan prior to discharge into the PCD	*Control* through inspection and monitoring, as well as stormwater management and sediment containment infrastructure.	Ongoing

Activity/ies	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Demolition and removal of infrastructure; Rehabilitation and closure.	• Erosion and sedimentation • Altered hydrology; and • Restoration of the pre-mining streamflow regime in the associated watercourses.	Aquatic Biodiversity	Decommissioning	• Restore the topography to pre-mining conditions as much as is practically possible; • Clearing of vegetation should be limited to the decommissioning footprint area and immediate revegetation of cleared areas; • Decommissioning activities should be prioritized during dry months of the year where practical; • Disturbance of soils during infrastructure demolition should be restricted to relevant footprint areas; • Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance; • Use of accredited contractors for removal or demolition of infrastructure during decommissioning is recommended; this will reduce the risk of waste generation and accidental spillages; • Ensure that the infrastructure (pipelines, fuel storage areas, pumps) are first emptied of all residual material before decommissioning; and • Capping, reprofiling and revegetation of TSF post-closure to limit the potential for future oxidation of stored tailings, and enable clean runoff to be discharged to the surrounding environment.	Storm water management: Control contamination of receiving waterbodies by consideration of potential contamination sources and strategic decommissioning to minimize on potential environmental impacts.	During the decommissioning phase And post-decommissioning phase

9 Aquatic Biomonitoring Programme

An aquatic biomonitoring programme has been developed for the monitoring and preservation of the aquatic ecosystems assessed for the proposed Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might severely affect the expected aquatic biota in the associated riverine systems.

Table 9-1 outlines the aquatic monitoring methods undertaken at the monitoring points set out above (see section 4.3) on a biannual basis by a qualified aquatic ecologist. The annual programme comprises of a single survey during the autumn season (or low flow season) for the Study Area and a single survey during the spring season (or high flow). This will determine the PES for the assessed aquatic ecosystems which will further determine whether the proposed Project is impacting the associated aquatic ecology and to what extent. The following stressor, habitat and response indicators should be evaluated:

- **Stressor indicators**
  - *In situ* water quality
  - Water toxicity
- **Habitat indicator:**
  - Instream and riparian habitat conditions (IHI, version 2)
  - Aquatic macroinvertebrate biotope evaluation (IHAS, Version 2.2).
- **Response indicators:**
  - Aquatic macroinvertebrate assessment (SASS5 and MIRAI)
  - Ichthyological assessment (FRAI)
  - Invertebrate incubation/hatching assessment
  - Determination of the integrated EcoStatus (EcoStatus 4, Version 1.02).

Table 9-1: Biomonitoring Programme

Method and Aquatic Component of Focus	Details	Goal/Target	Recommended Ecological Category
Water Quality: *In situ* water testing focusing on temperature, pH, conductivity and oxygen content.	Water quality should be tested on a biannual basis at each monitoring site to determine the extent of change from baseline results.	No noticeable change from the REC	Salt concentrations must be at levels that do not threaten the ecosystem and are suitable for users. Dissolved organic carbon concentrations must not cause the ecosystem to become unsustainable. The river water must not be toxic to aquatic organisms or be a threat

Method and Aquatic Component of Focus	Details	Goal/Target	Recommended Ecological Category
			to human health. Pathogens must be at levels safe for human use (excluding for direct consumption).
Habitat Quality: Instream and riparian habitat integrity; and Availability/suitability of macroinvertebrate habitat at each monitoring site.	The application of the IHI should be done on a reach basis for the Olifants River, the Steenkoolspruit and associated tributaries; The IHAS must be applied at each monitoring site prior to sampling.	The Ecological Category determined for each assessed site must be maintained and improved for the watercourses); and The baseline IHAS scores should improve.	Must be in a *Largely Modified* or better condition ≥ D (≥ 42)
Macroinvertebrates: Macroinvertebrate assemblages must be assessed biannually.	This must be done through the application of the latest SASS, incorporated with the application of the MIRAI as outlined in this Aquatic Study.	The baseline SASS5 scores should not noticeably deteriorate; and Baseline Ecological Categories should not be allowed to drop in category for each assessed site.	Must be in a *Largely Modified* or better condition ≥ D (≥ 42)
Fish: Fish assemblages must be assessed biannually	Sampling of fish must be undertaken by means of a standard electro-narcosis techniques followed by the application of FRAI for applicable reaches.	Baseline Ecological Categories should not be allowed to drop in category for each assessed site. The main goal for the Project	Must be in a *Largely Modified* or better condition ≥ D (≥ 42)

Method and Aquatic Component of Focus	Details	Goal/Target	Recommended Ecological Category
		must be to conserve the expected species.	

The Project should not commence without inclusion of the above Aquatic Biomonitoring Programme.

10 Conclusion and Way Forward

Amongst the water quality results, temperature values were recorded within typical summer season temperatures in South Africa. The pH values recorded exhibited close to neutral to slightly alkaline conditions, with all assessed sites partially exceeding the recommended guideline. Similarly, conductivity levels were elevated above the recommended guideline at all the sites. It is unlikely that these findings can be attributed to the existing Dorstfontein East mining activities since sites upstream of the mines (i.e. Site ETO2 and Site O1) show similar water quality conditions to those downstream of the mine, but there may be other parameters that are not being measured at the time of the assessment. It is therefore suspected that agricultural influences (i.e. nutrient runoff from crops and livestock) might be altering the pH and conductivity in the aquatic ecosystems. This was supported by the substantial algae observed within the watercourses.

The findings from the Index for Habitat Integrity assessments conducted during the current survey indicate that the habitat integrity along the assessed Eastern Tributary of the Olifants and the Olifants River ranged from *Largely Modified* (Ecological Category D) to *Moderately Modified* (Ecological Category C). The main modifications to the instream component of the assessed reaches were those facilitated by mining agricultural activities. Major modifications of the riparian habitat component include the removal of indigenous vegetation, consequently resulting in exotic vegetation encroachment.

The availability and integrity of aquatic macroinvertebrate biotopes were "*Poor"* across all sampled river reaches. The sites were dominated by shallow standing water with limited marginal vegetation. Sand and mud were the most prevalent biotopes within the watercourses. Consequently, the results of the South African Scoring System version 5 (SASS5) and Macroinvertebrate Response Assessment Index (MIRAI) indicate that conditions at the sampled reaches ranged between *Largely Modified* (Ecological Category D) and *Seriously Modified* (Ecological Category E) with macroinvertebrate community assemblages largely composed of taxa that have "*Low"* water quality requirements.

A total of 4 fish species were collected (or observed), of which one was regarded as alien invasive species (*Gambussia affinis,* or Mosquitofish). A single species was sampled at Site ETO1 (*Enteromius anoplus* or Chubbyhead Barb) whilst 3 were sampled at Site O1. In general, the collected or observed species are known to have a high preference/tolerance for slow-shallow water, modified water quality as well as no-flow conditions. Consequently, the sampled fish assemblages ranged from *Largely Modified* conditions to *Seriously-Critically Modified* conditions (Ecological Category E/F). This may have been attributed to: the timing of the survey; the migratory behaviour of some species; the modified water quality or low dissolved oxygen levels (which could not be determined at the time of the survey) and or the inefficiency of the sampling technique.

Following integration of the defined ecological conditions obtained for the instream biological integrity and the riparian component, it was determined that all assessed sites represented an integrated EcoStatus of *Largely Modified* (Ecological Category D).

The potential surface related impacts associated with the Proposed Project were determined to be *Minor* for the associated riverine systems and *Negligible* upon adequate implementation of mitigation measures. With gentle slopes for the associated watercourses, the Eastern Tributary of the Olifants River is approximately 400 m away from the closest point of the proposed infrastructure, whilst the Olifants River is approximately 2 km away.

An aquatic biomonitoring programme has been provided for the monitoring and preservation of the aquatic ecosystems associated with the Project. This programme is aimed at better determining the ecological health of the ecosystems as well as to act as an early detection tool for impacts that might significantly affect aquatic biota.

10.1 Reasoned Opinion Whether Project Should Proceed

In light of the distances, gentle slope and existing impacts between the Proposed Project boundary and the aquatic ecosystems under study, highlighted foreseeable negative impacts are likely to occur following rainfall events. Furthermore, impacts of the Proposed Project onto the associated water courses are predicted to be *Negligible* upon implementation of mitigation measures.

No notable fatal flaws were identified during the current study, thus the Proposed Project may proceed with an immediate implementation of the mitigation measures and the aquatic biomonitoring programme must be adhered to throughout the operation and decommissioning phases to ensure no deterioration of the associated watercourses occur.

10.2 Recommendations

Based on the results of the current study, the following actions have been recommended to allow for commencement of the proposed Project:

- The non-perennial nature of the associated watercourses presents challenges in limiting the adequacy of the indices utilised for the REMP, therefore toxicity testing (screening-level) should be implemented for a minimum of three biological groups (i.e. algae, invertebrates, and fish) during the wet season periods. This however, should be coupled with the SASS5 technique and visual assessment of the watercourses.
- A follow-up survey during the wet season should be undertaken as the current assessment was undertaken during the dry season survey.

The developed Aquatic Biomonitoring Programme must be adopted on an annual basis after commencement of the Construction Phase of the Project. This programme should continue for the life of the Project and for at least three years post the Decommissioning Phase

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Appendix A: Methodology

Water Quality

Selected *in-situ* water quality variables were measured at each of the sampling sites using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter and an ExStik DO600 Dissolved Oxygen Meter. Temperature, pH, electrical conductivity and dissolved oxygen were recorded prior to sampling, while the time of day at which the measurements were assessed was also noted for interpretation purposes.

Habitat Quality

The availability and diversity of aquatic habitat is important to consider in assessments due to the reliance and adaptations of aquatic biota to specific habitats types (Barbour *et. al*., 1996). Habitat quality and availability assessments are usually conducted alongside biological assessments that utilise fish and macroinvertebrates. Aquatic habitat will be assessed through visual observations on each river system considered.

Index for Habitat Integrity

The IHI (Version 2, Kleynhans, C.J., pers. comm., 2015) aims to assess the number and severity of anthropogenic perturbations along a river/stream/wetland and the potential inflictions of damage toward the habitat integrity of the system (Dallas, 2005). Various abiotic (e.g. water abstraction, weirs, dams, pollution, dumping of rubble, etc.) and biotic (e.g. presence of alien plants and animals, etc.) factors are assessed, which represent some of the most important and easily quantifiable, anthropogenic impacts upon the system (Table 11-1).

As per the original IHI approach (Kleynhans, 1996), the instream and riparian components were each analysed separately to yield two separate ecological conditions (i.e. Instream and Riparian components). However, it should be noted that the data for the riparian area is primarily interpreted in terms of the potential impact upon the instream component and as a result, may be skewed by a potentially deteriorated instream condition.

While the recently upgraded index (i.e. IHI-96-2; Dr. C. J. Kleynhans, pers. comm., 2015) replaces the aforementioned comprehensive and expensive IHI assessment model developed by Kleynhans (1996), it is important to note that the IHI-96-2 does not replace the IHI model developed by Kleynhans *et al.* (2008a) which is recommended in instances where an abundance of data is available (e.g. intermediate and comprehensive Reserve Determinations). Accordingly, the IHI-96-2 model is typically applied in cases where a relatively few numbers of river reaches need to be assessed, the budget and time provisions are limited, and/or any detailed available information is lacking (i.e. rapid Reserve Determinations and for REMP/RHP purposes).

Table 11-1: Descriptions of criteria used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Factors	Relevance
Water abstraction	Direct impact upon habitat type, abundance and size. Also impacted in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in the temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included
Water quality modification	Originates from point and diffuse sources. Measured directly, or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Alien/Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Alien/Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the riverbank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

In accordance with the magnitude of the impact created by the abovementioned criterion, the assessment of the severity of the modifications was based on six descriptive categories ranging between a rating of 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact; Table 11-2). Based on available knowledge of the site and/or adjacent catchment, a confidence level (high, medium, low) was assigned to each of the scored metrics.

Given the subjective nature of the scoring procedure utilised within the general approach to habitat integrity assessment (including IHI-96-2; see Appendix A), the most recent version of the IHI application (Kleynhans *et al.,* 2008) and the Model Photo Guides (Graham & Louw, 2008) were used to calibrate the severity of the scoring system. It should be noted that the assessment was limited to observed and/or suspected impacts present within the immediate vicinity of the delineated assessment units, as determined through the use of aerial photography (e.g. Google Earth) and observations made at each of the assessed sampling points during the field survey. However, in cases where major upstream impacts (e.g. construction of a dam, major water abstraction, etc.) were confirmed, potential impacts within relevant sections were considered and accounted for within the application of the method.

Table 11-2: Descriptive of scoring guidelines for the assessment of modifications to habitat integrity

Impact Category	Description	Score
None	No discernible impact or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.	0
Small	The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 - 5
Moderate	The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also 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 of almost the whole of the defined section are affected. Only small areas are not influenced.	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 detrimentally influenced.	21 - 25

Each of the allocated scores was then moderated by a weighting system (Table 11-3), which is based on the relative threat of the impact to the habitat integrity of the riverine system. The total score for each impact is equal to the assigned score multiplied by the weight of that impact. The estimated impacts (assigned score / maximum score [25] X allocated weighting) of all criteria are then summed together, expressed as a percentage and then subtracted from 100 to determine the Present Ecological State score (PES; or Ecological Category) for the instream and riparian components, respectively.

Table 11-3: Criteria and weightings used to assess 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 modification	14	Water abstraction	13
Inundation	10	Inundation	11
Alien/Exotic macrophytes	9	Flow modification	12
Alien/Exotic aquatic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

However, in cases where selected instream component criteria (i.e. water abstraction, flow, bed and channel modification, water quality and inundation) and/or any of the riparian component criteria exceeded ratings of large, serious or critical, an additional negative weight was applied. The aim of this is to accommodate the possible cumulative effect (and integrated) negative effects of such impacts (Kemper, 1999). The following rules were applied in this respect:

- Impact = Large, lower the integrity status by 33% of the weight for each criterion with such a rating.
- Impact = Serious, lower the integrity status by 67% of the weight for each criterion with such a rating.
- Impact = Critical, lower the integrity status by 100% of the weight for each criterion with such a rating.

Subsequently, the negative weights were added for both facets of the assessment and the total additional negative weight subtracted from the provisionally determined integrity to arrive at a final habitat integrity estimate (Kemper, 1999). The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific habitat integrity ecological category (Table 12-4).

Table 11-4: Ecological Categories for the habitat integrity scores

Ecological Category	Description	Score (% of Total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. A 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	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and there has been 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

Aquatic Invertebrate Assessment

Integrated Habitat Assessment System

Assessment of the available habitat for aquatic macroinvertebrate colonization at each of the sampling sites is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with the South African Scoring System, Version 5 (SASS5) as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorized according to the values in Table 11-5.

Table 11-5: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

IHAS Score (%)	Description
>75	Excellent
65–74	Good
55–64	Adequate / Fair

IHAS Score (%)	Description
<55	Poor

According to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores at assessed sampling sites, as its performance appears to vary between biotopes. However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until these studies have been conducted (Ollis *et al.,* 2006). In the interim and for the purpose of this assessment, the IHAS method was adapted by excluding the assessment of the aforementioned '*general stream characteristics*,' which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned Table 11-5. Consequently, the assessment index describes the quantity, quality and diversity of available macroinvertebrate habitat relative to an "ideal" diversity of available habitat.

South African Scoring System Version 5 (SASS5)

While there are a number of indicator organisms that are used within these assessment indices, there is a general consensus that benthic macroinvertebrates are amongst the most sensitive components of the aquatic ecosystem. This was further supported by their largely non-mobile (or limited mobility) within reaches of associated watercourses, which also allows for the spatial analysis of disturbances potentially present within the adjacent catchment area. However, it should also be noted that their heterogeneous distribution within the water resource is a major limitation, as this results in spatial and temporal variability within the collected macroinvertebrate assemblages (Dallas & Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates collected on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (Dallas, 1997). However, the method relies on a standardised sampling technique using a handheld net (300 mm x 300 mm, 1000 micron mesh size) within each of the various habitats available for standardised sampling times and/or areas. Niche habitats (or biotopes) sampled during SASS5 application include:

- Stones (both in-current and out-of-current);
- Vegetation (both aquatic and marginal); and
- Gravel, sand and mud.

Once collection is complete, aquatic macroinvertebrates are identified to family level and a number of assemblage-specific parameters are calculated including the total SASS5 score, the number of taxa collected, and the Average Score per Taxa i.e. SASS5 score divided by the total number of taxa identified (Thirion *et al*., 1995); Davies and Day, 1998; (Dickens and Graham, 2002; Gerber and Gabriel, 2002). The SASS5 bio-assessment index has been proven to be an effective and efficient means to assess water quality impairment and general river health (Chutter, 1998; Dallas, 1997).

Macroinvertebrate Response Assessment Index (MIRAI)

In order to determine the Present Ecological State (PES; or Ecological Category) of the aquatic macroinvertebrates collected/observed, the SASS5 data was used as a basic input (i.e. prevalence and abundance) into the recently improved MIRAI (Version 2, Thirion. C., *pers. comm.*, 2015). This biological index integrates the ecological requirements of the macroinvertebrate taxa in a community (or assemblage) and their respective responses to flow modification, habitat change, water quality impairment and/or seasonality (C. Thirion, 2008). The presence and abundance of the aquatic macroinvertebrates collected are compared to a derived reference list of families/taxa that are expected to be present under natural, un-impacted conditions (i.e. prior to the effect of anthropogenic activities). Consequently, the three (or four) aforementioned metric groups utilised during the application were combined within the model to derive the ecological condition of the site in terms of aquatic macroinvertebrates (Table 11-6).

Table 11-6: Allocation protocol for the determination of the Present Ecological State for aquatic macroinvertebrates following application of the MIRAI

MIRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

Ichthyofaunal Assessment

Fish were collected by means of electro-narcosis (or electro-fishing), whereby an anode and a cathode are immersed in the water to temporarily stun fish in the near vicinity. Each of the collected fish specimens were identified in the field – using the “Complete Guide to the Freshwater Fishes of Southern Africa” (Skelton, 2001) – and released back into the river.

Fish Response Assessment Index

Assessment of the Present Ecological State (PES; or Ecological Category) of the fish assemblage of the watercourses associated with the study area was conducted by means of the FRAI (Kleynhans, 2008). This procedure is an integration of ecological requirements of fish species in an assemblage and their derived (or observed) responses to modified habitat conditions. In the case of the present assessment, the observed response was determined by means of fish sampling, as well as a consideration of species requirements and driver changes (Kleynhans, 2008). The expected fish species assemblage within the study area was derived from (Kleynhans *et al*., 2008) and aquatic habitat sampled.

Although the FRAI uses essentially the same information as the Fish Assemblage Integrity Index (FAII), it does not follow the same procedure. The FAII was developed for application in the broad synoptic assessment required for the River Health Programme, and subsequently does not offer a particularly strong cause-and-effect basis. The purpose of the FRAI, on the other hand, is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblage from the perceived reference condition (Kleynhans, 2008).

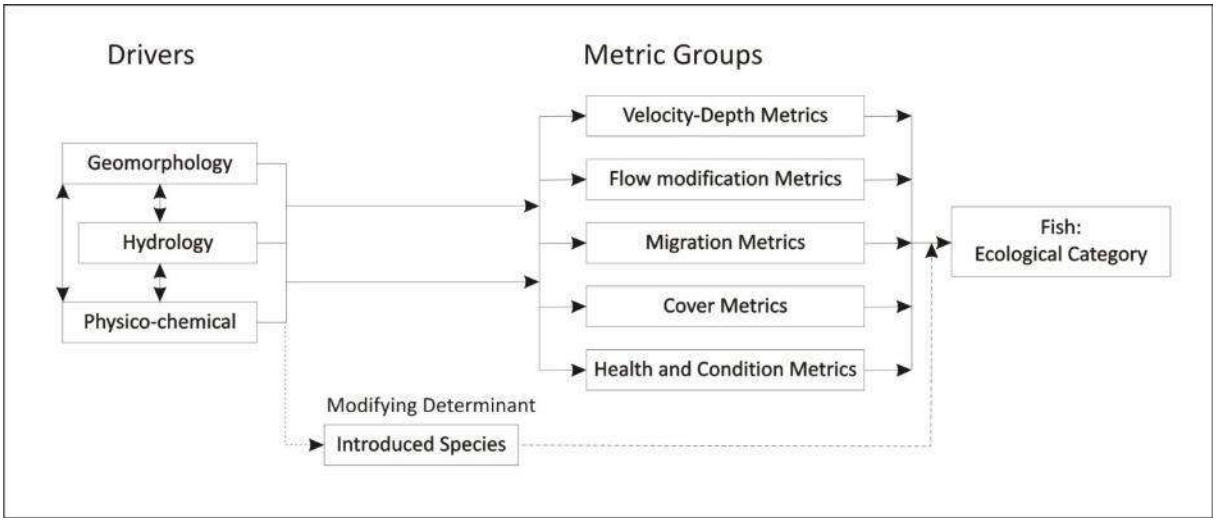

Figure 11-1: Relationship between drivers and fish metric groups

The FRAI is based on the assessment of selected metrics within metric groups, which are assessed in terms of:

- Habitat changes that are observed or derived;
- The impact of such habitat changes on species with particular preferences and tolerances; and
- The relationship between the drivers used in the FRAI and the various fish response metric groups, as are indicated in Figure 11-1. Table 11-7 provides the steps and procedures required for the calculation of the FRAI.

Table 11-7: Main steps and procedures followed in calculating the Fish Response Assessment Index

STEP	PROCEDURE
River section earmarked for assessment	As for study requirements and design
Determine reference fish assemblage: species and frequency of occurrence	• Use historical data & expert knowledge • Model: use ecoregional and other environmental information • Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	• Hydrology • Physico-chemical • Geomorphology; or • Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	• Assess fish habitat potential Assess fish habitat condition
Representative fish sampling at site or in river section	• Sample all velocity depth classes per site if feasible • Sample at least three stream sections per site
Collate and analyse fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	• Rate the FRAI metrics in each metric group • Enter species reference frequency of occurrence data • Enter species observed frequency of occurrence data • Determine weights for the metric groups • Obtain FRAI value and category • Present both modelled FRAI & adjusted FRAI.

Interpretation of the FRAI score follows a descriptive procedure in which the FRAI score is classified into a particular PES (or Ecological Category) based on the aforementioned integrity classes (Kleynhans, 1999). Each category describes the generally expected conditions for a specific range of FRAI scores (Table 11-8).

Table 11-8: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) of the sampled/observed fish assemblage following application of the FRAI

FRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

EcoStatus4 1.02 Model

For the purpose of the present assessment, the latest ECOSTATUS4 1.02 model was used, which is an upgraded and refined version of the original ECOSTATUS4 model (Kleynhans & Louw,2008). The results obtained from the fish and aquatic macroinvertebrate response indices (i.e. FRAI and MIRAI) are to be integrated within the model to determine an Instream Ecological Category, whereas the riparian elements from the IHI-96-2 model can be used as a surrogate for the Riparian Ecological Category in the following manner (Dr. C.J. Kleynhans, *pers. comm.*, 2015):

Riparian Vegetation EC = 100-(((IHI 'Natural vegetation removal')+(IHI 'Exotic Vegetation Encroachment'))/50*100).

Impact Assessment Methodology

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 11-11. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 11-10, which is extracted from Table 11-9. The description of the significance ratings is discussed in Table 11-11.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 11-9: Impact Assessment Parameter Ratings

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 11-10: Probability/Consequence Matrix

	Significance																																					
Probability 7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Consequence																																					

Table 11-11: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

Appendix B: Site Photographs

Site ETO1

Site ETO2

Site WTO1

Site WTO2

Site O1

Site O2

Site O3

Site TS1

Northern TributaryTrib of ET. (26º 11'50.1" S 29º 22'24.3" E)

Southern Trib of ET. (26º 15'22.5" S 29º 22'28.9" E)

Upstream culvert along R544 (26º 13'56.5" S 29º 19'47.4" E)