Aquatic Ecology Assessment for the proposed Palmietkuilen Project

Aquatic Ecology Specialist Report

Project Number:

CNC4065

Prepared for:

Pandospan (Pty) Ltd

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Name	Responsibility	Signature	Date
Russell Tate	Survey and Report		November 2016
Phil Patton Pr.Sci.Nat.	Senior Review		November 2016
Koos Smit	2nd Review		November 2016

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DECLARATION OF INDEPENDENCE

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I, Russell Tate as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Canyon Coal (PTY) Ltd, other than fair remuneration for work performed, specifically in connection with the proposed Palmietkuilen Coal Mine.

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EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) was appointed by Pandospan (Pty) Ltd (Pandospan) to complete the environmental authorisation for the proposed Palmietkuilen Coal Mining Project. As part of this appointment, Digby Wells was contracted to conduct an aquatic ecological baseline and impact assessment for the aquatic ecosystems associated with the proposed project.

The Prospecting Right includes Portions 1, 2, 4, 9, 13 and 19 of the Farm Palmietkuilen IR located in Springs, Sedibeng District, Gauteng Province (Figure 1-1). The mine, and mining-related infrastructure, will be placed on Portion 2.

The proposed activities and subsequent project area are located within the Upper Vaal Water Management Area (WMA) within the C21E quaternary catchment, which is classified as the Blesbokspruit River catchment area. According to desktop information these tributaries are unnamed and thus no Sub-Quaternary Reach (SQR) data is available. However, colloquially these rivers are known as the Dwars-in-die-wegvlei on the west and the Verdrietlaagte stream to the south of the project area.

In order to determine the baseline ecological status of rivers associated with the proposed project, the two river reaches of the C21E quaternary catchment were assessed on a bi-annual basis. Applying standard River Ecosystem Monitoring Programme techniques the Present Ecological Status of the river reaches was determined. The results of the assessment derived an overall Present Ecological Status class of largely/seriously modified (class D/E). This class was derived due to the existing habitat impacts within the catchment area. The central cause of the poor ecological status was found to be associated with various agricultural practices which have resulted in habitat modification of the assessed river reaches.

Considering this baseline, an impact assessment was completed using the available activity list for the proposed project. Based on this impact assessment, several key impacts were identified. These impacts included the following brief points:

- Potential impacts from a haul road crossing of a wetland;
- Potential decant of Acid Mine Drainage within the closure phase resulting in significant water quality modification in the Blesbokspruit drainage.

Considering the above potential impacts, and should the mining operation go ahead, provision should be made to mitigate against the contamination of surface water during the closure phase. It is further recommended that the Department of Water and Sanitation assess the impact of a loss of 3% Mean Annual Runoff on the ecological reserve of the Blesbokspruit.

Recommended monitoring conditions have been provided in this report along with various mitigation actions. However, it is noted that this report should not be considered in isolation and that other specialist reports should be reviewed including surface water, groundwater and wetland studies.

Important mitigation actions include the following:

- The Stormwater Management Plan provided in Figure 9-1 and detailed in the surface water report of this application should be utilised.
- Overburden and topsoil stockpiles should be vegetated to prevent erosion of occurring;
- The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows;
- Water treatment in the event Acid Mine Drainage is predicted; and
- Maintaining a buffer zone from the wetland system as prescribed by DWS

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1 Introduction

1.1 Project Background

In June 2016, Pandospan (Pty) Ltd (Pandospan) concluded a contract with Anglo Operations Limited in support of the acquisition of a Prospecting Right for coal (DMR Ref. No. GP 30/5/1/1/2 (201/10026) PR). The Prospecting Right includes Portions 1, 2, 4, 9, 13 and 19 of the Farm Palmietkuilen located in Springs, Sedibeng District, Gauteng Province (Figure 1-1). The mine, and mining-related infrastructure, will be placed on Portion 2.

This project involves the development of a new open pit coal mine and supporting infrastructure. The raw coal, once extracted, will be transported to a processing plant for crushing, screening and washing. The coal product will either be transported via haul roads from the product stockpile area to the existing Welgedacht siding for distribution by rail, or directly to prospective clients by road. The proposed mine will require supporting infrastructure such as water storage, sewage treatment, power supply, fuel storage and hauls roads.

1.2 Mining Method

Coal will be mined using open pit methods due to the shallow depth of the coal reserve (between 12 and 60 m below the surface). Bench mining and strip mining techniques are proposed. Bench mining involves the development of an open pit through a series of benches at varying depths while strip mining involves the movement of overburden laterally to an adjacent empty pit where the mineral has already been extracted. The proposed project will include one open pit.

Topsoil and subsoil will be stripped using an excavator and will be stored in separate stockpile areas on the mining area. Drilling and blasting will be employed for the hard overburden or bedrock to expose the coal seams. Once blasted, the hard overburden will be excavated and stockpiled separately for rehabilitation. The mined coal from the open pit will be transported via the haul roads and stored on the Run of Mine (RoM) stockpile area. The coal will be fed into a crushing and washing plant with a conveyor after which the coal product will be temporarily stored at the product stockpile area before being transported to the Welgedacht siding for distribution or directly via truck to the relevant markets. A temporary discard dump containing one year’s capacity will be constructed to store discard before being either rewashed or backfilled into mined out areas.

1.2.1 Stockpile Areas

Topsoil, subsoil and overburden material will be excavated and stored on site for rehabilitation. The mined coal will also need to be temporarily stored on a RoM stockpile and a product stockpile area.

1.2.2 Process Plant

1.2.2.1 Screening and Crushing

The RoM will be fed into the process plant by means of a feeder bin at the RoM pad. The feeding capacity of the plant will be 400 tons/hour. Coal will be manually fed into the bin by means of a Front-End Loader. The first stage of the process plant is to screen the coal into various particle sizes. This is done by the use of a 1.5 x 2.5 m primary vibrating grizzly screen fitted with 80 mm bar spacing. The coal fraction of 250 x 80 mm fraction will be discharged into a primary double roll crusher, which will reduce the oversize fraction to 90 mm in size. The primary crusher product will re-join the grizzly undersize fraction which feeds into a secondary 1.8 x 6.0 m double deck screen fitted with 60 and 50 mm bar spacing. The oversize (+75 mm) fraction will be fed to a secondary double roll crusher, the crushed product will be returned to the primary screen feed conveyor belt, in a closed crushing circuit.

1.2.2.2 Coal Washing and Processing

The eventual crushed and screened undersize fraction (-75mm) will be fed to the cyclone, drum and spiral sections of the wash plant which will then be deposited onto a product stockpile. The washing section will operate during mining hours.

The slurry from the thickener underflow will report to the filter press and make up 12 % to 15 % of the plant feed. The Dense Media Separation (DMS) plant will be capable of a 95 % organic efficiency with a product yield of 60 %. The remaining 25 % to 28 % solid discard will be placed in the opencast voids.

The plant will produce a product suitable for local and export markets.

1.2.2.3 Product Storage

The coal product will be stored on a product stockpile. The product stockpile conveyor belt will be fitted with a level probe to avoid over filling the stockpile and a mass meter for process accounting purposes.

1.2.3 Water Supply and Management

Possible water sources for use in the mining operations include the existing Aston Lake, owned by the Schoeman Boerdery as well as currently available or new boreholes. These water sources are still to be confirmed by undertaking the relevant feasibility studies and license applications. Pipes and pumps will be installed to pump water from these resources directly to the process plant. Process water will be managed and re-used throughout the operations of the project via clean and dirty water separation system, which shall include separate drains that lead into the following dams.

1.2.3.1 Waste Water Dams

Waste water dams will be constructed in the form of a slurry dam and pollution control dam. The purpose of the slurry dam is to collect and separate water from its dissolved constituents. A slurry dam will be constructed adjacent to the processing plant. The purpose of the pollution control dam is to store process water and stormwater for re-use in the plant and for dust suppression. The dams will be designed as per requirements of the Department of Water and Sanitation (DWS).

1.2.3.2 Power Supply

The project will obtain power from existing Eskom distribution power lines. Pandospan are proposing to construct a substation on the project site to connect to an existing power line to secure power for the operation of the proposed mine. The required power requirements would need to be confirmed with Eskom.

Electricity will also be generated by means of diesel generator sets for lighting and pumping of water. The maximum power requirements for the mine will be 5 MVA.

1.2.4 Waste Management

The proposed mining and related activities will result in the generation of slurry waste, which will be stored in the slurry dam. Furthermore, the solid coal discard will be temporarily stored on a discard dump before being taken back to the open pit for final disposal.

A proposed sewage treatment plant is proposed as part of the project to manage sewage waste. Other wastes including materials and chemicals from maintenance activities and daily operation of the proposed mine that will be generated onsite. All hazardous wastes will be stored and handled appropriately prior to being disposed of by a licensed hazardous waste disposal site. General domestic wastes will be managed in accordance with the requirements of the district municipality.

1.2.4.1 Access and Site Roads

The project site is bordered by an unnamed road to the north that also serves as the boundary between the Gauteng and Mpumalanga Provinces. The R29 serves as a partial southern boundary. There are various farm roads present on the proposed project area that can be used to navigate to the site.

Access to the site will be from the R29 onto an unnamed farm road heading north. Pandospan intend on using the surrounding road network to haul coal to the existing Welgedacht siding.

1.2.5 Rail Siding

Coal product may be transported via road to the Welgedacht siding from where the coal product will be distributed to the intended local and export markets.

1.2.6 Workshop Area

A workshop and office area is proposed which will also include a contractor's yard where machinery and equipment can be maintained and repaired. It is likely that this area will include offices, a laboratory, wash bays and storage facilities. These buildings are proposed to be approximately 3 m in height.

1.2.7 Hazardous Storage

Diesel storage tanks are proposed to be located in close proximity to the workshop area. This facility will be adequately bunded and have the necessary control systems in place to manage the potential risks of fire and/or explosion.

1.2.8 Vehicles and Equipment

The following vehicles and machinery will be used for the construction and operation of the proposed mine:

- Excavators;
- Dozers to move material;
- Load Haul Dump (LHD);
- Front End Loaders;
- 34 ton interlink haul trucks;
- Mine passenger vehicles;
- Graders for road maintenance;
- Water Bowsers for dust suppression;
- Generators for lighting and water pumping; and
- 2 ton Light Duty Vehicles (LDV).

1.2.9 Re-location of Existing Infrastructure

An existing public gravel road transgressing the site in a SW – NE direction would need to be relocated as it currently runs through the proposed open pit area.

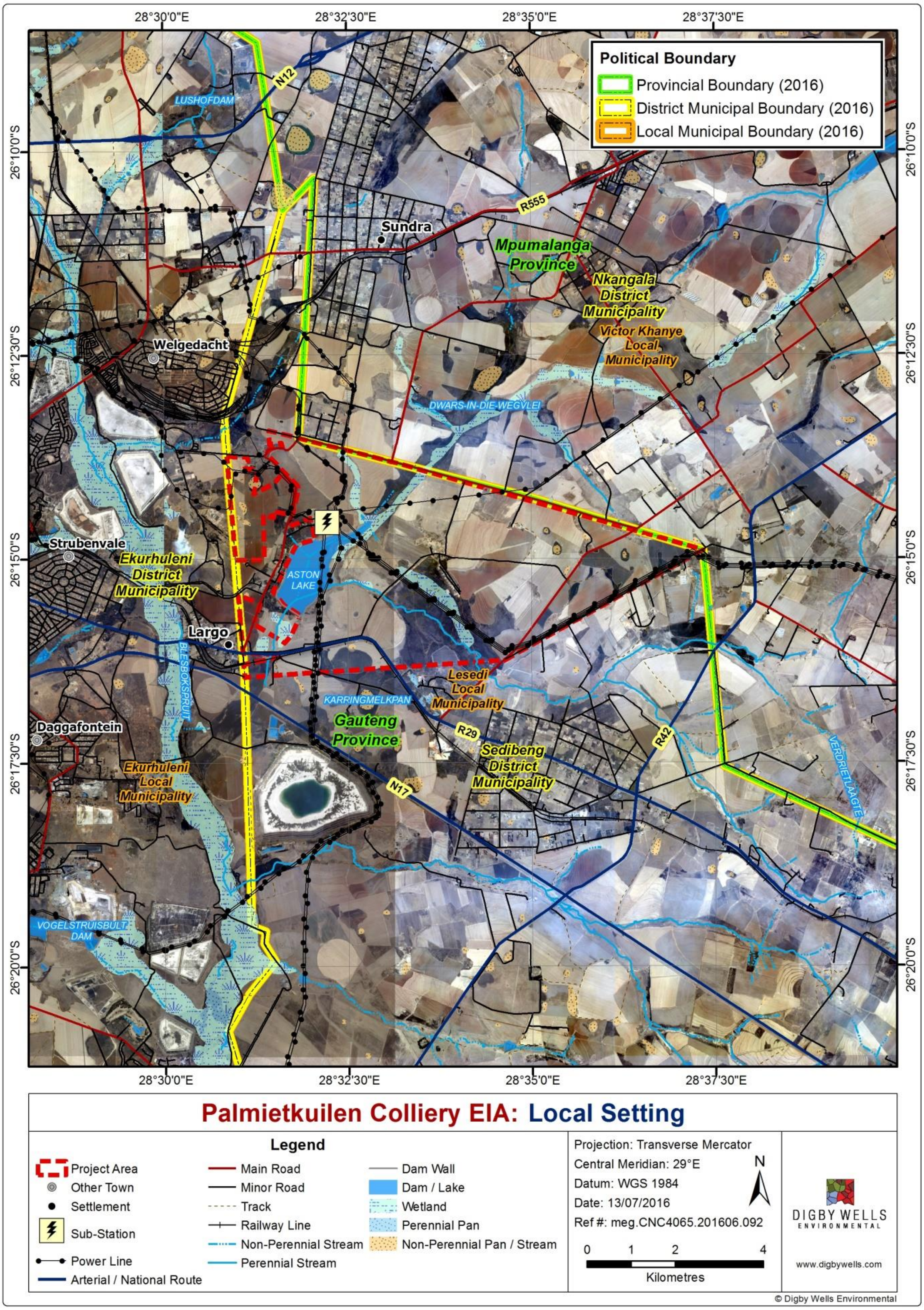

Figure 1-1: Local setting of the proposed Palmietkuilen Project Area

1.3 Activities per Project Phase

The following activities are envisioned for each of the project phases:

- Construction:
  - Site establishment;
  - Site clearing, including the removal of topsoil and vegetation;
  - Construction of mine related infrastructure, including haul roads, pipes, dams, etc.;
  - Construction of a coal washing plant;
  - Relocation of Infrastructure;
  - Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts; and
  - Temporary storage of hazardous products, including fuel and explosives, as well as waste and sewage.
- Operational:
  - Stripping topsoil and soft overburden;
  - Removal of overburden, including drilling and blasting of hard overburden;
  - Loading, hauling and stockpiling of overburden;
  - Drilling and blasting of coal;
  - Load, haul and stockpiling of RoM coal;
  - Use and maintenance of haul roads for the transportation of coal to the washing plant;
  - Water use and storage on-site; and
  - Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.
- Decommissioning and closure:
  - Demolition and removal of all infrastructure, including transporting materials off site;
  - Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring;
  - Environmental monitoring of decommissioning activities;
  - Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste; and
  - Post-closure monitoring and rehabilitation.

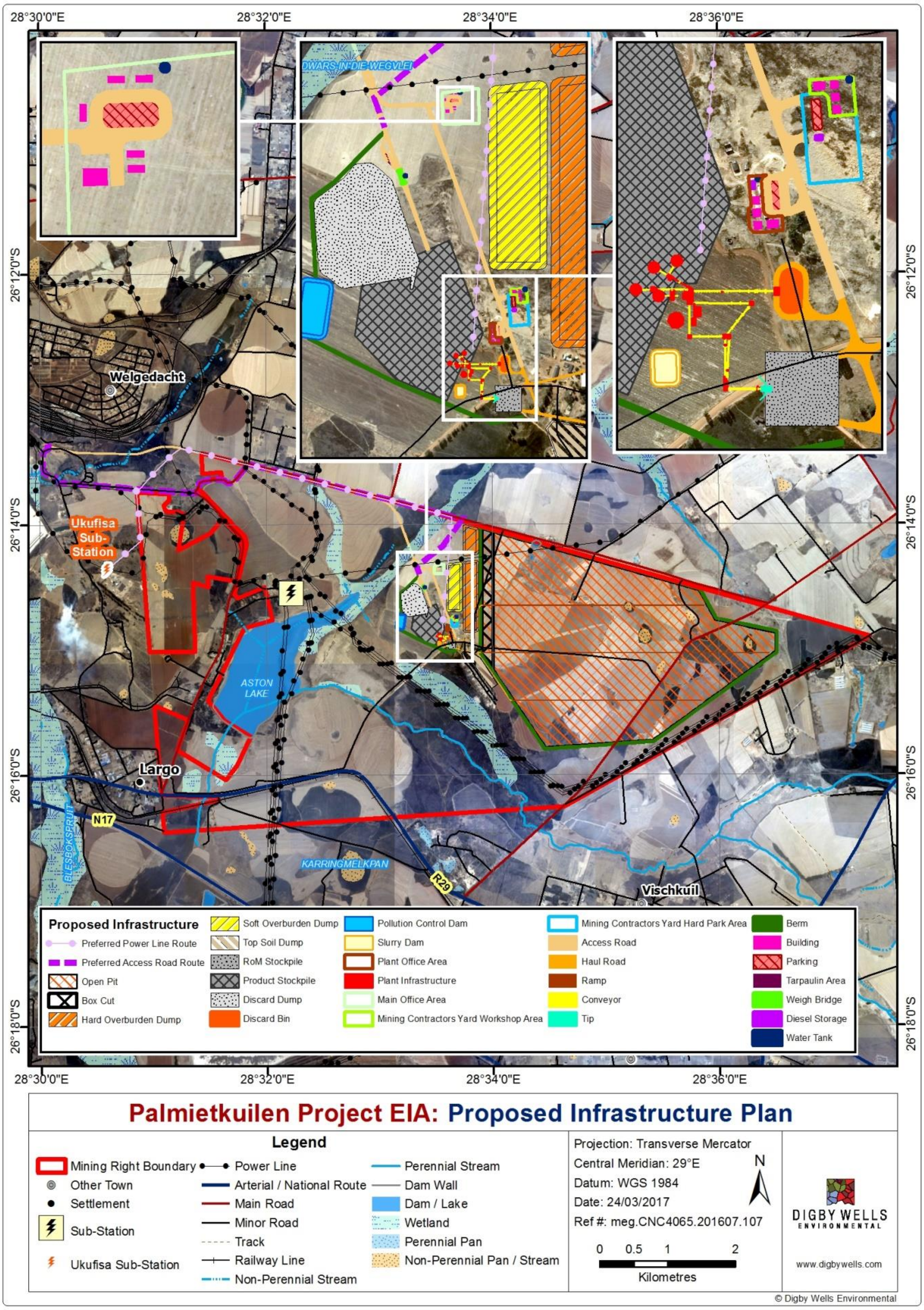

Figure 1-2: Proposed Palmietkuilen Infrastructure Layout

1.4 Terms of Reference

Digby Wells Environmental (Digby Wells) was appointed by Pandospan (Pty) Ltd (Pandospan) to complete the environmental authorisation for the proposed Palmietkuilen Coal Mining Project (as described above). As part of this appointment, Digby Wells was contracted to conduct an aquatic ecological baseline and impact assessment for the aquatic ecosystems associated with the proposed project.

2 Details of the Specialist

Russell Tate is a published, registered Professional Scientist (Pr. Sci. Nat Aquatic Health: 400089/15) with an M.Sc. in aquatic eco-toxicology. Russell has completed aquatic ecology related projects in South Africa, Mozambique, Botswana, Zambia, Ivory Coast, Ghana, Mali, Liberia, Sierra Leone, Senegal, Cameroon and throughout north, eastern and central Democratic Republic of Congo.

Considering the wide geographical range of the projects completed, Russell has a good technical understanding on the variable conditions within African rivers, as well as their biological compositions. This has allowed Russell to gain knowledge of a diversity of freshwater ecoregions within Africa.

3 Aims and Objectives

This report aims to establish the baseline aquatic ecological condition of the water courses associated with the proposed activities. Through the use of this baseline assessment, an impact assessment will be completed. As part of the impact assessment various mitigation actions will be recommended. In addition a recommended site specific monitoring programme is provided.

4 Methodology

4.1 Literature Review and Desktop Assessment

Published articles related to aquatic ecosystems of the region were reviewed to gain an understanding of the nature of the aquatic ecosystem of the surrounding environment. Desktop information consulted was based primarily on the most up to date version of the Desktop Assessment for the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) per Sub Quaternary Reaches (SQR) of Secondary Catchments in South Africa (Department of Water and Sanitation DWS, 2016).

4.2 Fieldwork and Seasonal Influence

In order to identify temporal ecological trends within the associated river systems, a survey was conducted in the low flow season (August 2016), and again within the high flow season (November 2016).

4.3 Present Ecological Status (PES)

The PES of the associated aquatic ecosystems was determined using the River Eco-status Monitoring Programme (REMP) Ecological Classification manuals (Kleynhans and Louw, 2007). The PES was derived through the characterisation of the various biophysical attributes for the considered river systems as presented in the sections below.

4.4 Water Quality

Water quality was measured using a calibrated Extech DO 700 multimeter. Constituents considered included temperature, pH, Dissolved Oxygen (DO) (mg/l) and conductivity (µS/cm). The results of the Digby Wells Surface Water Assessment (DWE, 2016), in which the chemical analysis of water was completed, was used to supplement these results. Water quality guidelines used in this report are for Aquatic Ecosystems (DWAF, 1996).

4.5 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*., 1999). Aquatic habitat (habitat) quality and availability assessments are usually conducted alongside biological assessments that utilise fish and macroinvertebrates. Habitat was assessed through visual observations on each river system considered.

4.5.1 Intermediate Habitat Integrity Assessment

To define a general habitat, for baseline purposes, the instream and riparian habitat was assessed and characterised according to “Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D).

The Intermediate Habitat Integrity Assessment (IHIA) model was used to assess the integrity of the habitats from a riparian and instream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The criteria utilised in the assessment of habitat integrity in the current study are presented in Table 4-1.

Table 4-1: Criteria in the Assessment of Habitat Integrity (Kleynhans, 1996)

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated 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 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.

Criterion	Relevance
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 point sources. Measured directly or alternatively 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
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
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.
Indigenous 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 river bank 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.

The relevant criteria is then weighted and scored according to Kleynhans (1996), as seen in the tables below (Table 4-2 and Table 4-3).

Table 4-2: Table giving Descriptive Classes for the Assessment of Modifications to Habitat Integrity (Kleynhans, 1996)

Impact Category	Description	Score
None	No discernible impact or the modification 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 very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are 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 in almost the whole of the defined area 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 influenced detrimentally.	21-25

Table 4-3: Criteria and Weights used for the Assessment of Habitat Integrity (Kleynhans, 1996)

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

Scores are calculated based on ratings received from the assessment. The estimated impacts of the criteria are summed and expressed as a percentage to arrive at a provisional habitat integrity assessment. The scores are placed into the IHIA categories (Kleynhans, 1996) as seen in Table 4-4.

It should be noted that the IHIA was based on regions assessed in the current studies and therefore may only constitute the assessment of conditions within the considered Sub Quaternary Reach (SQR) length.

Table 4-4: Intermediate Habitat Integrity Categories (Kleynhans, 1996)

Category	Description	Score
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.	80-90
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 the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

4.6 Macroinvertebrates

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream) (Barbour *et. al*., 1999). Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects (Barbour *et. al*., 1999). The assessment and monitoring of benthic macroinvertebrate communities forms an integral part of the monitoring of the health of an aquatic ecosystem.

4.6.1 Integrated Habitat Assessment System (IHAS)

The Integrated Habitat Assessment System (IHAS) was specifically designed to be used in conjunction with the South African Scoring System version 5 (SASS5), benthic macroinvertebrate assessment. The IHAS assesses the availability of the biotopes at each site and expresses the availability and suitability of habitat for macroinvertebrates, this is determined as a percentage, where 100% represents "ideal" habitat availability. A description based of the IHAS percentage scores is presented in Table 4-5.

Table 4-5: Description of IHAS Scores with the Respective Percentage Category

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

4.6.2 South African Scoring System (version 5) (SASS5)

The SASS5 is the current biological index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Muscidae and Psychodidae) to highly sensitive families (e.g. Oligoneuridae). SASS5 results are expressed both as an index score (SASS5 score) and the Average Score Per recorded Taxon (ASPT value).

Sampled invertebrates were identified using the “Aquatic Invertebrates of South African Rivers” (Gerber and Gabriel, 2002). Identification of organisms was made to family level (Thirion *et. al*., 1995; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Highveld lower ecoregion. This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database. The table and figure below illustrate the biological banding and classification (Figure 4-1).

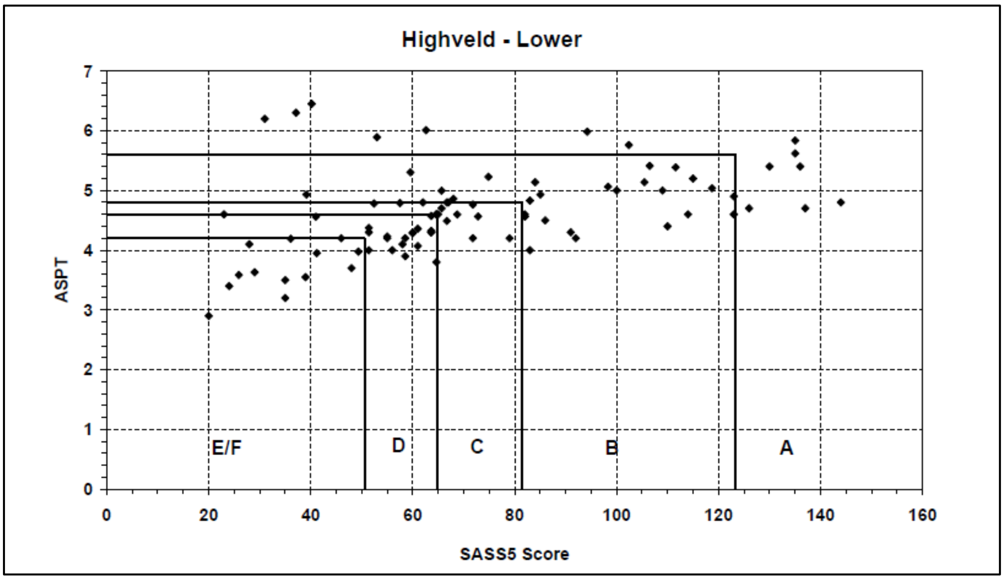

Figure 4-1: Guidelines used for the Interpretation and Classification of the SASS5 Scores (Dallas, 2007)

The SASS5 biotope scores will be used for habitat diversity comparison due to limitations in the IHAS methodology (Tate and Husted, 2015).

4.6.3 Macroinvertebrate Response Assessment Index (MIRAI)

The Macroinvertebrate Response Assessment Index (MIRAI) was used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions for the Highveld Lower. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed riparian vegetation assessment.

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES.

4.7 Fish Response Assessment Index

Due the depths of water observed at the sites, fish were captured by means of electroshocking. All fish were captured, identified and counted in the field and released unharmed at the point of capture. Fish species were identified using the “Complete Guide to the Freshwater Fishes of Southern Africa” (Skelton, 2001). The identified fish species were compared to those expected to be present for the C21E quaternary catchment. The expected fish species list was developed from a literature survey and included sources such as Kleynhans *et. al*. (2007) and Skelton (2001).

The information gained using the Fish Response Assessment Index (FRAI) provides an indication of the PES of the river based on the fish assemblage structures observed. It must be noted that a reach based FRAI assessment was completed. For this assessment it is assumed that habitat is evenly distributed. Frequency of Occurrence (FROC) ratings were adjusted according to the habitat available at each site.

5 Assumptions and Limitations

The methods outlined in this study assume that aquatic ecology within the associated river courses is evenly distributed. The surveys were completed during a severe drought and therefore the PES trends may have been affected by the drought conditions.

The naming of the fish species belong to *Barbus* (Skelton, 2001) have been updated to *Enteromius*. However, for this report the species will be referred to as *Barbus.*

Groundwater and geochemical studies have not yet been completed. Considering that it is assumed that Acid Mine Drainage will occur.

6 Study Site

The proposed activities and subsequent project area are located within the Upper Vaal Water Management Area (WMA) within the C21E quaternary catchment, which is classified as the Blesbokspruit River catchment area. According to the National Freshwater Ecological Priority Areas (NFEPA), the project area falls within an upstream management area (Nel et al., 2011). These areas (upstream management areas) are regions which require management to promote downstream FEPA's (Nel et al., 2011). The project area in relation to the quaternary catchments is presented below (Figure 6-1). According to the Resource Water Quality Objectives (WQO) in the upper and lower Vaal WMA (Department of Water Affairs (DWA), 2014) the rivers associated with the study site (Blesbokspruit) provide critical ecosystem services to the southern portion of Gauteng. Based on the WQO gazette (DWA, 2014) the rivers are heavily impacted and it is important that the ecosystem is maintained in "an acceptable quality (D status or better)". Habitat and water quality modification is seen as a priority in the river reach and should be avoided in order to maintain the current ecological status.

The figure below (Figure 6-2) shows that tributaries of the Blesbokspruit are directly associated with the proposed project area. According to desktop information these tributaries are unnamed and thus no Sub-Quaternary Reach (SQR) data is available (DWS, 2016). However, colloquially these rivers are known as the Dwars-in-die-wegvlei on the west and the Verdrietlaagte stream to the south of the project area. As discussed above, these streams report to the Blesbokspruit a tributary of the Suikerbosrand River which forms a tributary of the Vaal River. Due to the fact that the streams in the project area have not been delineated in terms of the data provided by the Department of Water and Sanitation (DWS) the watercourses in this study will be referred to as their colloquial names. Considering the absence of available DWS data, the available desktop information will be extrapolated for the project area. The PES assessment will be completed according to the catchment area of the project and not the potentially effected individual streams.

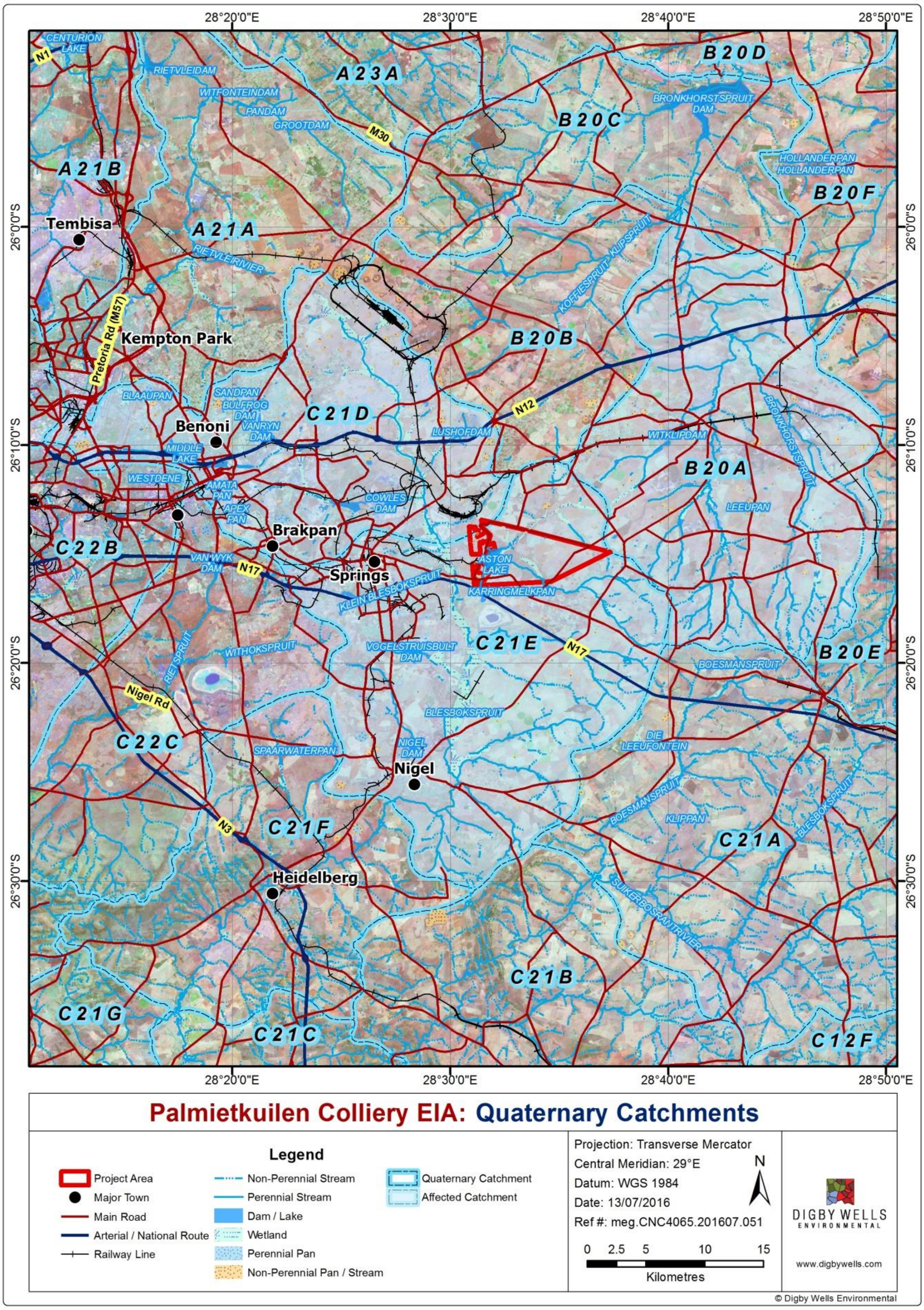

Figure 6-1: Location of the proposed Palmietkuilen Project Area in relation to quaternary catchments

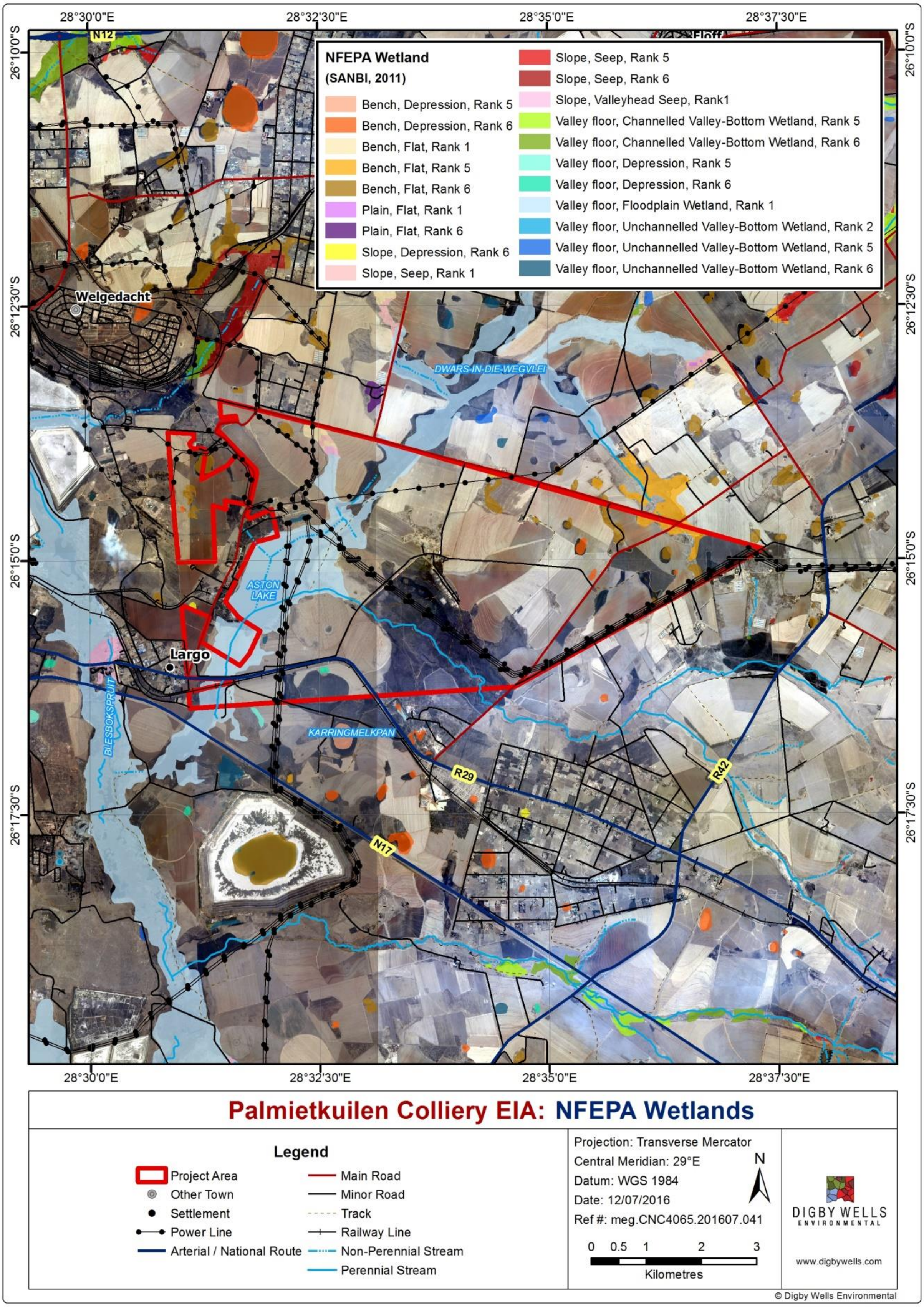

Figure 6-2: NFEPA Wetlands in the proposed Palmietkuilen Project Area

6.1 Desktop Ecological Status

Based on the most recent available information on the Present Ecological Status (PES) (DWS, 2016), the status of the reach of the Blesbokspruit associated with this project is given in the table below (Table 6-1).

Table 6-1: Present Ecological Status, Ecological Importance and Ecological Sensitivity

Component/Catchment	C21E-01356
Present Ecological Status	Class E
Ecological Importance	Moderate
Ecological Sensitivity	Moderate

Based on the classification provided above, the reach of the Blesbokspruit associated with the project can be classified as Class E and therefore is considered to be in a seriously modified state. The ecological importance and sensitivity is seen as moderate indicating that some sensitive and important species are present in the associated river reach.

Available imagery of the project area indicates the presence of an impoundment within the main tributary considered. Due to the presence of modified aquatic habitat and flow dynamics, compounded by poor water quality, the aquatic biodiversity in terms of macroinvertebrates and ichthyofauna is expected to be poor. The expected species in the quaternary catchment is presented in the table below (Table 6-2).

Table 6-2: Expected fish species in the C21E quaternary catchment area

Common Name	Scientific Name	Conservation status (IUCN)
Common rock catlet	*Austroglanis sclateri*	Least Concern
Chubbyhead barb	*Barbus anoplus*	Least Concern
Sidespot barb	*Barbus pallidus*	Least Concern
Straightfin barb	*Barbus paludinosus*	Least Concern
Sharptooth catfish	*Clarias gariepinus*	Least Concern
Smallmouth yellowfish	*Labeobarbus aeneus*	Least Concern
Largemouth Yellowfish	*Labeobarbus kimberleyensis*	Near Threatened
Mudfish	*Labeo capensis*	Least Concern
Moggel	*Labeo umbratus*	Least Concern

Common Name	Scientific Name	Conservation status (IUCN)
Southern mouthbrooder	*Pseudocrenilabrus philander*	Least Concern
Banded tilapia	*Tilapia sparrmannii*	Least Concern

According to previous literature (EWR11, DWA 2008) the fish community structure in the Blesbokspruit has been altered as a result of poor water quality and the loss of specific habitat biotypes. As an example the species *Austroglanis sclateri, Labeo capensis* and *Labeo umbratus* have been lost due to “deteriorated water quality and substrate habitats” (EWR11, DWA 2008).

Based on available data on fish communities, it can be concluded that fish diversity is low as a result of poor quality substrate and habitat quality compounded by poor water quality. It should be noted that the red data species *Labeobarbus kimberleyensis* is expected to be present within the quaternary catchment and subsequently is potentially present in the downstream regions.

The location of the selected study sites is provided in the Figure 6-3 below. Photographs obtained at the sites are also provided in the Table 6-3 below.

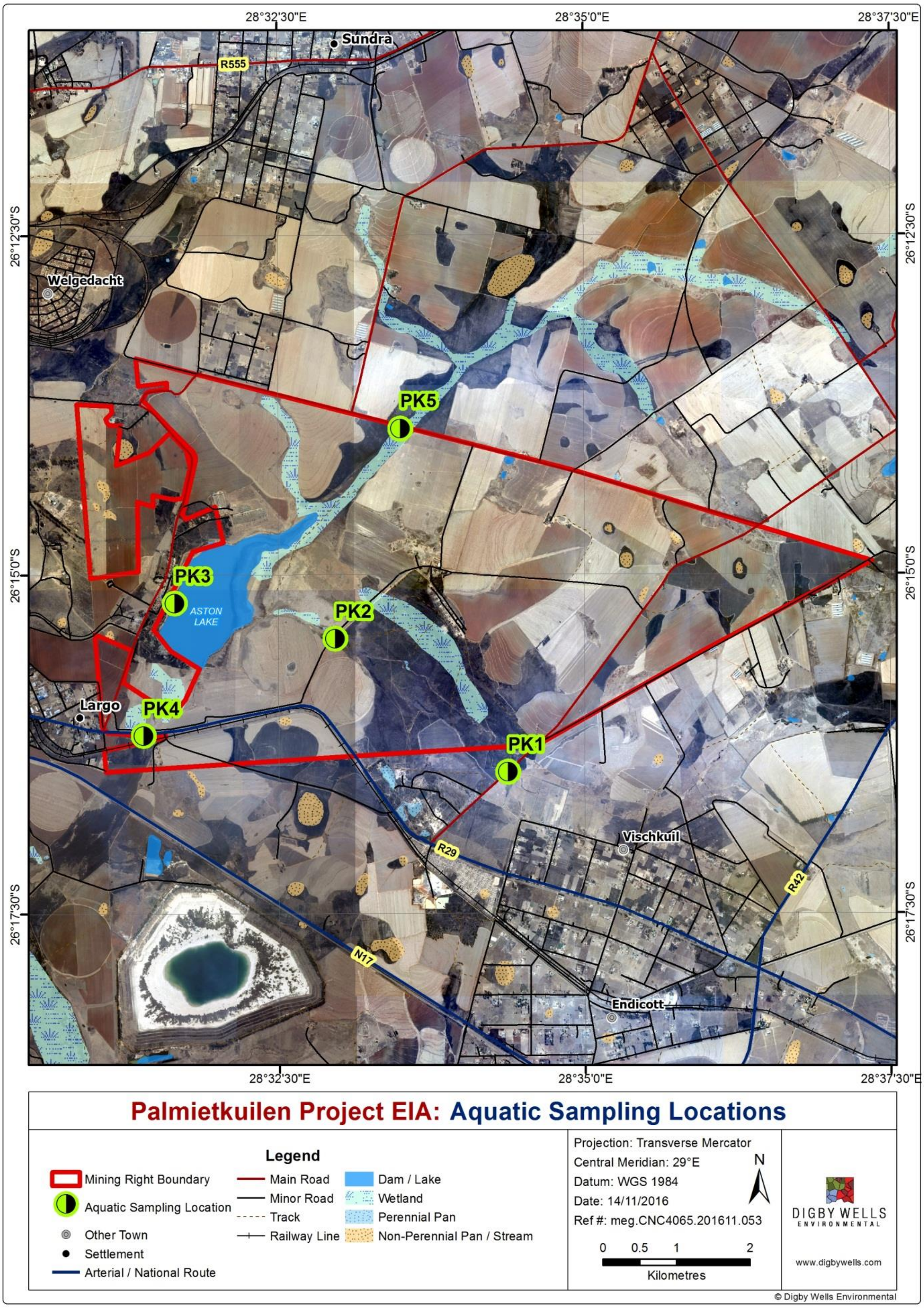

Figure 6-3: Location of aquatic sampling points (August and November 2016)

Table 6-3: Photographs obtained from the sites during August and November 2016

Site	August 2016	November 2016
PK1		
PK2		
PK3 (August 2016)		
PK4		

Site	August 2016	November 2016
PK5		

7 Baseline Environment

7.1 Water Quality

The results of the *in situ* water quality analysis are presented in Table 7-1 for the low flow (August 2016) and Table 7-2 for the high flow (November 2016) surveys.

Table 7-1: *In Situ* Water Quality Results for the August 2016 Survey

Constituent	Temperature (ºC)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)
Guidelines	**5-35**	**6-9**	**<700**	**>5**
PK1	18	8.8	1190	4.5
PK2	DRY	DRY	DRY	DRY
PK3	18	8.7	315	4.0
PK4	18	8.6	214	4.8
PK5	18	8.3	318	4.2

The *in situ* water quality analysis shows that temperature was an expected value of 18 ºC for a winter survey. The pH values were observed to range between 8.3 at PK5 to 8.8 at PK1. Conductivity values ranged from 1190 at PK1 to 214 µS/cm at PK4. The concentrations of dissolved oxygen ranged from 4.2 at PK5 to 4.8 mg/l at PK4.

A surface water assessment completed during August 2016 (Digby Wells, 2016) confirms the results depicted in the above *in situ* assessment. The chemical assessment completed in the study shows that the total dissolved solid component at the site PK1 is indeed elevated. The dissolved elements predominantly responsible for the exceeding conductivity results are Calcium (80 mg/l), Magnesium (52 mg/l), Sodium (127 mg/l) with Chlorides and sulphates making up the highest component of the dissolved solids at 178 mg/l and 109 mg/l respectively.

The concentrations of dissolved oxygen at the sites was found to be predominately uniformly low (>5mg/l). These low concentrations would likely have a direct effect on the types of aquatic biota which will be found at the sites. Dissolved oxygen content in wetlands differs from those in river systems due to the comparable geomorphology of the water body type. Typically, a wetland dissolved oxygen concentration ranges from 3 to 7.5 mg/l and is sensitive to changes in nutrient input (McCormick and Laing 2003). As observed in the surface water results, the concentrations of nutrients (Phosphate, Nitrates and Ammonia) are relatively low. However, considering the extensive dry land agriculture and the presence of livestock it can be expected that nutrient concentrations are exceeding the original reference conditions, and thus most likely contributing to lowered concentrations of dissolved oxygen (Morgan *et. a*l., 2005).

Table 7-2: *In Situ* Water Quality Results for the November 2016 Survey

Constituent	Temperature (ºC)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/l)
Guidelines	**5-35**	**6-9**	**<700**	**>5**
PK1	DRY	DRY	DRY	DRY
PK2	DRY	DRY	DRY	DRY
PK3	27	7.2	300	5.2
PK4	26	6.8	194	6.2
PK5	26	7.1	240	6.4

The high flow survey was completed in early November in order to obtain the required information before the submission of the Environmental Authorisations. Despite sufficient rainfall in the region, it appears that the rainfall may have been scattered as the southern tributary was found to be dry during the assessment. The reasoning for the dry nature of the site is difficult to discuss as site PK4 and PK5 were noted to contain more water than the previous surveys.

Water quality trends observed during the high flow survey show low dissolved solid content in the water bodies at inundated sites. This provides an indication that land use in the catchment area is not extensively affecting water chemistry. In addition, industrial activities within the catchment area appear to be limited resulting in fair water quality.

Within the receiving waterbody, the Blesbokspruit, a historical analysis of surface water quality by Ambani *et. al*., 2015 shows that water in the river system has been impacted through mining and industrial (papermill) activities upstream of the confluence with the considered river reach. Although, there are high levels of mineralization in the Blesbokspruit, acidic conditions stemming from Acid Mine Drainage is limited in the river system with pH ranges of 6.7 to 8.8 over the period of 11 years (Ambani *et. al*., 2015). The pH values obtained in this study are within this range and thus confirm the abovementioned study for the 2016 period.

Previous studies in the Blesbokspruit have identified several sources for increased dissolved solids in the river system. These sources include a historical pulping plant, sewage discharge and the historical dewatered mine water discharge (Ambani *et. al*., 2015). It should be noted that these industrial and sewage discharges occur upstream of the study site. However, mine water discharge at the Grootvlei Mine ceased in 2011 and the pulp mill ceased functioning at the end of 2010. Thus, it the likelihood of some recovery in the Blesbokspruit is expected. In addition, the treatment of contaminated groundwater as part of the Short Term Intervention measures for Acid Mine Drainage will likely serve to further improve water quality in the Blesbokspruit.

As per the water quality assessment completed for this study, good water quality will emanate from the considered river systems and thus will likely serve to improve conditions within the Blesbokspruit by diluting the levels of contamination within the river system.

7.2 The Intermediate Habitat Integrity Assessment (IHIA)

The IHIA was completed on the streams of concern and populated with observations recorded during the two surveys. The results of the IHIA on instream habitat are presented in the table below (Table 7-3) with the riparian integrity assessment presented in Table 7-4.

Table 7-3: Intermediate Habitat Integrity Assessment for Instream Habitat

Instream	Average score	Score	Comment
Water abstraction	5.00	2.80	Limited to approximately four pivots.
Flow modification	16.67	8.67	Discharge of water from sewerage. Impoundments and several road crossings.
Bed modification	15.00	7.80	Some bed modification associated with roads and the construction of Aston Lake.
Channel modification	11.67	6.07	Largely intact upper reaches. However, the Aston Lake does impact on the channel.

Instream	Average score	Score	Comment
Water quality	13.33	7.47	Agricultural return flows and some sewerage discharge.
Inundation	13.33	5.33	Flooding as a result of the Aston Dam. River crossings has resulted in localised inundation upstream.
Exotic macrophytes	5.00	1.80	None observed within the waterbodies. However, confidence is not high.
Exotic fauna	10.00	3.20	Carp, mosquito fish and Bass are known to occur in the area.
Solid waste disposal	8.33	2.00	Some solid waste was observed in the active channel.
Total Instream	**54**		
Category		**class D**	

Table 7-4: Intermediate Habitat Integrity Assessment for Riparian Habitat

Riparian	Average score	Score	Comment
Indigenous vegetation removal	5.00	2.60	Wetland zone surrounding the channels are generally intact.
Exotic vegetation encroachment	6.67	2.40	Within the catchment area there is farming with some alien plants observed.

Riparian	Average score	Score	Comment
Bank erosion	6.67	5.60	Some erosion around the river crossings.
Channel modification	11.67	2.40	Largely intact upper reaches. However, the Aston Lake does impact on the channel.
Water abstraction	5.00	2.60	Small amounts of abstraction upstream.
Inundation	13.33	4.40	Flooding as a result of the Aston Dam. River crossings have resulted in localised inundation upstream.
Flow modification	16.67	7.20	Discharge of water from sewerage. Impoundments and several road crossings.
Water quality	13.33	10.40	Agricultural return flows and some sewerage discharge.
Total Riparian	**62**		
Category		**class C**	

The IHIA results of the instream aquatic habitat was derived to be a class D or largely modified status whilst the riparian habitats within the streams assessed are classified as class C or moderately modified.

The results of the habitat assessment for instream habitat show that there are several principle drivers for the current status of the river system. The construction of the Aston Lake impoundment has resulted in the modification of natural flows, river bed and channel characteristics and extent of inundation in the catchment area. Runoff and seepage emanating from agricultural activities compounded by livestock and sewerage effluent has also acted to cumulatively reduce the integrity of the available instream habitat.

The results of the riparian component of the IHIA show that the habitat is moderately modified. Similarly to instream habitat, the primary causative impacts to riparian habitat can be attributed to the Aston Lake impoundment which has altered the natural hydrology of the catchment.

7.3 Macroinvertebrates

Sites which were inundated were selected for macroinvertebrate assessment.

7.3.1 Integrated Habitat Assessment System (IHAS) and Biotope Assessment

The results of the IHAS completed during the surveys are presented in the table below (Table 7-5).

Table 7-5: Integrated Habitat Assessment System results for the 2016 surveys

Site	Score	Suitability	Score	Suitability
Survey	**Low Flow**		**High Flow**	
PK1	48	Poor	DRY	DRY
PK2	DRY	DRY	DRY	DRY
PK3	36	Poor	38	Poor
PK4	48	Poor	48	Poor
PK5	36	Poor	38	Poor

The results of the biotope diversity assessments are presented in the table below (Table 7-6). It is noted that this is the typical habitat present during both surveys and can serve as a guide to the available habitat should the sites become inundated.

Table 7-6: Invertebrate Biotope Diversity August (2016)

Biotope/Site	PK1	PK2	PK3	PK4	PK5
Stones in current	0	DRY	0	0	0
Stones out of current	1	DRY	0	1	1
Bedrock	1	DRY	0	1	0
Aquatic Vegetation	0	DRY	0	2	2
Marginal Vegetation In Current	0	DRY	0	0	0
Marginal Vegetation Out Of Current	1.5	DRY	2	1.5	3
Gravel	0	DRY	0	0	0
Sand	1	DRY	1	1	1
Mud	2	DRY	2	2	2

Biotope/Site	PK1	PK2	PK3	PK4	PK5
Biotope Score	6.5	DRY	5	8.5	9
Biotope Score (%)	**14**	DRY	**11**	**19**	**20**
Biotope suitability	**Poor**	DRY	**Poor**	**Poor**	**Poor**

7.3.2 South African Scoring System

The results of the SASS5 assessments completed for the study are presented below (Table 7-7 and Table 7-8).

Table 7-7: SASS5 Results of the Low Flow Survey

Site	PK1	PK2	PK3	PK4	PK5
SASS5	25	DRY	41	64	34
Taxa	8	DRY	12	18	12
ASPT	3.1	DRY	3.4	3.5	2.8
Category	E	DRY	E	D	E

Table 7-8: SASS5 Results of the High Flow Survey

Site	PK1	PK2	PK3	PK4	PK5
SASS5	DRY	DRY	36	50	50
Taxa	DRY	DRY	11	13	13
ASPT	DRY	DRY	3.2	3.8	3.8
Category	DRY	DRY	E	E	E

The results of the SASS5 assessment illustrate that the conditions within the considered river reach are not favourable to support diverse and sensitive aquatic invertebrates which are included in the assessment. Considering typical interpretation guidelines, the sites are classified as seriously and largely modified from reference conditions (class E and class D respectively). However, based on the poor habitat available at the sites and the non-flowing nature of the waterbody, the classification is largely due to the poor invertebrate habitat diversity at the sites rather than instream aquatic conditions (Dallas, 2007). On assessment of the Baetidae, two taxa were identified to genus level, these included *Baetis* and *Pseudocloeon* both of which are common Southern African species and are known to be tolerant to water quality deterioration. The results of the macroinvertebrate assessment are therefore indicative of polluted waters likely attributed to nutrient enrichment.

Although zooplankton species are not typically included in macroinvertebrate indices, it is noted that zooplankton taxa at the site PK5 were diverse and abundant and included two large groups of taxa belonging to the class Branchiopoda. These taxa included *Triops* and *Branchipodosis* as illustrated below (Figure 7-1).

Figure 7-1: Zooplankton observed at PK5 during the November 2016 survey (left: *Triops spp.*; Right: *Branchipodosis spp.*)

Although these taxa are not regarded as being sensitive, they are rare and ecologically important (Soininen *et al.,* 2007). Due to the presence and richness of zooplankton at the site, PK5 is regarded as being unique on a catchment scale and will be further assessed in Section 8.

In addition to zooplankton, the Odonata observed within the catchment were noted as per the table below (Table 7-9). A total of five species of dragonflies were observed. This low diversity of dragonflies illustrates and confirms the poor available aquatic habitat at the various sites and throughout the catchment area.

Table 7-9: Odonata observed during the November 2016 survey

Photograph	Species	Common Names
	*Crocotehmis erythraea*	Broad Scarlet
	*Africallagma glaucum*	Swamp Bluet

Photograph	Species	Common Names
	*Ischnura senegalensis*	Tropical Bluetail
	*Anax emperator*	Blue Emperor
	*Pantala flavescens*	Wandering Glider

7.3.3 Macroinvertebrate Assessment Index

The results of the MIRAI assessment are presented in the table below (Table 7-10).

Table 7-10: MIRAI scores for the 2016 surveys

Invertebrate Metric Group	Score Calculated
Flow modification	34.9
Habitat	33.2
Water Quality	29.6
Ecological Score	**32.6**
Invertebrate Category	**E**

The result of the MIRAI shows that the ecological category of the river reach was determined to be a class E or seriously modified. According to the zonation and types of habitat available at the sites, it is expected that fast flowing water and cobbled substrates did not form part of the original reference conditions within the study area. These abovementioned components were thus weighted accordingly.

The results of the assessment indicate that water quality within the assessed river reaches is impacted and confirms the results of the water quality assessment

7.4 Fish Response Assessment Index

The results of the FRAI assessment are presented in Table 7-11. It is noted that no Red Data Listed species were captured during this assessment. It is noted that taxa not expected to be in the river reach assessed and thus rated as 0 for the Frequency of Occurrence (FROC) have been removed from the table below.

Table 7-11: FRAI Results of the 2016 Study

Fish Species	Reference Frequency of Occurrence	Observed Frequency of Occurrence	Site observed
Barbus anoplus	3	1	PK4 and PK1
Barbus pallidus	2	0	None
Barbus paludinosus	3	0	None
Clarias gariepinus	3	1	PK4 and PK3
Labeo umbratus	1	0	None
Pseudocrenilabrus philander	2	1	PK4
Tilapia sparmanni	2	1	PK4
FRAI (Adjusted) %		31	
Ecological category		E	

The overall FRAI category was calculated to be seriously modified (class E). The FROC for each fish species was determined based on the presence of available habitats. The results of the FRAI indicate that although habitat was available for small *Barbus* species very few were sampled. The poor FROC of the various fish species can be linked to poor connectivity between the various river reaches. During the two surveys no water was observed between the sites PK1, PK2, PK3 and PK4. Similarly, no surface water directly connects the site PK5 with PK3. Considering these results habitat impacts are the principal driver for poor fish community responses.

7.5 Present Ecological Status

The results of the ecological classification and PES for the river reach considered are provided in the table below (Table 7-12).

Table 7-12: The Present Ecological Status of the river reach in this study

Category	**Score**	**Ecological category**
Riparian Habitat Ecological Category	62	class C
Fish Ecological Category	31	class E
Macroinvertebrate Ecological Category	32	class E
Ecostatus		class D/E Largely/Seriously modified

The results of the ecological classification indicate that the PES of the reach assessed in this study is a class D/E or largely/seriously modified. As discussed in the various sections above, modification of habitat quality within the assessed river reach has resulted in the loss of suitable aquatic habitat.

8 Sensitivity Analysis and No-Go Areas

The overall Ecological Importance and Sensitivity (EIS) of the catchment area potentially affected in the study area were assessed according to Kleynhans (1999). The results of the EIS assessment are provided below (Table 8-1).

The results of the EIS assessment derived an overall Moderate EIS score. The results of this assessment are important to consider for the impact assessment. As mentioned in the above table (Table 8-1) the Gauteng Conservation Plan has categorised several portions of the considered river systems in the study area as Ecological Support and Important Areas (Figure 8-1).

Considering the various sensitivities of the aquatic and associated wetland ecosystems associated with the proposed project, a buffer zone of 100m is recommended from the edges of the delineated wetland areas. The extent of the buffer zones and the various infrastructures are illustrated in Figure 8-2. Based on the layout of the project it is noted that a haul road crosses a wetland and in proximity to the species rich site PK5.

Table 8-1: EIS assessment for the catchment area (Kleynhans (1999))

Biological determinants		
Determinant	**Rating**	**Comments**
Rare and endangered biota	3	One or more species regarded as rare or endangered on a regional scale (Zooplankton and downstream *Labeobarbus kimberlyensis*).
Unique biota	2	The zooplankton observed are unique on a local scale.
Intolerant biota	1	A very low proportion of the taxa are sensitive to water quality impacts.
Species richness	2	Moderate species richness particularly in reference to zooplankton.
Habitat determinants		
Diversity of aquatic habitat	1	Not diverse and illustrated by low diversity of Odonata.
Refuge value of habitat types	1	Limited connectivity between the main-stem of the Blesbokspruit and the catchment area in the study area.
Sensitivity of habitat to flow modification	1	The taxa observed in the study area are all tolerant to low flow conditions.
Sensitivity to flow related water quality changes	1	The taxa observed in the study area are all tolerant to low flow conditions coupled with related

		increases in the concentrations of salts.
Migration route corridor for instream and riparian biota	2	The wetland area plays an important role in migration for terrestrial fauna.
National parks and wilderness areas	3	The areas considered are part of the Gauteng Conservation Plan with delineated Ecological Support and Important Areas. Further, the RAMSAR wetland downstream of the site.
Mean	1.7	
EIS class	Moderate	

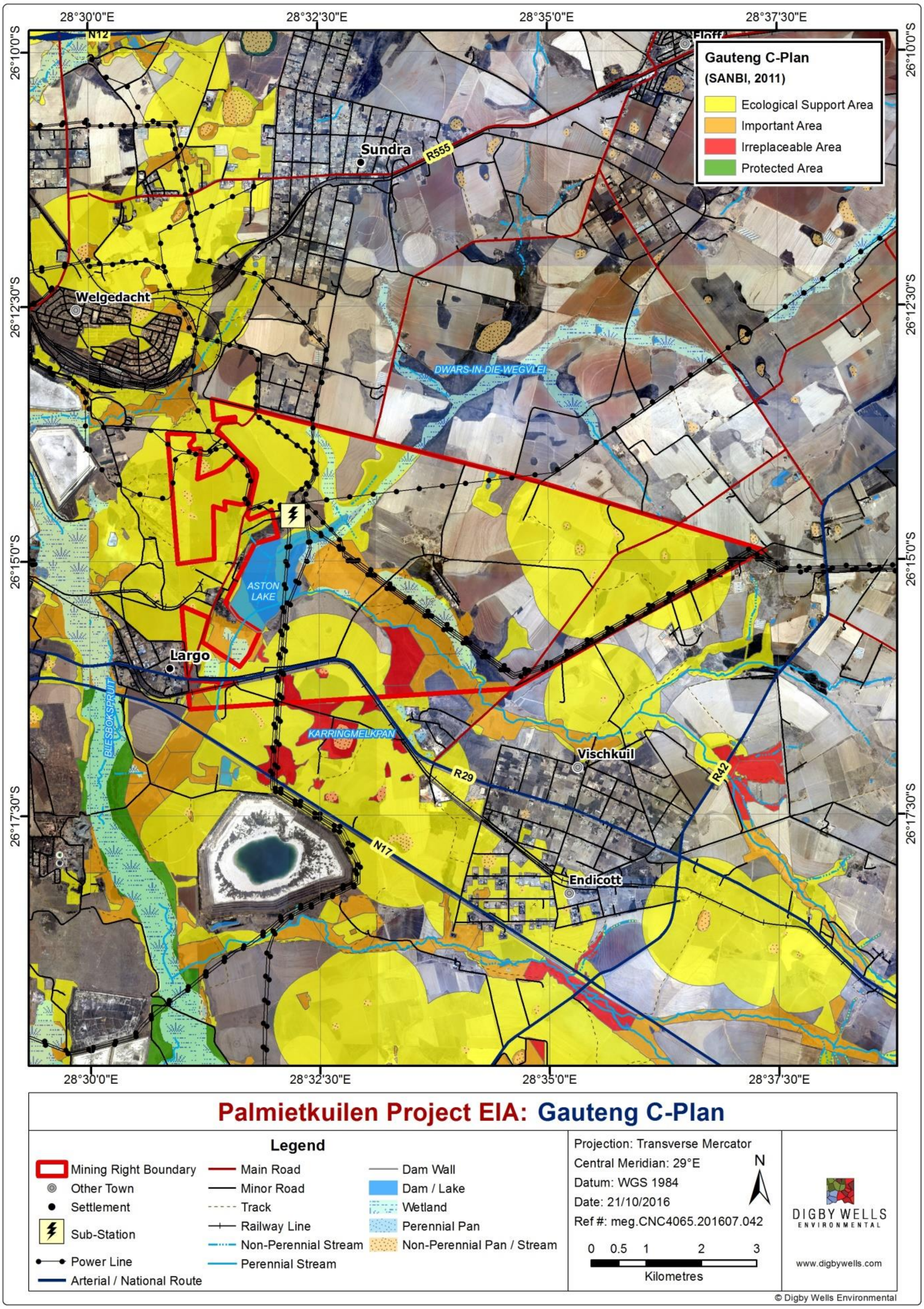

Figure 8-1: Gauteng Conservation Plan

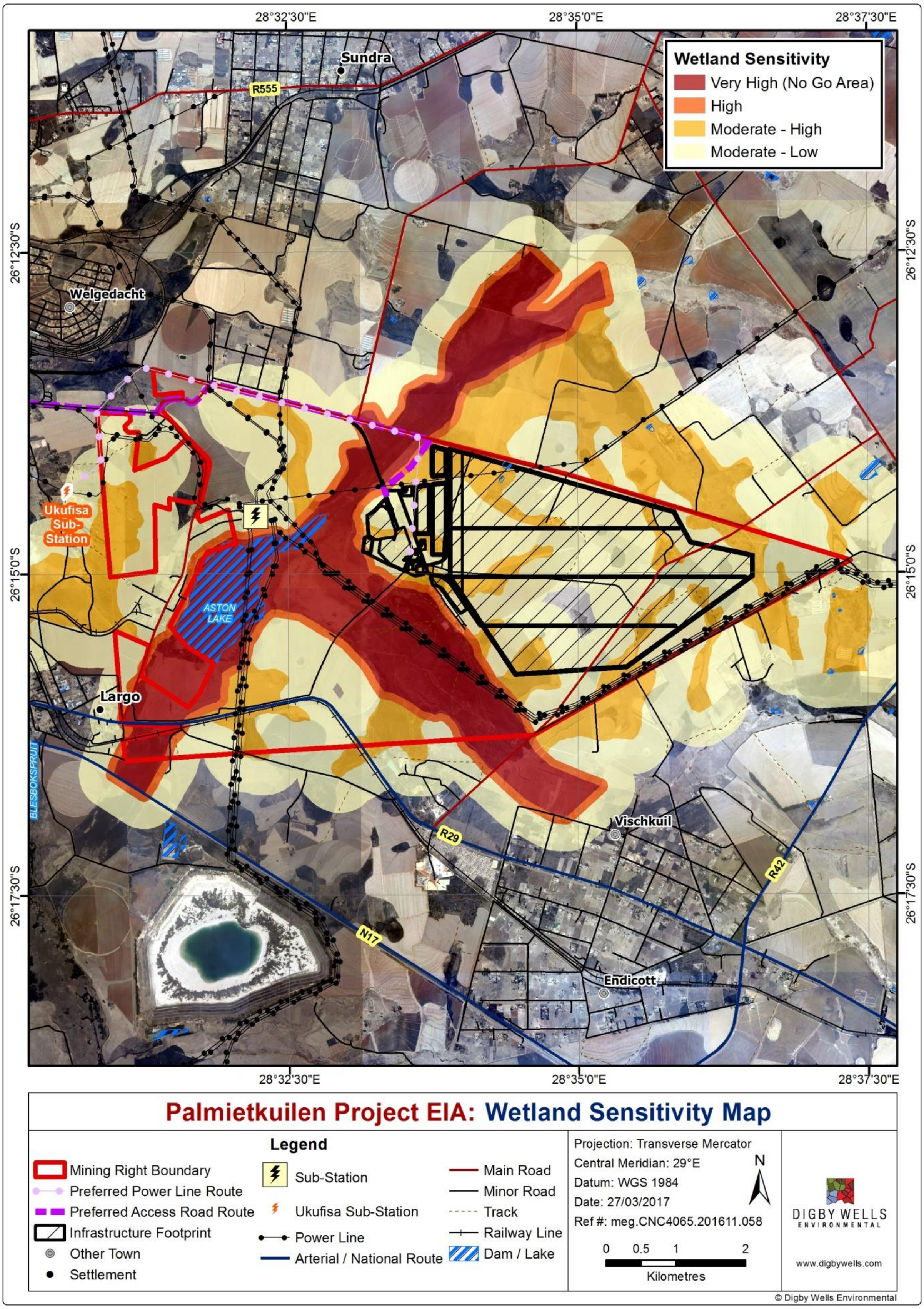

Figure 8-2: Recommended Buffer and Sensitivity Zones

9 Impact Assessment

9.1 Methodology used in Determining and Ranking the Nature, Significance, Consequence, Extent, Duration and Probability of Potential Environmental Impacts and Risks

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 9-3. 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 EIA/EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 9-2, which is extracted from Table 9-1. The description of the significance ratings is discussed in Table 9-3.

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 9-1: Impact Assessment Parameter Ratings

Rating	Intensity		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		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss 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 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		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		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 9-2: Probability/Consequence Matrix

Probability	Significance																																					
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 9-3: Significance Rating Description[1]

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) (-)

[1] It is generally sufficient to only monitor impacts that are rated as negligible or minor

9.2 Impact Assessment: Construction Phase

The activities which will be assessed in this phase are presented below (Table 9-4). Based on the activities listed above, Table 9-5 listed the various interactions and potential impacts of the activities. It is noted that only direct impacts are assessed, risks are assessed in Section 13.

Table 9-4: Activities for the Construction Phase

Project Phase	Project Activity
Construction	Site clearing, including the removal of topsoil and vegetation.
	Construction of mine related infrastructure, including haul roads, pipe lines, dams, etc.
	Construction of washing plant.
	Blasting and development of initial box-cut for mining, including stockpiling from initial box-cuts.
	Temporary storage of hazardous products, including fuel and explosives, as well as waste and sewage.
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.

Table 9-5: Interactions and Impacts of the Construction Phase

Interaction	Impact
Removal of vegetation and exposure of soils (Table 9-6)	Direct loss of marginal and riparian habitats. Increased runoff and erosion resulting in habitat change downstream. Increased sedimentation resulting in habitat loss and impairment of sensitive aquatic biota. All abovementioned impacts will result in loss of aquatic biodiversity.
Movement of heavy machinery (Table 9-7)	Compaction of soils causing in lowered rainfall infiltration rates and increased runoff result resulting in reduced baseflow and an alteration of aquatic habitats.
Lay down of impenetrable surfaces (Table 9-8)	Reduced surface water infiltration and alteration of baseflow and surface water drainage patterns.
Alteration to the natural topography for the new boxcut (Table 9-9)	Alteration in surface water drainage patterns resulting in changes to downstream habitat structures.

Interaction	Impact
Construction of stockpiles (Table 9-10)	Runoff from the exposed soils in stockpiles will contain un-weathered soluble and insoluble elements which may alter water chemistry downstream. This is particularly relevant to carboniferous materials. This interaction may result in the loss of sensitive aquatic species due to water chemistry modification.

9.2.1 Impact Description

The activities and interactions listed above (Table 9-5) have the potential to degrade water and habitat quality within the considered river systems. Water quality impacts may include increased dissolved/suspended solids, as well as potential persistent pollutants within the water column and sediments of the associated watercourse. In addition, general water chemistry modification may occur as a result of changed salt balances. Habitat quality impacts may include sedimentation, bed, channel and flow modification, as well as the general loss of aquatic habitat through direct modification during watercourse crossings. It is noted that the Aston Lake impoundment will be particularly sensitive due to the sediments of impoundments acting as contaminant sinks.

Although the PES (baseline) of the river reach assessed was derived to be modified from reference conditions, further deterioration is possible and thus a potential decline in the PES could be observed.

9.2.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.2.3 Management Actions

General mitigation actions provided in the surface water, wetlands and groundwater studies (Digby Wells, 2016) for this project should be used to guide the effective management of aquatic resources potentially affected by the proposed project. The proposed Stormwater Management Plan is provided below (Figure 9-1).

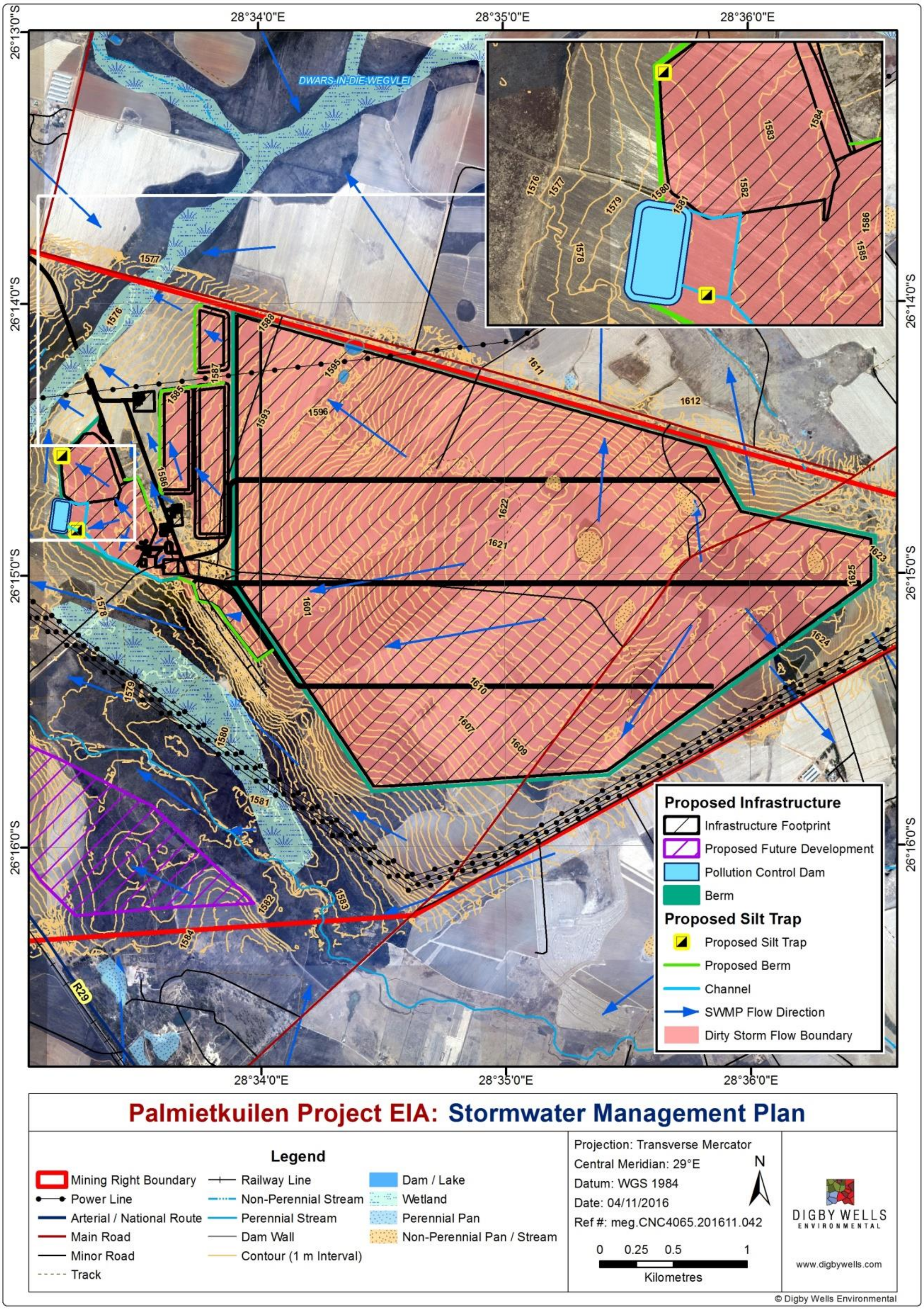

Figure 9-1: Stormwater Management Plan

The establishment of a clearly marked buffer zone, which is defined as a region of natural vegetation between the rivers/wetlands and the proposed activity, is the primary management action that should take place. Literature suggests that a buffer zone can reduce aquatic habitat and water quality impacts of large developments, making this management action of particular importance (WRC, 2014). According to GDARD 2014, a buffer zone of 32 m (from the 1:100 year floodline or defined wetland/riparian zone) is required in urban and 100 m in non-urban regions. However, according to WRC (2014) the efficacy of a buffer is related to the distance between the river system and the zone of disturbance. Therefore, by increasing the length of a buffer, the potential aquatic modification related to the proposed activity is reduced. Considering this, it is recommended that, if possible, a buffer zone of 100 m is placed between infrastructure and riparian zones or the 1:100 floodline (in this case the wetland delineation). The designated buffer zones should then be demarcated using signage or fences.

The removal of vegetative cover, as well as the construction of roads has been recognised as being responsible for increased runoff, sedimentation and subsequent water and habitat quality degradation in downstream portions of river systems (WRC, 2014). As such the careful management of vegetation removal and sedimentation control should take place. This can be achieved through the brief points below:

- Minimise the removal of vegetation in the infrastructure footprint area;
- Re-vegetation of the disturbed areas within the construction footprint area once construction is completed;
- Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration;
- Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events;
- Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1);
- 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;
- The vegetation of unpaved roadsides; and
- Inspection of paved and unpaved roads to monitor for erosion.

9.2.4 Impact Ratings

Table 9-6: Potential Impacts of Removal of Vegetation and Exposure of Soils

Dimension	Rating	Motivation	Significance
Activity and Interaction: Removal of vegetation and exposure of soils			
Impact Description: Direct loss of marginal and riparian habitats. Increased runoff and erosion resulting in habitat change downstream. Increased sedimentation resulting in habitat loss and impairment of sensitive aquatic biota. All abovementioned impacts will result in loss of aquatic biodiversity.			
Prior to Mitigation/Management			
Duration	Medium term (3)	Construction phase. More sediment deposition may occur during rainy months.	Minor (negative) – 40
Extent	Local (3)	Downstream of the construction area.	
Intensity x type of impact	Medium term (-4)	Serious loss to moderately sensitive environment limiting ecosystem function.	
Probability	Probable (4)	It is probable that the impact may occur.	
Nature	negative		
Mitigation/Management Actions			
▪ Minimise the removal of vegetation in the infrastructure footprint area; ▪ Re-vegetation of the disturbed areas within the construction footprint areas once construction is completed; ▪ Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration; ▪ Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events; ▪ Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1); ▪ 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; ▪ The vegetation of unpaved roadsides; and ▪ Inspection of paved and unpaved roads to monitor for erosion.			
Post-Mitigation			
Duration	Short term (2)	Less than a year to reverse the impact reversed if mitigation measures are applied.	Negligible (negative) – 24

Dimension	Rating	Motivation	Significance
Extent	Limited (2)	Storm water management structures will limit sedimentation to the infrastructure site and surrounding areas.	
Intensity x type of impact	Medium term (-4)	Serious loss to moderately sensitive environment limiting ecosystem function.	
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented.	
Nature	negative		

Table 9-7: Potential Impacts of the Movement of Heavy Machinery

Dimension	Rating	Motivation	Significance
Activity and Interaction: Movement of heavy machinery			
Impact Description: Compaction of soils causing in lowered rainfall infiltration rates and increased runoff resulting in reduced baseflow and an alteration of aquatic habitats.			
Prior to Mitigation/Management			
Duration	Medium term (3)	Impacts will occur during the construction phase and can be reversed once construction is completed.	Minor (negative) – 60
Extent	Local (3)	Reduced baseflow may have a minor impact on local streamflow within the Palmietkuilen Farm. However, the impact may extend beyond the site.	
Intensity x type of impact	Medium term - negative (4)	Environmental damage can be reversed in less than a year.	
Probability	Highly Probable (6)	It is highly probable that the impact may occur.	
Nature	negative		
Mitigation/Management Actions			

Dimension	Rating	Motivation	Significance
▪ Minimise the removal of vegetation in the infrastructure footprint area; ▪ Re-vegetation of the disturbed areas within the construction footprint area once construction is completed; ▪ Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration; ▪ Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events; ▪ Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1); ▪ 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; ▪ The vegetation of unpaved roadsides; and ▪ Inspection of paved and unpaved roads to monitor for erosion.			
Post-Mitigation			
Duration	Short term (2)	Less than a year to reverse the impact.	Negligible (negative) – 18
Extent	Limited (2)	Limited to the site.	
Intensity x type of impact	Minor - negative (-2)	Minor effects on the environment.	
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented.	
Nature	negative		

Table 9-8: Potential Impacts of the Placement of Impenetrable Surfaces

Dimension	Rating	Motivation	Significance
Activity and Interaction: Placement of Impenetrable Surfaces			
Impact Description: Reduced surface water infiltration and alteration of baseflow and surface water drainage patterns.			
Prior to Mitigation/Management			
Duration	Project Life (5)	Impacts will occur throughout the project life.	Minor (negative) – 72
Extent	Local (3)	Reduced baseflow may have a minor impact on local streamflow within the Palmietkuilen Farm. However, the impact may extend beyond the site.	
Intensity x type of impact	Serious - negative (4)	Serious impacts to local aquatic ecology due to changes in aquatic habitats.	

Dimension	**Rating**	**Motivation**	**Significance**
Probability	Highly Probable (6)	It is highly probable that the impact may occur.	
Nature	negative		
Mitigation/Management Actions			
▪ Minimise the removal of vegetation in the infrastructure footprint area; ▪ Re-vegetation of the disturbed areas within the construction footprint areas once construction is completed; ▪ Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration; ▪ Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events; ▪ Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1); ▪ 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; ▪ The vegetation of unpaved roadsides; and ▪ Inspection of paved and unpaved roads to monitor for erosion.			
Post-Mitigation			
Duration	Project Life (5)	Impacts will occur throughout the project life.	Negligible (negative) – 36
Extent	Local (3)	Reduced baseflow may have a minor impact on local streamflow within the Palmieitkuilen Farm. However, the impact may extend beyond the site.	
Intensity x type of impact	Serious - negative (4)	Serious impacts to local aquatic ecology due to changes in aquatic habitats.	
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented.	
Nature	negative		

Table 9-9: Potential Impacts of the Alteration of the Natural Topography for the new Boxcut and Stormwater management

Dimension	**Rating**	**Motivation**	**Significance**
Activity and Interaction: Alteration to the natural topography for the new boxcut			
Impact Description: Alteration in surface water drainage patterns resulting in changes to downstream habitat structures.			

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Impacts will occur throughout the project life.</td><td rowspan="5">Minor (negative) – 72</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Reduced baseflow and runoff reporting to the nearby streams may have a minor impact on local streamflow within the Palmiekuilen Farm. However, the impact may extend beyond the site.</td></tr>
<tr><td>Intensity x type of impact</td><td>Serious - negative (4)</td><td>Serious impacts to local aquatic ecology due to changes in aquatic habitats.</td></tr>
<tr><td>Probability</td><td>Highly Probable (6)</td><td>It is highly probable that the impact may occur.</td></tr>
<tr><td>Nature</td><td colspan="2">negative</td></tr>
<tr><td colspan="4">Mitigation/Management Actions</td></tr>
<tr><td colspan="4">
Minimise the removal of vegetation in the infrastructure footprint area;
Re-vegetation of the disturbed areas within the construction footprint area once construction is completed;
Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration;
Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events;
Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1);
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;
The vegetation of unpaved roadsides; and
Inspection of paved and unpaved roads to monitor for erosion;
</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Impacts will occur throughout the project life.</td><td rowspan="3">Negligible (negative) – 36</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>Reduced baseflow and runoff reporting to the nearby streams may have a minor impact on local streamflow within the Palmiekuilen Farm. However, the impact may extend beyond the site.</td></tr>
<tr><td>Intensity x type of impact</td><td>Serious - negative (4)</td><td>Serious impacts to local aquatic ecology due to changes in aquatic habitats</td></tr>
</table>

Dimension	Rating	Motivation	Significance
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented.	
Nature	negative		

Table 9-10: Potential Impacts of the Alteration of the Construction of Stockpiles

Dimension	Rating	Motivation	Significance
Activity and Interaction: Construction of stockpiles			
Impact Description: Runoff from the exposed soils in stockpiles will contain un-weathered soluble and insoluble elements which may alter water chemistry downstream. This is particularly relevant to carboniferous materials. This interaction may result in the loss of sensitive aquatic species due to water chemistry modification.			
Prior to Mitigation/Management			
Duration	Project Life (5)	Impacts will occur throughout the project life.	Moderate (negative) – 78
Extent	Local (3)	Runoff from stockpiles may enter into local river systems and likely collect in the Aston Lake.	
Intensity x type of impact	Serious - negative (5)	Very serious impacts to local aquatic ecology due to changes in aquatic habitats.	
Probability	Highly Probable (6)	It is highly probable that the impact may occur.	
Nature	negative		
Mitigation/Management Actions			
▪ Effective Stormwater management (Figure 9-1).			
Post-Mitigation			
Duration	Project Life (5)	Impacts will occur throughout the project life.	Minor (negative) – 39
Extent	Local (3)	Runoff from stockpiles may enter into local river systems and likely collect in the Aston Lake.	
Intensity x type of impact	Serious - negative (5)	Very serious impacts to local aquatic ecology due to changes in aquatic habitats.	
Probability	Unlikely (3)	Unlikely but may happen if mitigation measures are not implemented.	
Nature	negative		

9.3 Impact Assessment: Operational Phase

The activities which will be assessed in this phase are presented below (Table 9-11). Based on the activities listed above, Table 9-12 listed the various interactions and potential impacts of the activities. It is noted that only direct impacts are assessed, risks are assessed in Section 13.

Table 9-11: Activities for the Operation Phase

Project Phase	Project Activity
Operation	Stripping topsoil and soft overburden.
	Removal of overburden, including drilling and blasting of hard overburden.
	Loading, hauling and stockpiling of overburden.
	Drilling and blasting of coal.
	Load, haul and stockpiling of RoM coal.
	Use and maintenance of haul roads for the transportation of coal to the washing plant.
	Water use and storage on-site.
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.

Table 9-12: Interactions and Impacts of the Operation Phase

Interaction	Impact
Runoff from the dirty water areas (waste water dams, crushing plant, conveyors and product stockpile) (Table 9-13).	Runoff reporting into the Aston Lake and the unnamed streams flowing to it resulting in water contamination or the deterioration of the water quality.
Development and operation of surface infrastructure (pollution control dams, stockpiles, workshops & offices, crushing and screening plant) (Table 9-14).	Reduction of catchment yield as dirty water runoff within the mine will be contained in the PCD. Groundwater loss and flow from the pit will also contribute toward baseflow reduction.

9.3.1 Impact Description

As discussed in the construction phase, the activities and interactions listed above have the potential to degrade water and habitat quality within the associated river systems. The storage and processing of carboniferous material presents a risk to contaminate the downstream river reaches. During rainfall events runoff which has been in contact with this material may enter local aquatic ecosystems. Once rainwater is in contact with the carboniferous material, dissolved substances will alter downstream water chemistry resulting in the loss of sensitive aquatic biota.

Containment of dirty water runoff from the mining area will reduce the amount of runoff reporting to the Aston Lake. A decrease in the catchment yield may have an impact on the flow required for the ecological reserve in the Blesbokspruit and downstream river reaches.

According to the Surface Water Report (Digby Wells, 2016) the total provided infrastructure footprint area amounts to approximately 10.72km^2 which approximates to 3.1% the of total catchment are for the Aston Lake of 344 km^2.

The percentage anticipated decrease in Mean Annual Runoff reporting to Aston Lake will be approximately 3%. Water and habitat quality alteration within the river systems will have negative effects on local aquatic ecology resulting in a decrease of the PES.

9.3.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.3.3 Management Actions

General mitigation actions provided in the surface water, wetlands and groundwater studies (Digby Wells, 2016) for this project should be used to guide the effective management of aquatic resources potentially affected by the proposed project. It is noted that the DWS should consider the loss of 3% of the catchment Mean Annual Runoff to the ecological reserve in the Blesbokspruit.

In order to prevent this, the use of diversion and containment management is of importance. This can be achieved through effective groundwater and surface water management as per the Digby Wells surface and groundwater studies (2016); however important management actions are briefly listed below:

- Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control impoundments (Figure 9-1);
- Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from stockpiles and pollution control facilities from entering the local aquatic systems;

- Where storm water enters river systems from disturbed sites, sediment and debris trapping, as well as energy dissipation control measures must be put in place;
- The planting of indigenous vegetation around pollution control impoundments and structures should be completed as this has been shown to be effective in erosion prevention and nutrient control;
- Ensure that all the dirty water emanating from the dirty water areas be collected in the PCD for re-use within the mine, to prevent unnecessary discharge into the environment;
- The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows. The sludge should be disposed to an appropriate licenced facility;
- Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels;
- Stockpiles of overburden and topsoil should be vegetated; and
- In addition to the control of storm water, water quality supplemented by aquatic ecology monitoring should form part of the system where water in the PCD's and surrounding streams are monitored for quality. This ensures that pollution sources are monitored during the mining process.

9.3.4 Impact Ratings

Table 9-13: Potential Impacts of Runoff from the Dirty Water Areas

Dimension	Rating	Motivation	Significance
Activity and Interaction: Runoff from the dirty water areas			
Impact Description: Runoff water reporting into the Aston Lake and the unnamed streams flowing to it resulting in water contamination or the deterioration of the water quality.			
Prior to Mitigation/Management			
Duration	Project Life (5)	Due to the nature of the mining activities the contamination of water resources may occur over the project life if mitigation measures are not in place.	Moderate (negative) – 90
Extent	Region (5)	The impacts may affect the Aston Lake. However, soluble pollutants may affect the Blesbokspruit.	
Intensity x type of impact	Serious - negative (-5)	This may have serious impacts on the water quality that will be made available to the downstream aquatic ecology.	

Dimension	Rating	Motivation	Significance
Probability	Almost Certain (6)	Without appropriate mitigation, the probability of the impact occurring is almost certain <80 %.	
Nature	negative		
Mitigation/Management Actions			
▪ Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control impoundments (Figure 9-1); ▪ Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from stockpiles and pollution control facilities from entering the local aquatic systems; ▪ Where storm water enters river systems from disturbed sites, sediment and debris trapping, as well as energy dissipation control measures must be put in place; ▪ The planting of indigenous vegetation around pollution control impoundments and structures should be completed as this has been shown to be effective in erosion prevention and nutrient control; ▪ Ensure that all the dirty water emanating from the dirty water areas be collected in the PCD for re-use within the mine, to prevent unnecessary discharge into the environment; ▪ The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows. The sludge should be disposed to an appropriate licenced facility; ▪ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels; and ▪ In addition to the control of storm water, water quality supplemented by aquatic ecology monitoring should form part of the system where water in the PCD's and surrounding streams are monitored for quality. This ensures that pollution sources are monitored during the mining process.			
Post-Mitigation			
Duration	Medium term (5)	Impact may occur over the project life if mitigation measures are not in place.	Moderate (negative) – 60
Extent	Region (5)	The impacts may affect the Aston Lake. However, soluble pollutants may affect the Blesbokspruit.	
Intensity x type of impact	Moderate - negative (-5)	This may have serious impacts on the downstream aquatic ecosystems.	
Probability	Probable (4)	Has occurred here or elsewhere and could therefore occur. <50% probability.	
Nature	negative		

Table 9-14: Potential Impacts of the Development and Operation of Surface Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction: Development and operation of surface infrastructure			
Impact Description: Reduction of catchment yield as dirty water runoff within the mine will be contained in the PCD. Groundwater loss and flow from the pit will also contribute toward baseflow reduction			
Prior to Mitigation/Management			
Duration	Project Life (5)	Water loss in the catchment will likely occur throughout the project life.	Moderate (negative) – 84
Extent	Region (5)	The impacts of water loss may influence the Blesbokspruit.	
Intensity x type of impact	Serious - negative (-4)	This may have serious impacts on the water availability at a local scale.	
Probability	Almost Certain (6)	Without appropriate mitigation, there probability of the impact occurring is almost certain <80 %.	
Nature	negative		
Mitigation/Management Actions			
▪ Effective surface water management whereby all clean water is diverted into the nearby streams (Figure 9-1).			
Post-Mitigation			
Duration	Project Life (5)	Water loss in the catchment will likely occur throughout the project life.	Moderate (negative) – 56
Extent	Region (5)	The impacts of water loss may influence the Blesbokspruit.	
Intensity x type of impact	Serious - negative (-4)	This may have serious impacts on the water availability at a local scale.	
Probability	Probable (4)	The probability of water loss during the project is reduced if clean water is allowed into the river systems.	
Nature	negative		

9.4 Impact Assessment: Decommissioning and Post Closure Phase

The activities which will be assessed in this phase are presented below (Table 9-15). Based on the activities listed above, Table 9-16 listed the various interactions and potential impacts of the activities. It is noted that only direct impacts are assessed, risks are assessed in Section 13.

Table 9-15: Activities for the Decommissioning and Closure Phase

Project Phase	Project Activity
Mine Decommissioning and Closure	Demolition and removal of all infrastructures (including transporting materials) off site.
	Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring.
	Environmental monitoring of decommissioning activities.
	Storage, handling and treatment of hazardous products (including fuel, explosives and oil) and waste.
	Post-closure monitoring and rehabilitation.

Table 9-16: Interactions and Impacts of the Decommissioning and Closure Phase

Interaction	Impact
Removal of infrastructure and surface rehabilitation (Table 9-17).	Similarly to the construction phase, the removal of the infrastructure will lead to potential negative impacts on the integrity of the associated aquatic ecosystems.
Mine closure and rehabilitation (Table 9-18).	Post-mining decant of groundwater will have negative impacts on the downstream water quality should it occur.

9.4.1 Impact Description

Similarly to the construction phase the removal of infrastructure and rehabilitation activities will be a large scale operation and thus has the potential to contaminate surface water. Particular areas which will require attention includes the run of mine stockpiles, screening areas and pollution control facilities. The rehabilitation of these areas will require special attention to avoid contamination of the surrounding aquatic ecosystems.

Typically, following the cessation of mining activities groundwater returns to the voids created by the mining process. This process results in the contamination of the groundwater resource. Following this influx of groundwater, seepage and decant at specific locations can result in the ingress of contaminated water in downstream river systems, thus severely degrading the local PES. It is noted that the groundwater and geochemical studies have not yet been completed and thus it is assumed that contaminated groundwater seepage will occur.

9.4.2 Management Objectives

The objective for management is to preserve the PES and prevent further degradation of local aquatic environments. This objective can be achieved through the management of potential water and habitat quality impacts as listed in the section below.

9.4.3 Management Actions

General mitigation actions provided in the surface water, wetlands and groundwater studies (Digby Wells, 2016) for this project should be used to guide the effective management of aquatic resources potentially affected by the proposed project.

As described in the construction phase, a clearly demarcated 100 m buffer zone must be maintained. In order to mitigate against the decant of contaminated water, the actions recommended in the groundwater report of this project should be considered. However, water treatment and the discharge of clean water is an option available to reduce the ingress of contaminated water.

9.4.4 Impact Ratings

Table 9-17: Potential Impacts of the Removal of Infrastructure and Surface Rehabilitation

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Activity and Interaction: Removal of infrastructure and surface rehabilitation.</td></tr>
<tr><td colspan="4">Impact Description: Similarly to the construction phase, the removal of the infrastructure will lead to potential negative impacts on the integrity of the associated aquatic ecosystems due to the clearing of land and thus exposing it to erosion which could lead to further sedimentation of the river systems.</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>Medium term (3)</td><td>The impact will only occur during the closure and decommissioning phase.</td><td rowspan="5">Minor (negative) – 66</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>The extent of the impact will likely affect the downstream regions.</td></tr>
<tr><td>Intensity x type of impact</td><td>High - Negative (-5)</td><td>Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.</td></tr>
<tr><td>Probability</td><td>Almost Certain (6)</td><td>It is highly likely this impact will occur.</td></tr>
<tr><td>Nature</td><td colspan="2">negative</td></tr>
<tr><td colspan="4">Mitigation/Management Actions</td></tr>
</table>

Dimension	Rating	Motivation	Significance
▪ Established buffer zones as per regulations; and ▪ Phased approach to clearing with concurrent rehabilitation.			
Post-Mitigation			
Duration	Medium term (3)	The impact will only occur during the decommissioning and closure phase.	Minor (negative) – 44
Extent	Local (3)	The extent of the impact will likely affect the downstream regions.	
Intensity x type of impact	High - Negative (-5)	Aquatic ecosystems are sensitive to disturbance and thus any impact is regarded as serious.	
Probability	Probable (4)	The impact could happen.	
Nature	negative		

Table 9-18: Potential Impacts of the Mine Closure and Rehabilitation

Dimension	Rating	Motivation	Significance
Activity and Interaction: Mine closure and rehabilitation			
Impact Description: Post-mining decant of groundwater will have negative impacts on the downstream water quality			
Prior to Mitigation/Management			
Duration	Permanent (7)	Decant of contaminated water will likely be permanent.	Major (negative) – 126
Extent	Municipal (4)	The impact will change salt balances of the entire upper reach of the assessed river but could affect the Blesbokspruit.	
Intensity x type of impact	Serious - negative (-6)	The change of water quality in the headwaters of a river system will seriously affect the functioning of the downstream river reaches.	
Probability	Definite (7)	Should mining occur, there is a very high likelihood of the impact occurring.	
Nature	negative		
Mitigation/Management Actions			
▪ Water treatment options.			
Post-Mitigation			
Duration	Permanent (7)	The decant of contaminated water will likely be permanent.	Minor (negative) – 51

Dimension	Rating	Motivation	Significance
Extent	Municipal (4)	The impact will change salt balances of the entire upper reach of the assessed River.	
Intensity x type of impact	Serious - negative (-6)	The change of water quality in the headwaters of a river system will seriously affect the functioning of the downstream river reaches.	
Probability	Unlikely (3)	If water treatment is completed, there will likely be no impact.	
Nature	negative		

10 Cumulative Impacts

The PES of the river course assessed was observed to be class D/E or largely/seriously modified as a result of the absence of sensitive aquatic ecology. This is largely attributed to habitat level impacts.

Based on the results of the impact assessment, limited impacts are anticipated in the catchment should mitigation actions take place. However, during the closure phase Acid Mine Drainage can be expected and thus a significant impact.

The following cumulative impacts have therefore been identified, and can occur due to the proposed development:

- Cumulative temporary deterioration of water quality within the river systems. This will likely be a significant cumulative impact should Acid Mine Drainage occur; and
- Cumulative deterioration of aquatic habitat. There will potentially be a loss should stormwater management mitigation actions prove to be ineffective. However, the likelihood of this impact is low.

11 Unplanned Events and Low Risks

The risks and unplanned events identified in this study are presented in the table below (Table 11-1).

Table 11-1: Unplanned Events, Low Risks and their Management Measures

Potential Project Risk (Unplanned Occurrences)	Aspect Potentially Impacted	Mitigation / Management / Monitoring
Hydrocarbon spills from vehicles and heavy machinery or hazardous materials or waste storage facilities. Spills during decommissioning and removal of infrastructure will also add to water contamination.	Hydrocarbon contamination of surrounding surface water resources through surface water runoff.	▪ Hydrocarbons and hazardous materials must be stored in bunded areas and refuelling should take place in contained areas; ▪ Ensure that oil traps are well maintained; and ▪ Vehicles and heavy machinery should be serviced and checked on a regularly basis to prevent leakages and spills.
Spills/leaks from the dewatering pipeline or surface water berm.	Contamination of surrounding surface water resources through surface water runoff.	▪ Regular inspections of the pipeline for any leaks; and ▪ Ensure that storm water management structures are put in place to capture all spills and to convey to the PCD.
Blockage of storm water management structures and silt trap.	Overflow of dirty water into the clean water environment.	▪ Inspect storm water management structures and silt trap after large storm events; and ▪ Regular inspections of the silt trap.
Contamination from the ROM, overburden and discard dump.	Runoff from the ROM and overburden dump has the potential to pollute the surface water environment.	▪ Ensure that storm water management structures are put in place to capture all runoff from the ROM and overburden dumps and to convey to the PCD.

12 Environmental Management Plan: Aquatic Ecology

The objective of an Environmental Management Plan (EMP) is to present mitigation to manage undue or reasonably avoidable adverse impacts associated with the development of a project and to enhance potential positives.

12.1 Project Activities with Potentially Significant Impacts

The following is a summary of the identified significant impacts to rivers and streams that will require mitigation measures for the project to go ahead (Table 12-1).

Table 12-1: Potentially Significant Impacts of the proposed project

Activity	Impact
Construction Phase	
Site clearance within associated wetland habitats and river catchment and construction of surface infrastructure.	Increased runoff resulting in erosion and sedimentation of downstream habitats. Increased runoff from manmade structures resulting in the erosion and sedimentation of downstream river reaches.
Construction over watercourses.	Construction over sensitive riparian habitats resulting in the loss of degradation of aquatic habitat.
Operational Phase	
Storage, hauling, processing, and stockpiling of coal.	Runoff of water which has come into contact with the carboniferous material will contain various pollutants that may contaminate downstream river reaches.
Closure and Decommissioning Phase	
Closure and rehabilitation.	Post-mining decant of groundwater will have negative impacts on the downstream water quality.

12.2 Summary of Mitigation and Management

Table 12-2 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 EMP. All of the mitigation measures have been previously listed in the impact assessment tables as well.

Table 12-2: Mitigation and Management Plan

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Construction activities (Table 9-4)	Construction Phase	10 km^2	■ Minimise the removal of vegetation in the infrastructure footprint area to prevent erosion and sedimentation of the river systems; ■ Re-vegetation of the disturbed areas within the construction footprint once construction is completed; ■ Soils compacted by heavy machinery in areas that are not utilised post construction can be ripped to allow infiltration; ■ Ensure that storm water management structures are within good working condition through regular inspection, especially after large storm events; ■ Where storm water enters river systems, sediment/silt and debris trapping, as well as energy dissipation control measures must be put in place (Figure 9-1); ■ Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the	National Water Act, 1998 (Act No. 36 of 1998).	Construction Phase.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
			concentration of storm water flow; ▪ The vegetation of unpaved roadsides; and ▪ Inspection of paved and unpaved roads to monitor for erosion.		
Operation Activities (Table 9-11)	Operation Phase	10 km^2	▪ Diversion trench and berm systems which diverts clean storm water around pollution sources and convey and contain dirty water to central pollution control impoundments (Figure 9-1); ▪ Barrier systems, including synthetic, clay and geological or other approved mitigation methods to minimise contaminated seepage and runoff from stockpiles and pollution control facilities from entering the local aquatic systems; ▪ Where storm water enters river systems from disturbed sites, sediment and debris trapping, as well as energy dissipation control measures must be put in place; ▪ The planting of indigenous vegetation around pollution control	National Water Act, 1998 (Act No. 36 of 1998).	Operation Phase.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
			impoundments and structures should be completed as this has been shown to be effective in erosion and nutrient control; ■ Ensure that all the dirty water emanating from the dirty water areas be collected in the PCD for re-use within the mine, to prevent unnecessary discharge into the environment; ■ The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows. The sludge should be disposed to an appropriate licenced facility; ■ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels; and ■ In addition to the control		

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
			of storm water, water quality supplemented by aquatic ecology monitoring should form part of the system where water in the PCD's and surrounding streams are monitored for quality. This ensures that pollution sources are monitored during the mining process.		
Closure and decommissioning phase	Closure and decommissioning phase	10 km^2	▪ Water treatment options.	National Water Act, 1998 (Act No. 36 of 1998).	Closure and decommissioning phase.

Table 12-3: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable Standard, Practice, Guideline, Policy or Law
Aquatics	National Water Act, 1998 (Act No. 36 of 1998).

12.3 Monitoring Plan

An aquatic biomonitoring programme is an essential management tool. The monitoring programme should be designed to enable the detection of potential negative impacts brought about by the proposed project. Table 12-4 highlights some important aspects to monitor in reference to aquatic biota for the duration of the proposal.

Table 12-4: Aquatic ecology monitoring programme

Location	Monitoring objectives	Frequency of monitoring	Parameters to be monitored
Current sites used in this study.	Overall PES.	Bi-annual (dry and wet season)	Standard River Ecosystem Monitoring Programme (Ecostatus) methods.
Current sites used in this study.	Determine if water quality deterioration is occurring.	Bi-annual	SASS5 scores should not decrease as and be related to mining activities.
Site used in this study and the surface water assessment.	Determine if water quality deterioration is occurring.	Monthly	Standard water quality monitoring, as per the surface water specialist report.
Current sites used in this study.	Determine if water/habitat quality deterioration is occurring.	Bi-annual	Monitor for presence of fish.

13 Consultation Undertaken

No consultation has been undertaken for completion of the aquatic ecology study.

14 Comments and Responses

Results from the draft EIA comment period will be incorporated into the finalised report.

15 Conclusion and Recommendation

In order to determine the baseline ecological status of rivers associated with the proposed project, two river reaches of the C21E quaternary catchment were assessed on a bi-annual basis. Applying standard River Ecosystem Monitoring Programme techniques the Present Ecological Status (PES) of the river reaches was determined. The results of the assessment derived an overall PES class of largely/seriously modified (class D/E). This class was derived due to the existing habitat impacts within the catchment area. The central cause of the poor ecological status was found to be associated with various agricultural practices which have resulted in habitat modification of the assessed river reaches.

Considering this baseline assessment results, an impact assessment was completed using the available activity list for the proposed project. Based on this impact assessment, several key impacts were identified. These impacts included the following brief points:

- Potential impacts from a haul road crossing of a wetland; and
- Potential decant of Acid Mine Drainage within the closure phase resulting in significant water quality modification in the Blesbokspruit drainage.

Considering the above potential impacts, and should the mining operation go ahead, provision should be made to mitigate against the contamination of surface water during the closure phase. It is further recommended that the Department of Water and Sanitation assess the impact of a loss of 3% Mean Annual Runoff on the ecological reserve of the Blesbokspruit.

Recommended monitoring conditions have been provided in this report along with various mitigation actions. However, it is noted that this report should not be considered in isolation and that other specialist reports should be reviewed including surface water, groundwater and wetland studies.

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