APPENDIX I1

BASELINE AQUATIC AND IMPACT STUDY

Baseline Aquatic and Impact Study for the Proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2A) (MCWAP-2A): Water Transfer Infrastructure & Borrow Pits

Limpopo, South Africa

June 2018

CLIENT

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Report Name	**Baseline Aquatic and Impact Study for the Proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2A) (MCWAP-2A): Water Transfer Infrastructure & Borrow Pits**	
Reference	**MCWAP 2018**	
Submitted to	**Nemai Consulting**	
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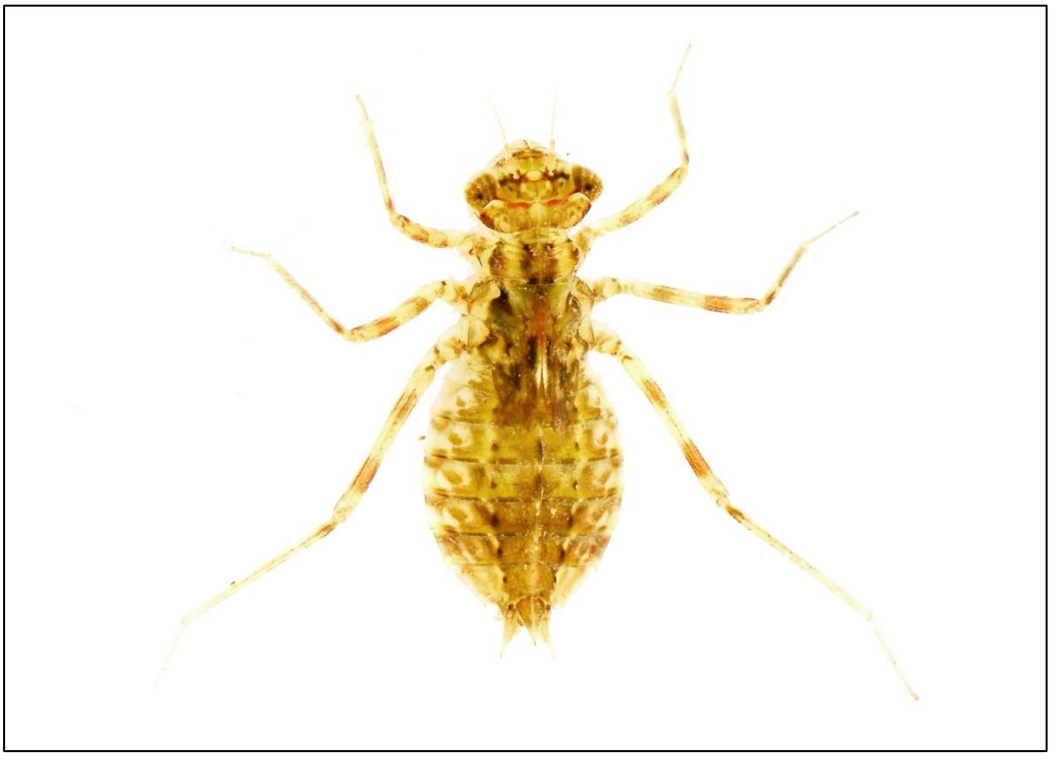

Executive Summary

The Biodiversity Company was commissioned by Nemai Consulting to conduct a baseline aquatic assessment as part of the Environmental Impact Assessment (EIA) and environmental authorisation process for the proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2A) (MCWAP-2A), which further includes Water Transfer Infrastructure (WTI) and Borrow Pits.

The proposed water augmentation project is to meet increasing water requirements in the Lephalale area due to various planned developments associated with the Waterberg coalfields. The project proposes to transfer water from the Crocodile River (West) to the Steenbokpan and Lephalale area.

Standard aquatic sampling methods recognised by the River Ecosystem Monitoring Programme (REMP) to determine the Present Ecological Status (PES) of the potentially effected watercourses.

The results from the aquatic baseline study indicates that the Crocodile River reach assessed was in a moderately modified state (class C), with the Matlabas River reach derived to be in a moderately modified state (class C). Due to the ephemeral nature of the Sandspruit and the Bierspruit, an ecological class for the reaches could not be determined during the survey period.

Pipeline Alternatives D1 and D4 for the northern section of the water transfer infrastructure were identified as preferential routes, with pans occurring in excess of 500 m of the proposed route. Therefore, no impacts to identified pans are anticipated.

The risk assessment for the construction phase of the Vlieëpoort Weir poses several moderate risks to the Crocodile River, with mitigation measures not being able to lower the risk status. The limited mitigation actions available are due to the nature of the activity and proximity to instream sensitive areas. The physical construction of the weir poses the highest risk to the Crocodile River system, with additional moderate risks associated with river diversion, and clearing of the riparian areas for infrastructure. The flooding of the weir poses the highest initial risk to the Crocodile River, as this will inundate instream habitat, and modify downstream flows. Based on data provided to the specialist, an estimated 7,3 km of the Crocodile will be inundated, and an additional 1,5 km of the Bierspruit. This will result in permanent impacts to upstream areas of the weir. The construction of the Sandspruit and Bierspruit gauging weirs will pose a lower risks to the systems, as these watercourses are ephemeral, and should be constructed during the dry season.

The abstraction of water from the Crocodile River is rated as moderate. The moderate rating remains high due to the long duration of the activity, however, due to the increase in expected runoff from upstream reaches, the flow modifications within the reach are expected to be improved and base flows within the lower reaches of the Crocodile River are likely to be maintained. The discharge of sediment into the Crocodile River poses a moderate risk. This is due to the potential of altered sediment balance, modifications to downstream instream habitat, bank and channel erosion.

The construction of the central pipeline across the Matlabas River system poses a moderate risk to the riparian and instream habitats. Furthermore, during the scouring of the pipeline

into the system, risks were rated as moderate due to the potential modifications to water quality and instream habitat.

Overall, there will be a reduced PES of the aquatic ecosystems directly associated with the proposed project. The magnitude of the impact is considered moderate, as habitats will be altered but not completely lost. The scale of the anticipated impact will be limited to the immediate river reaches and is therefore considered a local impact. The impact is reversible should the weir structure be removed and rehabilitated. However, the impact will occur through the life of the project which is considered a long-term impact. Overall the cumulative impact of the proposed project was derived to be moderate.

It is noted that should mitigation actions be implemented, and the calculated EWR allocated, limited changes to riverine PES will be anticipated downstream of the proposed project after the completion of the construction phase.

A buffer zone of 30 m from the edge of the riparian zone is recommended. Considering that the proposed project is for an instream barrier and a water pipeline crossing the buffer derived is only applicable for associated construction activities such as mixing areas, stockpiles and laydown yards. Based on the proposed developments level of disturbance, a riverine buffer zone of 32 m from the delineated riparian zones, and National Freshwater Ecological Priority Area wetlands identified (pans and floodplains) are recommended.

The ecological status of the Matlabas River needs to be determined during the high-flow period, prior to construction. The high flow survey needs to address potential impacts of the valve scouring on water quality, erosion and sedimentation of the Matlabas. Furthermore, a study of the potential introduction of nuisance and invasive species into the Matlasbas should be conducted. This should include a diatom assessment of the Crocodile and Matlabas Rivers to determine risk during valve scouring and leaks. This will determine the requirements for crossing the watercourse (i.e. open trench), as well as for scouring (i.e. draining water from the pipeline, typically during maintenance). A high flow baseline assessment of the Bierspruit and Sandspruit is recommended as no surface water was available during the low flow survey.

Provision for a fishway at the Vlieëpoort abstraction weir should be included based on the considerations mentioned under maintenance of connectivity.

It is recommended that a sediment study be conducted by a fluvial-geomorphologist to determine the baseline sediment balance of the Crocodile River, and the potential risks and benefits of sediment abstraction and return during the operational phase of the MCWAP project.

A single borrow pit (BP BSS1) was identified which has the potential to modify the instream channel, banks and flows within the Crocodile River. The results of the risk assessment determined low risks for activities occurring outside of the delineated watercourse areas. However, activities occurring within the instream and riparian zones were derived to be moderate risk activities despite mitigation. The reason for this classification even after mitigation was due to the location of the activities within the direct associated instream and riparian habitats.

A rehabilitation plan for the borrow pit BP BSS1 should be established and implemented post-operation, with emphasis on establishing natural vegetation within the riparian zones and ensuring bank stabilisation within the reach to mitigate against further erosion.

It is the opinion of the specialist that according to the bassline conditions of the Crocodile and Matlabas Rivers, and the proposed activities for the MCWAP-2A project, no fatal flaws have been identified for the project.

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Declaration

I, Christian Fry declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

Christian Fry

MSc. Aquatic Health

The Biodiversity Company

25 June 2018

1 Introduction

The Biodiversity Company was commissioned by Nemai Consulting to conduct a baseline aquatic assessment as part of the Environmental Impact Assessment (EIA) and environmental authorisation process for the proposed Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2A) (MCWAP-2A), which further includes Water Transfer Infrastructure (WTI) and Borrow Pits.

The proposed water augmentation project is to meet increasing water requirements in the Lephalale area due to various planned developments associated with the Waterberg coalfields. The project proposes to transfer water from the Crocodile River (West) to the Steenbokpan and Lephalale area. The aquatic assessment focused on the flowing components during the study:

- Abstraction works:
    - Abstraction weir (Vlieëpoort Weir);
    - River abstraction pumping station;
    - Desilting works; and
    - Sediment return pipeline (into Crocodile River).
- Pipeline:
    - Central pipeline; and
    - Alternatives.
- Gauging Weirs:
    - Bierspruit;
    - Sandspruit; and
    - New Paul Hugo Weir.
- Borrow pits

The aquatic systems affected by the proposed developments include the Crocodile River, Beirspruit, Sandspruit, and the Matlabas River. A single low flow survey was conducted from the 20th to the 22nd of June 2018 to characterise the current state of these systems and potential impacts during the construction and operational phases of the project. The following objectives were set for the study:

- The determination of the baseline Present Ecological Status (PES) of the local river ecosystems;
- The evaluation of the extent of site-related impacts;
- A risk assessment for the development; and
- The prescription of mitigation measures and recommendations (including monitoring programmes) for identified risks.

This report, after taking into consideration the findings and recommendation provided by the specialist herein, should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

2 Project Area

The relevant aquatic systems associated with the proposed MCWAP-2A project include the perennial Crocodile River (West), and the ephemeral systems; Bierspruit, Sandspruit, and Matlabas River (Figure 2-3, Figure 2-4, Figure 2-5, and Figure 2-6). The potentially effected aquatic systems lie in the quaternary catchments A24C, A24H, A24F, A24J, and A41C within the Limpopo Water Management Area (WMA1).

According to StatsSA (2010), the Limpopo WMA is semi-arid and the mean annual rainfall ranges from 300 to 700 mm over most of the region. Economic activity is predominantly game, livestock and irrigation farming, while mining activity is increasing. A significant increase in water requirements from mining activities in the Bushveld Igneous Complex, which extends across the south-eastern part of the region, and coal reserves proximate to Lephalale also increases water requirements. According to StatsSA 2010, the Limpopo WMA area, in the year 2000, was in a negative water balance, indicating a water shortage within the WMA, and the potential for development within the WMA was estimated at 8 million m^3/annum, with a negative water balance of -47 million m^3/annum. To meet future demands for the mining sector, the Limpopo WMA will rely entirely on importing resources through water transfer schemes and effluent return flows.

The study area considered in this assessment is located within the Zambezian Lowveld Freshwater Ecoregion. This ecoregion is known to contain approximately 120 freshwater fish species of which 22 are known to be endemic (Figure 2-1). The lower reaches of the rivers in this ecoregion are known to support numerous seasonal pans and extensive floodplains.

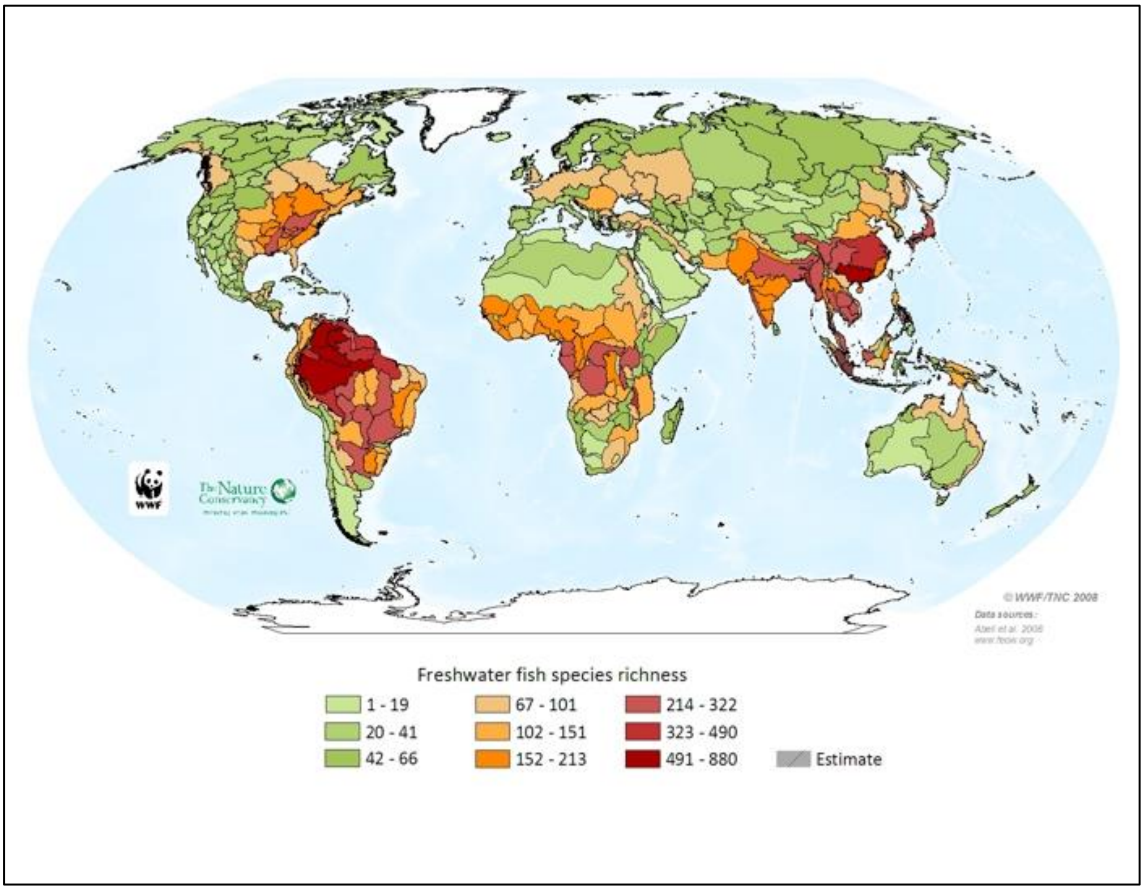


Figure 2-1: Endemic Fish of the Freshwater Ecoregion of the World

The catchment of this reach drains the Limpopo sweet bushveld floristic region. The project area falls within three different freshwater ecoregions, including the Bushveld basin, Western Bankenveld, and the Limpopo Plain. Upstream catchment areas of the Crocodile River reach considered in this study area are drained by extensive agricultural, industrial and urban areas along the Crocodile West River catchment. These areas include the northern portions of Johannesburg, the metropolitan region of Pretoria and industrial areas of Thabazimbi and Rustenburg. The Matlabas River reach is associated with large scale game farming areas and minor agricultural activities. Several weirs occur within the system, modifying flows and riparian and instream habitat.

Activities directly associated with the abstraction weir project area on the Crocodile River consist of large scale game, agriculture, livestock farming and the Thabazimbi Iron Mining operations. Several irrigated agricultural fields as well as several weirs are also associated with the river course. Irrigated agricultural activities located upstream of the project area have an influence on water quantities and qualities due to irrigation return flows.

Current desktop information pertaining to the ecological status and designated National Freshwater Ecosystem Priority Areas (NFEPAs) of each Sub-Quaternary Reach (SQR) are presented in Table 2. The NFEPA database forms part of a comprehensive approach to the sustainable and equitable development of South Africa's scarce water resources. This database provides guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition to support the water resource protection goals of the National Water Act (Act 36 of 1998). This directly applies to the National Water Act, which feeds into Catchment Management Strategies, water resource classification, Reserve determination, and the setting and monitoring of resource quality objectives (Nel et al. 2011). The NFEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act's biodiversity goals (NEM:BA) (Act 10 of 2004), informing both the listing of threatened freshwater ecosystems and the process of bioregional planning provided for by this Act (Nel et al., 2011). The NFEPAs associated with the project area on the Crocodile and Bierspruit are illustrated in Figure 2-2. The A24H-510 SQR lies within a Phase two FEPA: "*Phase 2 FEPAs and associated sub-quaternary catchment: Phase 2 FEPAs were identified in moderately modified (C) rivers. The condition of these Phase 2 FEPAs should not be degraded further, as they may in future be considered for rehabilitation once good condition FEPAs (in an A or B ecological category) are considered fully rehabilitated*". Furthermore, the Crocodile River and Bierspruit are designated as Wetland NFEPAs due to the floodplains within the reach.

Water Transfer Infrastructure (WTI), construction camps, borrow pits and associated infrastructure were assessed at a desktop level against recognised NFEPAs and water courses. A single point of concern outside the aquatic sampling points was identified and is illustrated in Figure 2-10. A proposed construction camp is situated adjacent to a pan.

According to the Limpopo Provincial Conservation Plan (C-Plan) version 2, September 2013, the project area falls within various Critical Biodiversity Areas (CBA) and Ecological support areas (ESA) (Figure 2-8 and Figure 2-9). According to SANBI (2018), "*Critical Biodiversity Areas are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as identified in a systematic biodiversity plan. Ecological Support Areas are not essential for meeting biodiversity targets but play an important role in supporting the* *ecological functioning of Critical Biodiversity Areas and/or in delivering ecosystem services".* A breakdown of the subcategories and landcover for the C-Plan are presented in Table 1.

Table 1: CBA and ESA Areas within the Limpopo Province (LEDET, 2016)

Category	% of the Province	Subcategory	% of the Province
CBA	40	CBA 1 - Irreplaceable areas required to meet biodiversity targets.	22
		CBA 2 – Best design selected sites required to meet biodiversity targets.	18
ESA	22	ESA 1 - Intact natural areas supporting CBAs	16
		ESA 2 – Areas with no natural habitat that is important for supporting ecological processes.	7

Based on Table 2, the desktop PES of this reach of the Crocodile River ranged from largely modified associated with sites CROC1 and CROC2, to largely natural within the reaches associated with CROC3 to CROC6.

Modifications within the Crocodile reach are associated were identified as the following:

- Critical: None;
- Serious: None;
- Large: Abstraction, agricultural fields, farm dams, alien aquatic macrophytes, inundation, and irrigation;
- Moderate: algal growth, roads, sedimentation, vegetation removal; and
- Small: bed and channel disturbances, erosion, alien vegetation removal, overgrazing, mining, recreation, grazing (DWS, 2018).

According to DWS (2017), the instream habitat of the river reach was largely impacted, meaning that modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influence. Based on DWS (2017) data, the impacts of flow modification in the considered reach are serious, indicating 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. According to existing desktop information (DWS, 2017), there are moderate existing impact in terms of water quality.

The Ecological Importance (EI) of the reaches are high. The high EI is due to the species richness within the reach. The Ecological Sensitivity (ES) for the reach are rated low to very low. This was calculated due to the presence of tolerant vertebrate and invertebrate species, with low specific preferences to alluvial habitat, flow and water quality modification (DWS, 2017).

The Sandspruit reach is rated as largely modified (class D). The modified state is a result of sedimentation, erosion, low water crossings, roads, agricultural fields, algal growth, and vegetation removal. The ES and EI are rated as high. The high EI rating is attributed to very high instream and riparian-wetland migration link class, instream and riparian habitat integrity class. The high ES is attributed to sensitivity of fish and macroinvertebrates within the reach.

The Bierspruit reach is rated as largely modified (class D). This is predominately due to modifications to instream habitat continuity and modifications, large flow modifications, and serious modifications to water quality within the reach. The EI and ES is rated as moderate. The EI class is moderate due to low habitat diversity within the reach, however, high connectivity and high natural vegetation within the riparian and wetland zones. The ES of the system is moderate due to high sensitivity of fish and macroinvertebrates, however, low stream sensitivity to flow modifications and low intolerance of riparian and wetland vegetation to water level changes.

The Matlabas reach ranges from largely modified (class D) at site MAT1 to moderately modified (class C) at site MAT2. The EI of both reaches are rated as moderate. Moderate instream migration link class and riparian zone integrity contribute to the moderate rating. Furthermore, habitat diversity within the reach is rated as low. The high ES of the upstream reach is attributed to the sensitivity of fish and macroinvertebrates to flow and physicochemical modifications. The downstream reach (MAT2) ES is rated as very low, which is attributed to low stream sensitivity to flow modifications, and very low sensitivity of riparian and wetland vegetation to water level modifications.

Table 2: The desktop information pertaining to the Sub-Quaternary Reaches

Crocodile River	
A24C-536 (CROC1)	
Present Ecological Status	**Largely modified (Class D)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**High**
NFEPAs	**0**
A24H-516 (CROC2)	
Present Ecological Status	**Largely modified (Class D)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**Low**
NFEPAs	**0**
A24H-510 (CROC3)	
Present Ecological Status	**Largely natural (Class B)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**Very low**
NFEPAs	Wetland ecosystem type Central Bushveld Group 2_Floodplain wetland Phase2FEPA: River ecosystem type Permanent/Seasonal - Western Bankenveld - Lowland river
A24J-438 (CROC4, CROC5, CROC6)	
Present Ecological Status	**Largely natural (Class B)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**Very low**
NFEPAs	Central Bushveld Group 2_Flat Central Bushveld Group 2_Floodplain wetland Central Bushveld Group 2_Valleyhead seep Central Bushveld Group 3_Unchannelled valley-bottom wetland
Sandspruit	
A24H-500 (SAND1)	
Present Ecological Status	**Largely modified (Class D)**
Ecological Importance	**High**
Ecological Sensitivity	**High**
NFEPAs	0
Bierspruit	
A24F-517 (BIER1, BIER2)	
Present Ecological Status	**Moderately modified (Class C)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**Low**
NFEPAs	Central Bushveld Group 2_Floodplain wetland
Matlabas River	
A41C-279 (MAT1)	
Present Ecological Status	**Largely modified (Class D)**
Ecological Importance	**Moderate**
Ecological Sensitivity	**High**

NFEPAs	1 WetCluster FEPA Central Bushveld Group 3_Channelled valley-bottom wetland Central Bushveld Group 3_Depression Central Bushveld Group 3_Flat Central Bushveld Group 4_Channelled valley-bottom wetland Central Bushveld Group 4_Depression Central Bushveld Group 4_Unchannelled valley-bottom wetland
A41C-206 (MAT2)	
Present Ecological Status	**Moderately Modified (Class C)**
Ecological Importance	**High**
Ecological Sensitivity	**Moderate**
NFEPAs	19 WetCluster FEPAs Central Bushveld Group 2_Floodplain wetland Central Bushveld Group 3_Depression Central Bushveld Group 3_Flat Central Bushveld Group 3_Seep Central Bushveld Group 4_Channelled valley-bottom wetland Central Bushveld Group 4_Depression Central Bushveld Group 4_Flat Central Bushveld Group 4_Unchannelled valley-bottom wetland

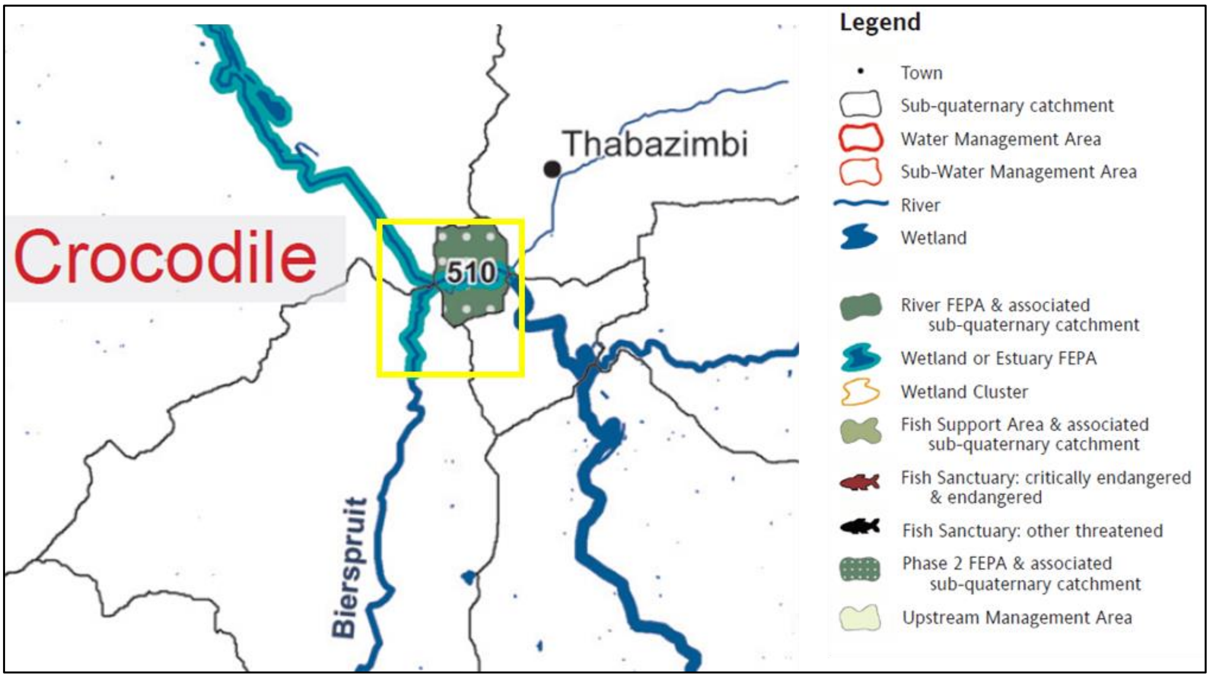


Figure 2-2: Illustration of NFEPAs associated with the Crocodile reach (Nel et al., 2011)

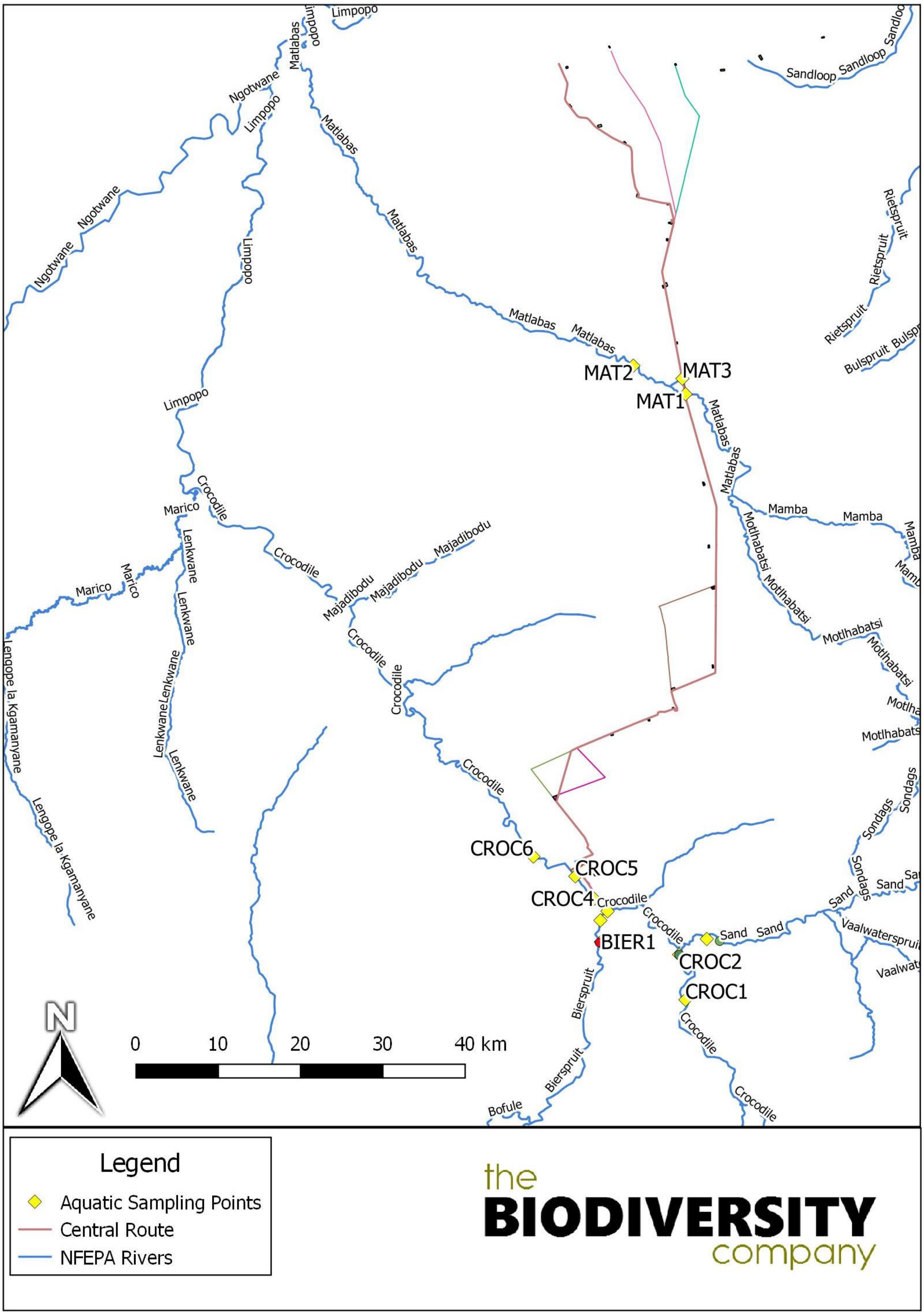


Figure 2-3: Infrastructure and project layout with associated water courses and aquatic sampling points

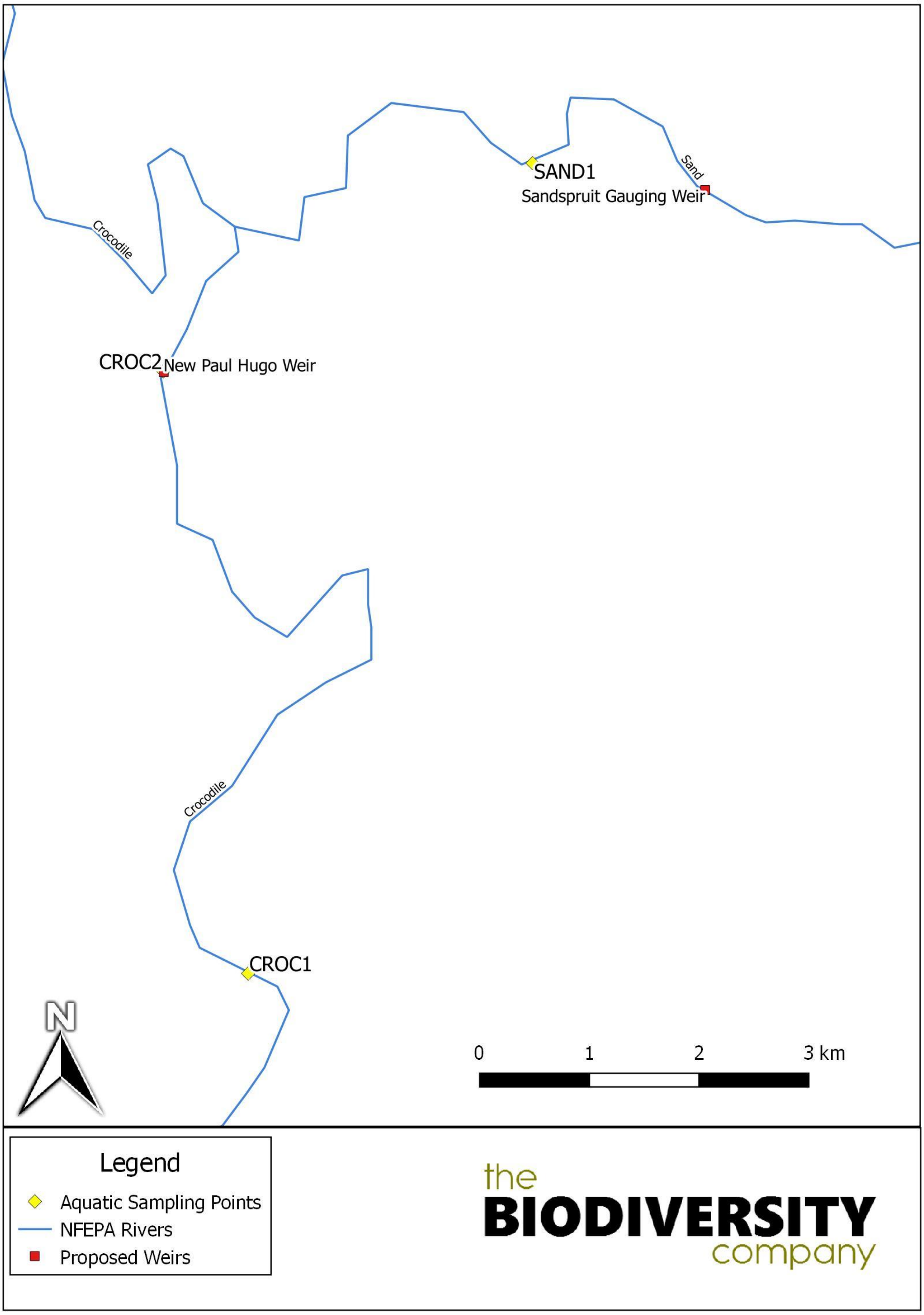


Figure 2-4: Illustration of the New Paul Hugo Weir, Sandspruit Weir and aquatic sampling points

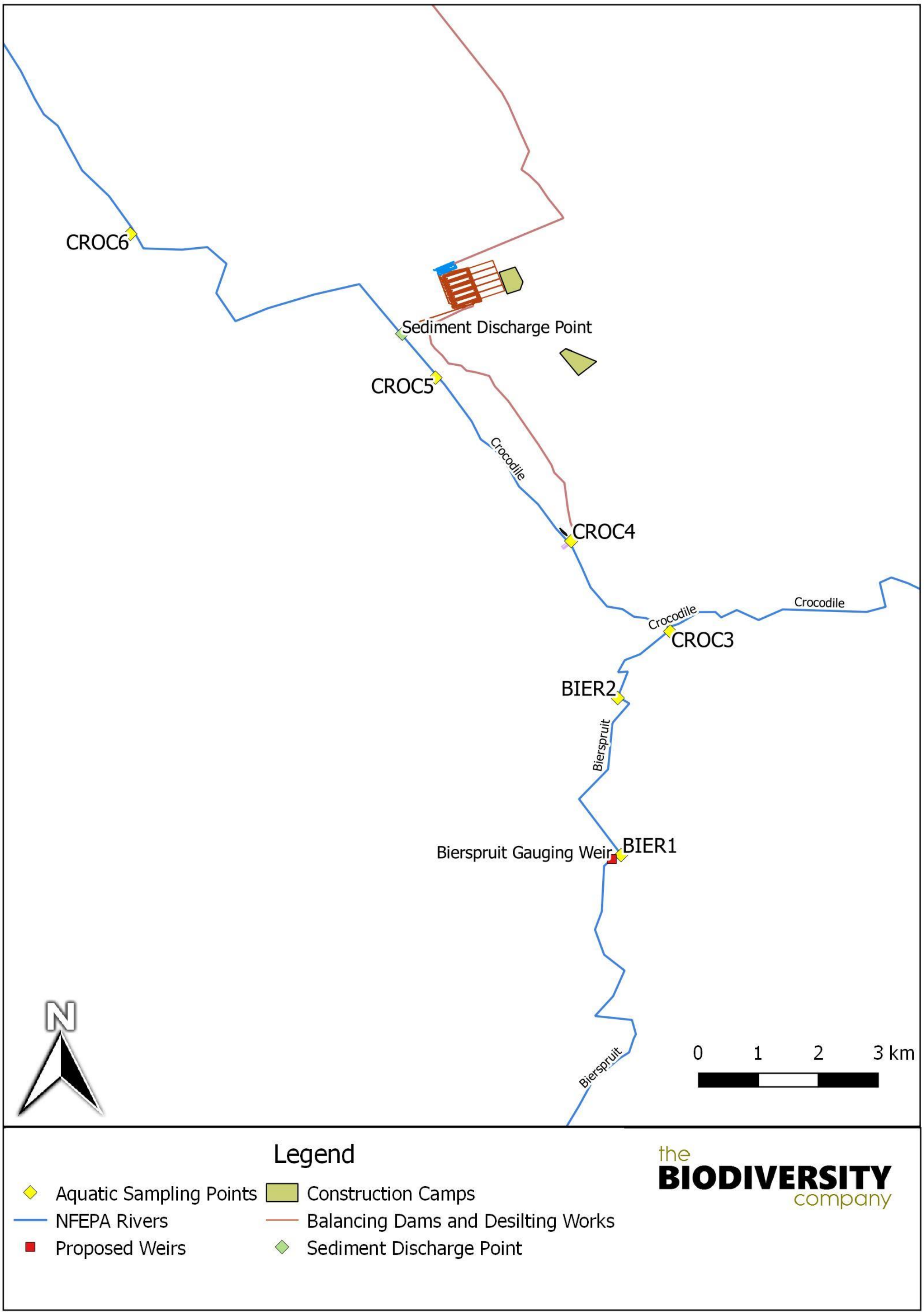


Figure 2-5: Illustration of the Bierspruit Gauging Weir, abstraction weir and sediment discharge point and aquatic sampling points

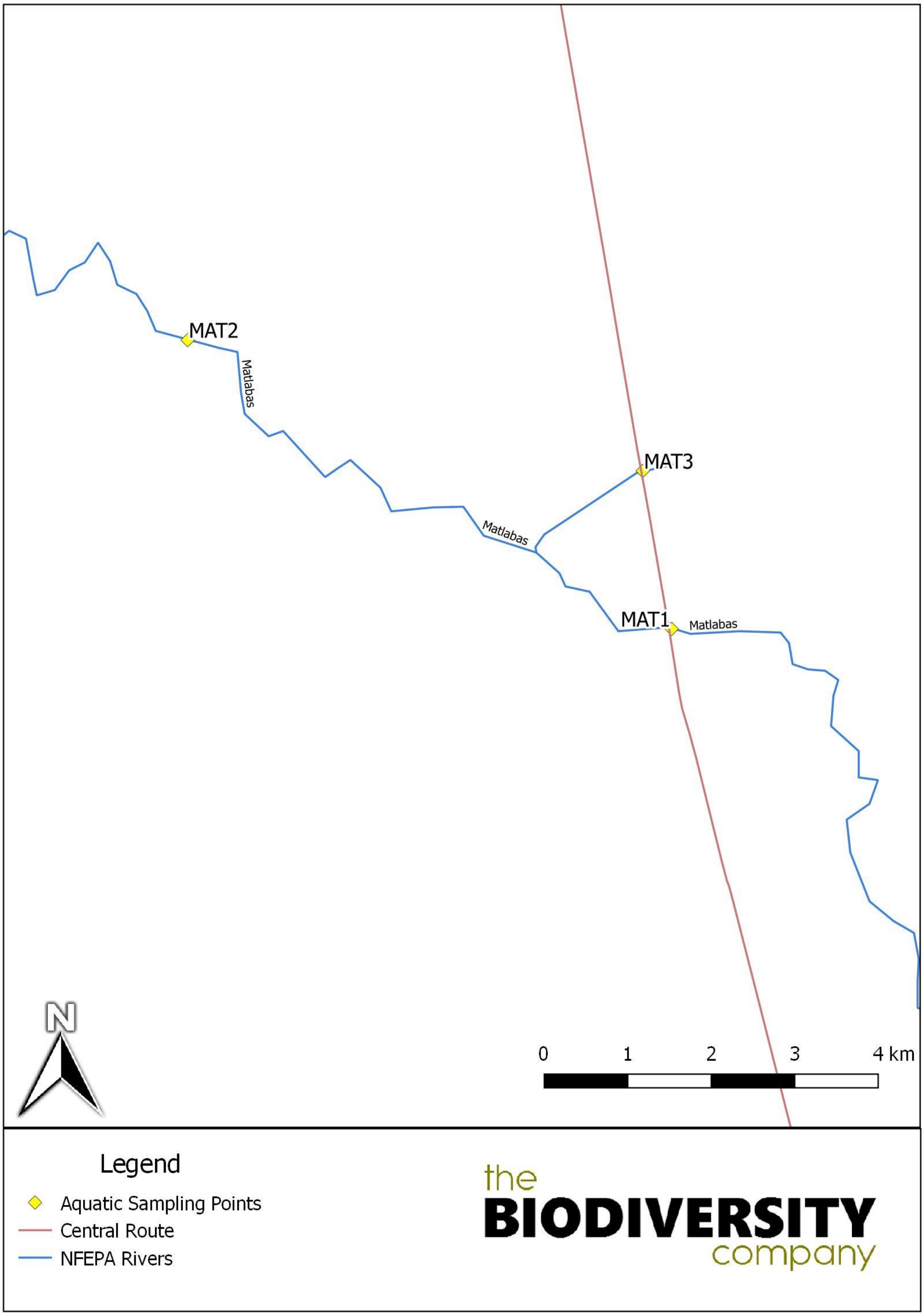


Figure 2-6: Illustration of the Matlabas River, central pipeline route and aquatic sampling points

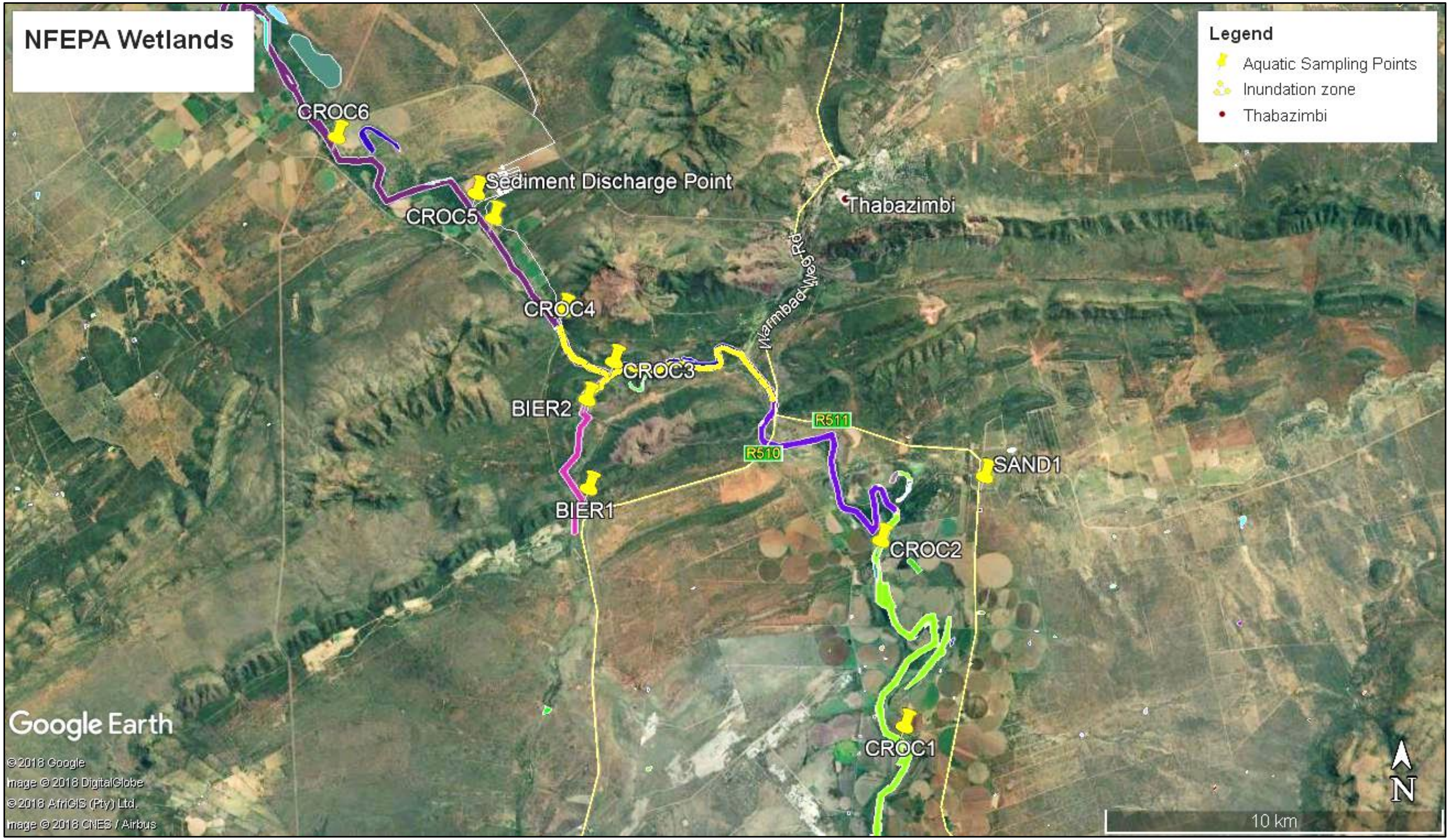


Figure 2-7: Illustration of NFEPAs identified within the project area (Nel et al., 2011)

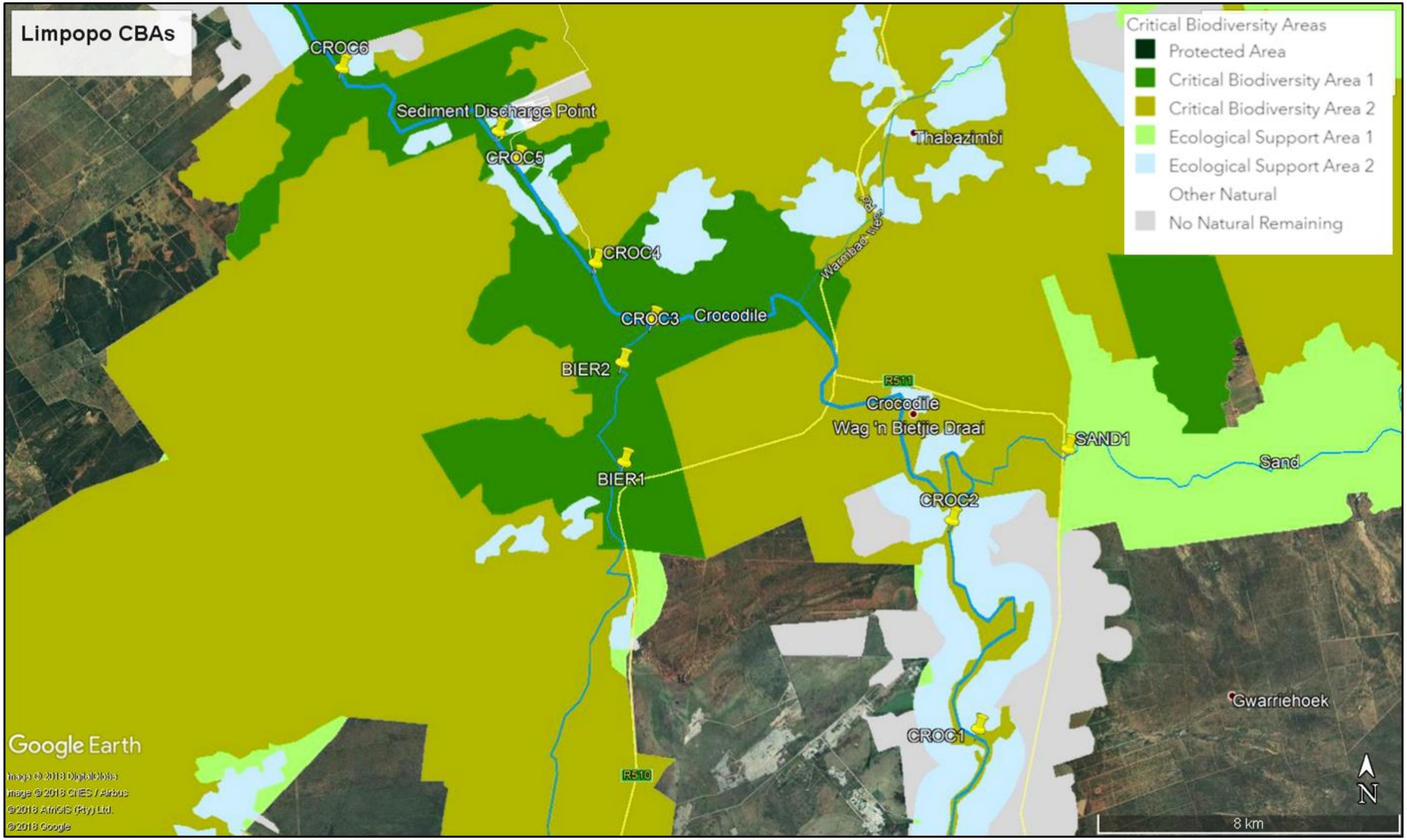


Figure 2-8: Illustration of Limpopo CBAs identified within the project area on the Crocodile River reach

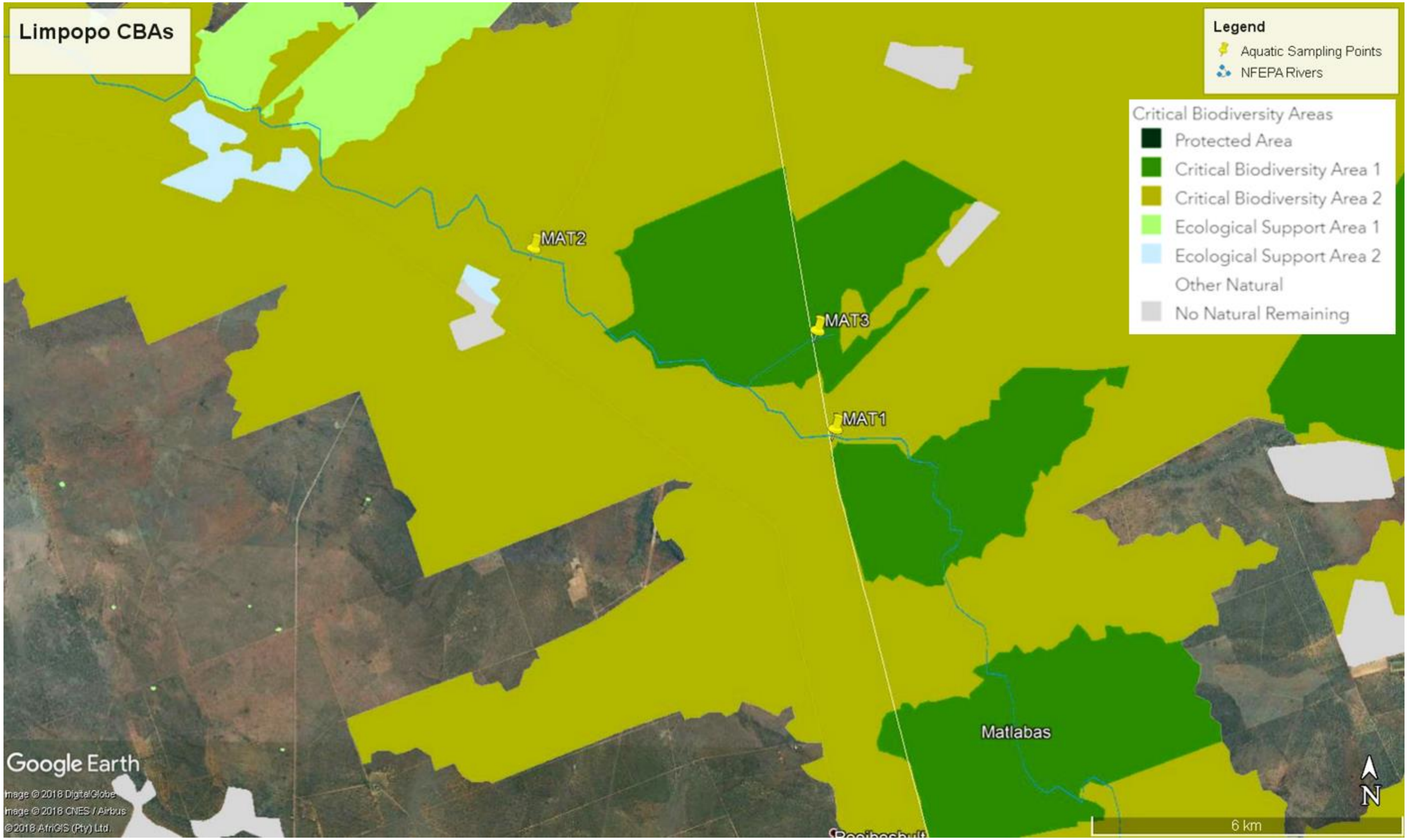


Figure 2-9: Illustration of Limpopo CBAs identified within the project area on the Matlabas River reach

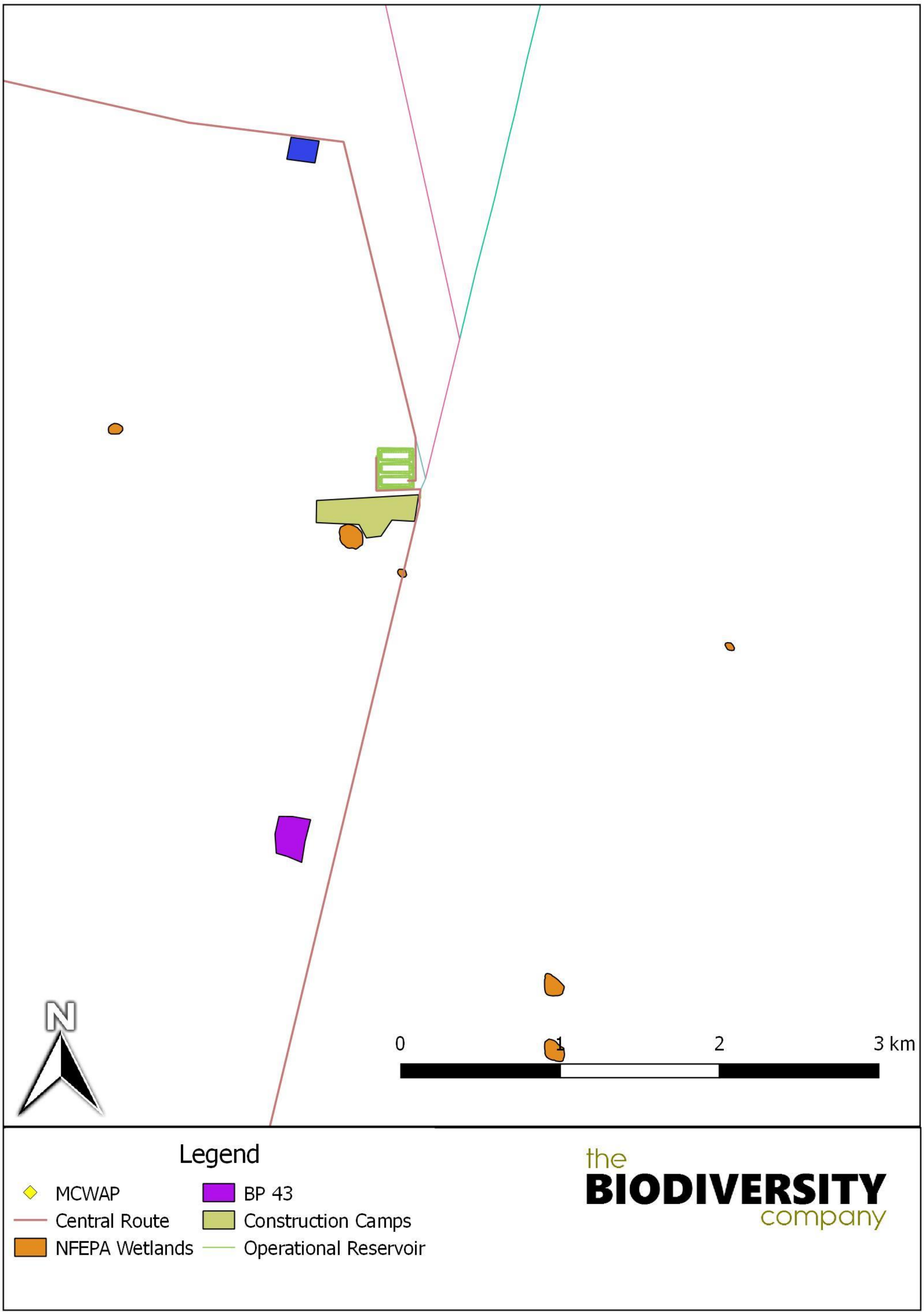


Figure 2-10: Illustration of proposed construction camp adjacent to a Pan labelled NFEPA Wetlands (23°53'44.95"S 27°24'3.25"E)

3 Methodology

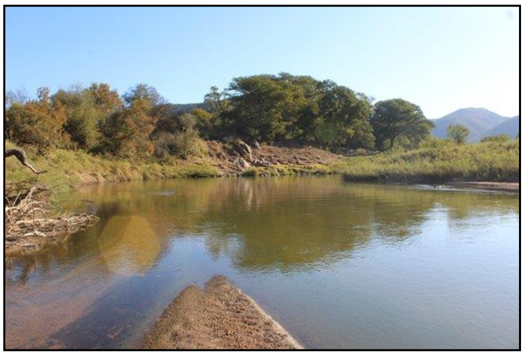
3.1 Site Selection

To determine the PES and potential impacts of each river system associated with the proposed development, site visits and sampling was conducted within each reach. As illustrated in Figure 2-3 to Figure 2-6, six aquatic sampling points were selected on the Crocodile River, a single site was assessed on the Sandspruit, two sites on the Bierspruit, two on the Matlabas River, and a single site on a tributary of the Matlabas system. A total of four comprehensive sites were conducted on the Crocodile River (CROC1, CROC2, CROC3, CROC5), and two visual assessments at CROC4 and CROC6.

Due to the ephemeral nature of the Sandspruit, Bierspruit, and Matlabas River, sampling was limited to available surface water if any was present. No flow was present in all three systems. Site photographs and GPS coordinates of each site is presented in Table 3.

Table 3: Photos, co-ordinates and descriptions for the sites sampled (Photographs taken June 2018)

Site	Upstream	Downstream
CROC1		
GPS coordinates	24°44'38.38"S 27°24'58.00"E	
CROC2		
GPS coordinates	24°41'40.74"S 27°24'33.00"E	

Site	Upstream	Downstream
CROC3		
GPS coordinates	24°38'50.09"S 27°19'51.92"E	
CROC4		
GPS coordinates	24°38'1.17"S 27°18'58.41"E	
CROC5		
GPS coordinates	24°36'32.80"S 27°17'44.97"E	
CROC6		

Site	Upstream	Downstream
GPS coordinates	24°35'1.77"S 27°14'49.87"E	
SAND1 **Dry**		
GPS coordinates	24°40'39.34"S 27°26'21.92"E	
BIER1 **Dry**		
GPS coordinates	24°40'51.03"S 27°19'25.36"E	
BIER2 **Dry**		
GPS coordinates	24°39'26.09"S 27°19'23.55"E	

Site	Upstream	Downstream
MAT1 **No flow**		
GPS coordinates	24° 4'56.48"S 27°24'58.29"E	
MAT2 **No flow**		
GPS coordinates	24° 3'4.67"S 27°21'32.90"E	
MAT3 **Dry (No channel)**		
GPS coordinates	24° 3'55.34"S 27°24'46.04"E	

3.2 Water Quality

Water quality was measured in situ using a handheld calibrated Extech ExStik II meter. The constituents considered that were measured included: pH, conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l.

3.3 Aquatic Habitat Integrity and Riparian Delineation

The Intermediate Habitat Assessment Index (IHIA) as described in the Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D), 1999 were used to define the ecological status of the river reach.

The 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 and ratings utilised in the assessment of habitat integrity in the current study are presented in Table 4 and Table 5 respectively.

Table 4: Criteria used in the assessment of habitat integrity (Kleynhans, 1998)

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.
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.

Table 5: Descriptions used for the ratings of the various habitat criteria

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

The riparian delineation was completed according to DWAF (2005a). Typical riparian cross sections and structures are provided in Figure 3-1. Indicators such as topography and vegetation were the primary indicators used to define the riparian zone. Contour data obtained from topography spatial data was also utilised to support the infield assessment.

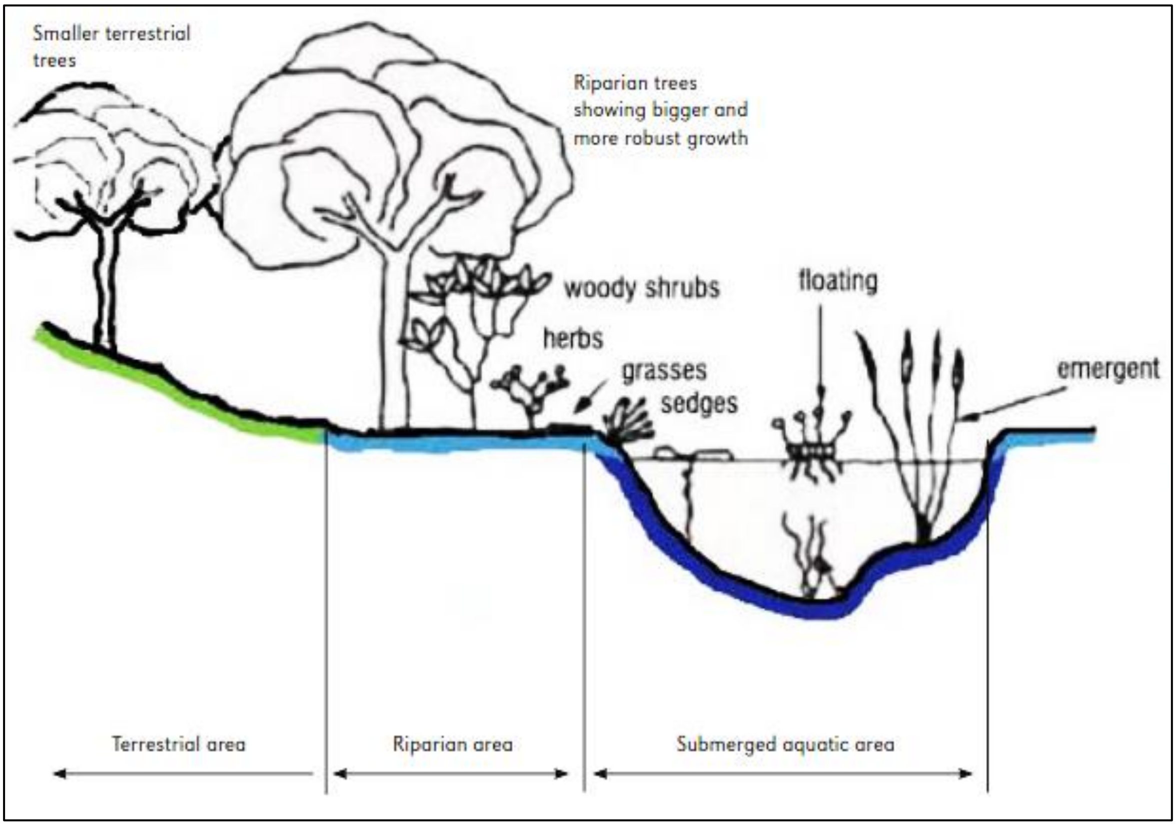


Figure 3-1: Riparian Habitat Delineations (DWAF, 2005a)

3.4 Aquatic Macroinvertebrate Assessment

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 studies) (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.

3.4.1 South African Scoring System

The South African Scoring System version 5 (SASS5) is the current 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. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value).

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

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Bushveld basin and the Limpopo Plain ecoregions (Figure 3-2 and Figure 3-3). 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.

Table 6: Ecological categories for the SASS5 index (adapted from Dallas, 2007)

Class	Description
A	Unimpaired. High diversity of taxa with numerous sensitive taxa.
B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
C	Moderately impaired. Moderate diversity of taxa.
D	Considerably impaired. Mostly tolerant taxa present.
E/F	Severely impaired. Only tolerant taxa present.

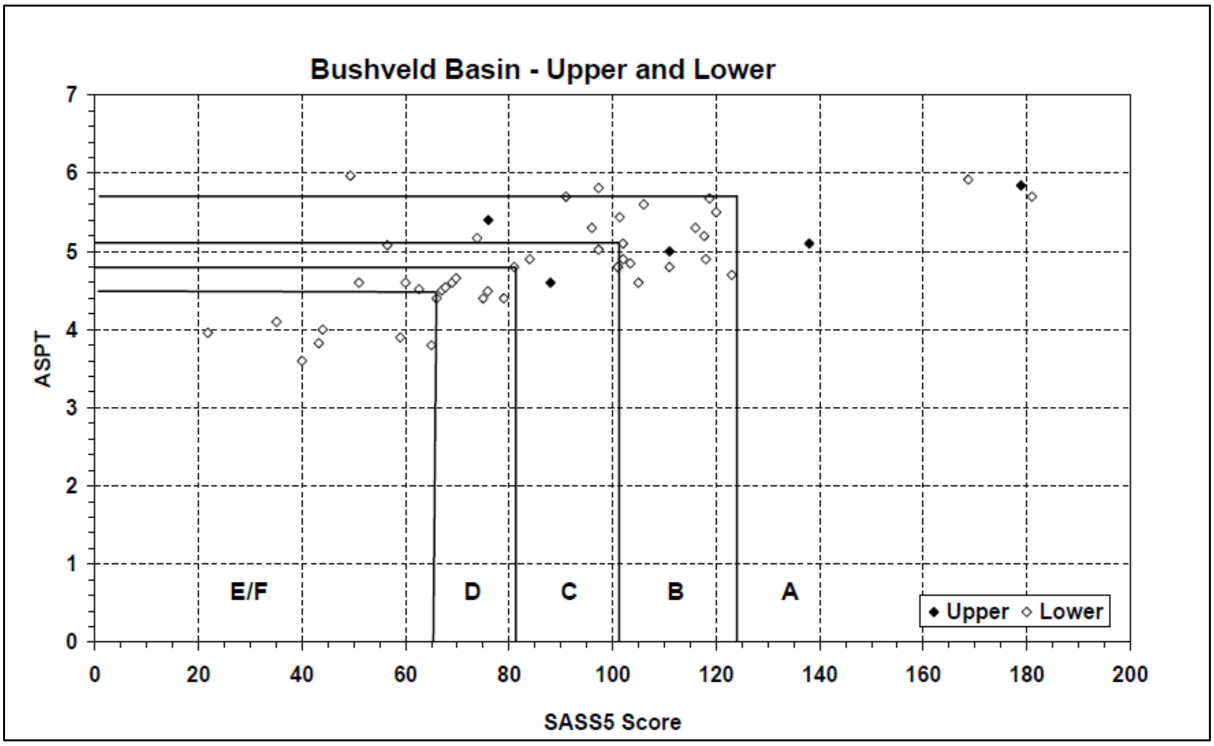


Figure 3-2: Biological Bands for the Bushveld Basin – Upper and Lower Ecoregion, calculated using percentiles

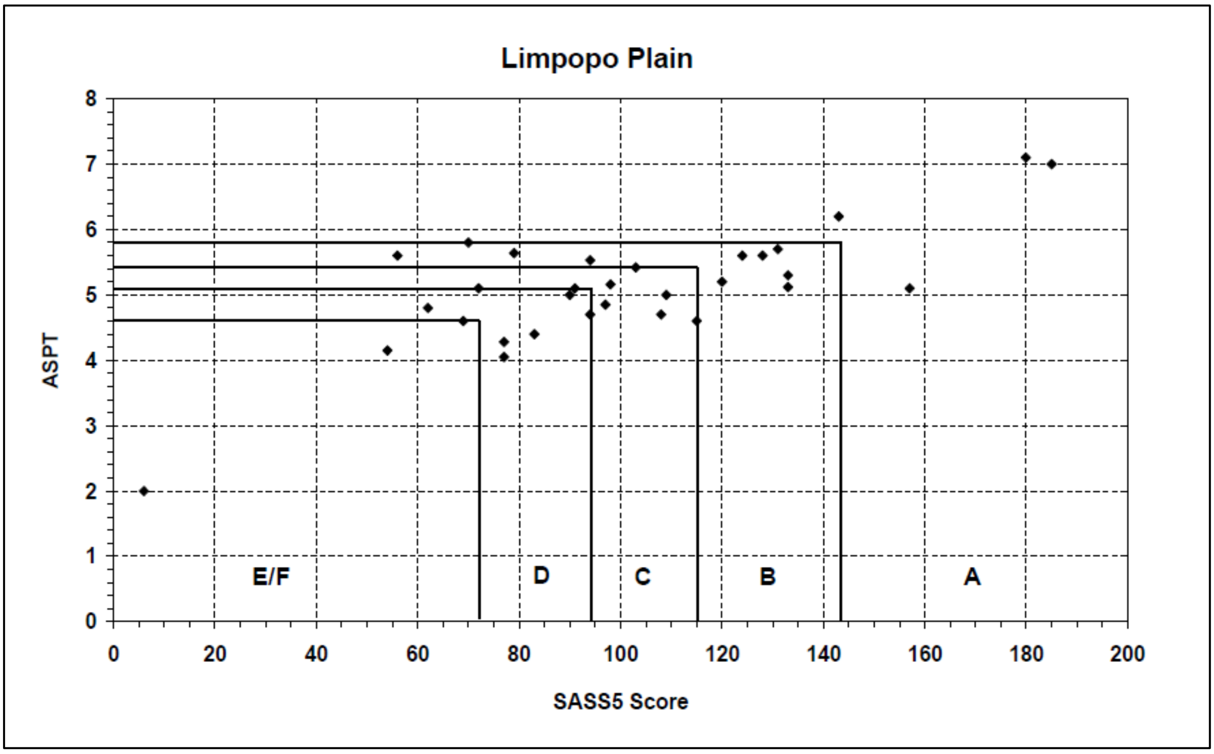


Figure 3-3: Biological Bands for the Limpopo Plain Ecoregion, calculated using percentiles

3.4.2 Macroinvertebrate Response Assessment Index

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 SQR. 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;
- Energy inputs from the watershed; and
- 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.

3.5 Fish Community Assessment

The information gained using the Fish Response Assessment Index (FRAI) gives an indication of the PES of the river based on the fish assemblage structures observed. Fish were captured through minnow traps, cast nets and electroshocking. All fish were identified in the field and released at the point of capture. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001). The identified fish species were compared to those expected to be present for the 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). It is noted that the FRAI Frequency of Occurrence (FROC) ratings were calculated based on the habitat present at the sites.

Table 7: Frequency ratings and probability of occurrence

Frequency Rating	Probability of occurrence
1	Low
3	Moderate
5	High

3.5.1 Fish Sensitivities

Fish have different sensitivities or levels of tolerance to various aspects that they are subjected to within the aquatic environment. These tolerance levels are rated with a sensitivity score as presented in Table 8. These tolerance levels are scored to show each fish species sensitivity to flow and physicochemical modifications.

Table 8: Intolerance rating and sensitivity of fish species

Sensitivity Score	Tolerance/Sensitivity Level
0-1	Highly tolerant = Very low sensitivity
1-2	Tolerant = Low sensitivity
2-3	Moderately tolerant = Moderate sensitivity
3-4	Moderately intolerant = High sensitivity
4-5	Intolerant = Very high sensitivity

3.6 Present Ecological Status

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). For the purpose of this study ecological classifications have been determined for biophysical attributes for the associated water course. This was completed using the river eco classification manual by Kleynhans and Louw (2007).

3.7 Risk Assessment

The risk assessment was conducted in accordance with the DWS risk-based water use authorisation approach and delegation guidelines. The matrix assesses impacts in terms of consequence and likelihood. Consequence is calculated based on the following formula:

Consequence = Severity + Spatial Scale + Duration

Whereas likelihood is calculated as:

Likelihood=Frequency of Activity + Frequency of Incident +Legal Issues + Detection.

Significance is calculated as:

Significance \Risk= Consequence X Likelihood.

The significance of the impact is calculated according to Table 9.

Table 9: Significance ratings matrix

Rating	Class	Management Description
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands may be excluded.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Wetlands are excluded.
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s)impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.

4 Limitations

The following aspects were considered as limitations for the aquatic assessment;

- A single dry season aquatic survey was completed for this assessment. Thus, temporal trends were not investigated;
- The aquatic study addressed water courses associated with the project, and not wetlands. NFEPAs have been addressed in this report to identify floodplains and pans at a desktop level. Furthermore, buffers for identified NFEPA wetlands have not been provided for in this report;
- The impact assessment completed in this study was completed in accordance to DWS Risk Assessment Guidelines for Section 21(c) and 21(i);
- As result of the footprint area and access to the project area, the focus of the in-field assessment was on watercourses directly impacted by the project; and
- Access to Sandspruit Gauging Weir was limited during the field survey, therefore a downstream site was assessed to characterise the reach.
- Riparian assessments were based on available contour data and ground-truthed in the field. The accuracy of the riparian delineation is of low confidence.

5 Results and Discussions

5.1 *In situ* Water Quality

In situ water quality analysis was conducted at sites containing surface water during the low flow survey. These results are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms. The results of the survey are presented in Table 10.

Table 10: In situ water quality results for the low flow survey (June 2018)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR*	**6.5-9.0**	**<700****	**>5.0**	**5-30**
CROC1	7,8	**825**	8,5	15,0
CROC2	7,7	**812**	7,9	15,0
CROC3	8,2	**819**	8,8	16,0
CROC5	8,2	**821**	8,0	15,2
MAT1	7,6	77,0	6,8	16,0
MAT2	7,6	331	6,8	13,0

*Target Water quality Range; **Expert opinion conductivity range

In situ water quality analysis of the Crocodile River indicated elevated dissolved solids during the survey (Table 10). The elevated dissolved solids are attributed to extensive anthropogenic activities upstream of these sites. These concentrations are above recommended levels, and would present adverse conditions to local aquatic biota, limiting diversity and abundances. The pH and DO levels within the Crocodile River fell within recommended TWQR limits and would not present adverse conditions to local aquatic biota. The water temperature ranges in the Crocodile River fell within expected limits for the region and did not present any marked fluctuations between sites.

In situ water quality results of the Matlabas River indicate good water quality conditions within the reach and would not present adverse conditions to local aquatic biota. A marked increase in dissolved solids was observed between the upstream and downstream sites (77,0 µS/cm at MAT1 and 331 µS/cm at MAT2). Low water levels and agricultural activities within the reach are contributing to the increase in dissolved solid levels.

5.2 Intermediate Habitat Integrity Assessment and Riparian Assessment

The IHIA was completed on a reach basis as described in the IHIA methodology component of this study. The results of the IHIA for each river reach assessed are presented in Table 11, and Table 12.

Table 11: Instream Intermediate Habitat Integrity Assessment for the Crocodile River reach

Criterion	Average Score	Score
Instream		
Water abstraction	17	9,52
Flow modification	16	8,32
Bed modification	13	6,76
Channel modification	11	5,72
Water quality	16	8,96
Inundation	11	4,4
Exotic macrophytes	10	3,6
Exotic fauna	8	2,56
Solid waste disposal	7	1,68
Total Instream Score		**48,5**
Instream Category		**D**
Riparian		
Indigenous vegetation removal	7	3,64
Exotic vegetation encroachment	5	2,4
Bank erosion	15	8,4
Channel modification	12	5,76
Water abstraction	16	8,32
Inundation	9	3,96
Flow modification	13	6,24
Water quality	10	5,2
Total Riparian Score		**56,1**
Riparian Category		**D**

Table 12: Instream Intermediate Habitat Integrity Assessment for the Matlabas River reach

Criterion	Average Score	Score
Instream		
Water abstraction	5	2,8
Flow modification	13	6,76
Bed modification	12	6,24
Channel modification	11	5,72
Water quality	4	2,24
Inundation	11	4,4
Exotic macrophytes	13	4,68
Exotic fauna	9	2,88
Solid waste disposal	2	0,48
Total Instream Score		**63,8**
Instream Category		**C**
Riparian		

Indigenous vegetation removal	9	4,68
Exotic vegetation encroachment	12	5,76
Bank erosion	9	5,04
Channel modification	11	5,28
Water abstraction	4	2,08
Inundation	9	3,96
Flow modification	10	4,8
Water quality	3	1,56
Total Riparian Score		**66,84**
Riparian Category		**C**

The results of the IHIA assessment indicate that the instream and riparian habitat integrity of the Crocodile River are largely modified (class D), indicating a large loss of natural habitat, biota and basic ecosystem functions has occurred. Modifications to instream habitat are a result of flow modifications due to numerous instream weirs (Figure 5-1), extensive water abstraction throughout the reach, water quality modifications (eutrophication), and erosion which has resulted in sedimentation of instream habitat. Modifications to riparian habitat are a result of bank and channel modifications (Figure 5-2), flow modifications and water abstraction. The riparian zone vegetation was largely indigenous with few alien invasive species observed.

The results of the IHIA assessment indicate that the instream and riparian habitat integrity of the Matlabas River are moderately modified (class C), indicating a loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged. Modifications to instream habitat include instream weirs, which have resulted in inundation, modifying bed, channel and banks within the reach (Figure 5-3). Agriculture activities and associated abstraction were observed along the reach (Figure 5-4).

Figure 5-1: Illustration of instream weirs (Site CROC2, taken June 2018)

Figure 5-2: Illustration of bank erosion and low water crossing (Site CROC4, taken June 2018)

Figure 5-3: Illustration of inundation due to instream weir on the Matlabas River (Google Earth imagery, 2016)

Figure 5-4: Illustration of agricultural activities along the Matlabas River (Google Earth imagery, 2016)

The riparian vegetation type of the Crocodile River within the study area is typical Savanna biome within the Central Bushveld Bioregion (Mucina and Rutherford, 2006). The study area is composed of a mixture of Dwaalboom Thornveld, Madikwe Dolomite Bushveld and Waterberg Mountain Bushveld. Typical riparian habitat in the Crocodile River is illustrated in Figure 5-5. The defined lower zone riparian habitat was found to be dominated by *Phragmites australis* particularly in the river reach which is to be potentially inundated. The upper zone was composed of a mixture of several typical subtropical bushveld tree species such as *Combretum imberbe* and *Senegalia galpinii*. Alien riparian vegetation was also prominent during the survey and was dominated by *Amaranthis hybridus* and *Melia azedarach.* The riparian delineation for the upper zone of the Crocodile River is provided in Figure 5-6, for the Bierspruit in Figure 5-7, for the Sandspruit in Figure 5-8, and the New Paul Hugo weir in Figure 5-9.

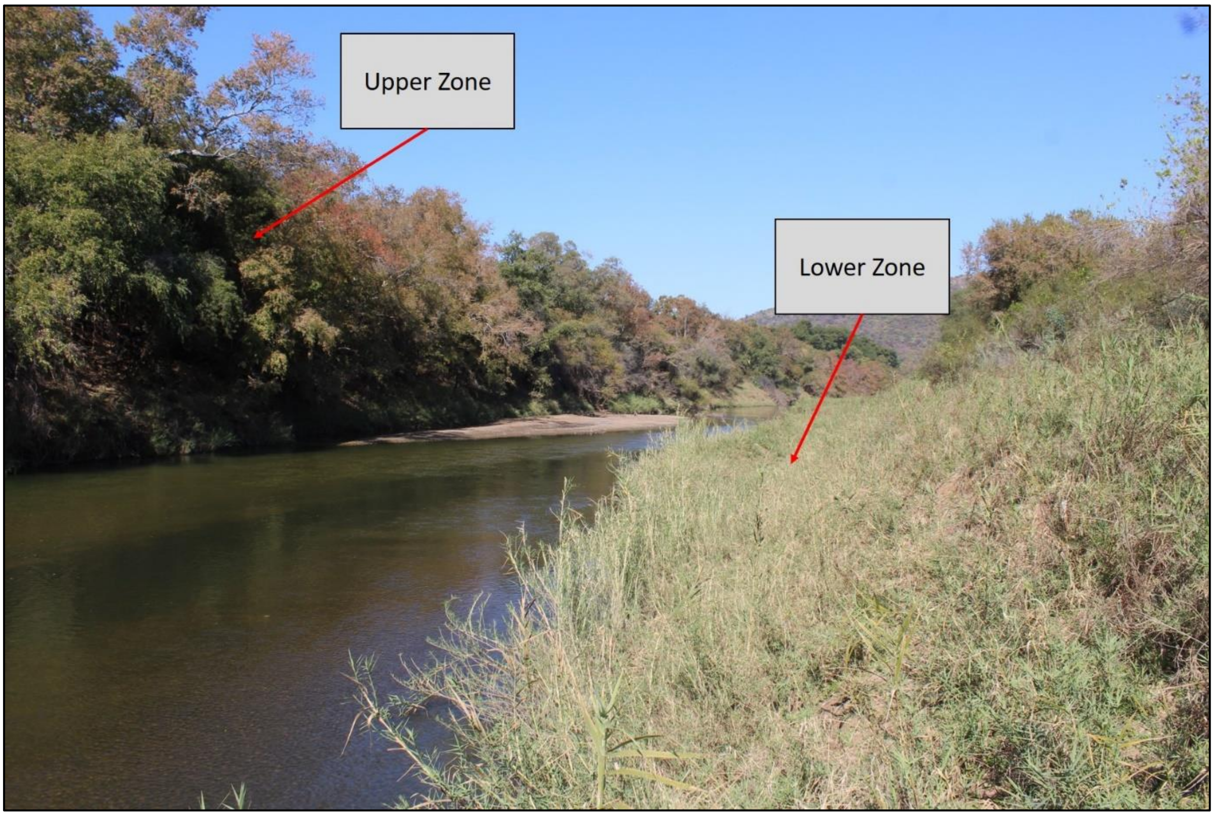


Figure 5-5: Typical riparian vegetation in the Crocodile River at the proposed Vlieëpoort Abstraction Point (May 2018)

Figure 5-6: Upper Zone Riparian delineation for the Crocodile River in vicinity of the Vlieëpoort Abstraction Point

Figure 5-7: Riparian delineation for the Bierspruit gauging weir

Figure 5-8: Riparian delineation for the Sandspruit in vicinity of the gauging weir

Figure 5-9: Riparian delineation for the Crocodile River in vicinity of the New Paul Hugo Weir

5.3 Aquatic Macroinvertebrate Assessment

5.3.1 Macroinvertebrate Habitat

A biotope rating of available habitat was conducted at each site assessed to determine the suitability of habitat to macroinvertebrate communities. The sites on the Crocodile River fell within lowland river geoclass (Table 13), and the Matlabas reach fell within a lower foothills geoclass. Each geoclass has different weightings for the various biotopes according to importance value (Table 14). The categories were calculated according to the biotope rating assessment as applied in Tate and Husted (2015). The results of the biotope assessment are provided below (Table 15). A rating system of 0 to 5 was applied, 0 being not available.

Table 13: Geoclass of the Crocodile and Matlabas Rivers

Zonation	Sites
Class E: Lower Foothills	MAT1, MAT2
Class F: Lowland River	CROC1, CROC2, CROC3, CROC5

Table 14: Biotope weightings for each geoclass

Biotope	Lower Foothills	Lowland River
Stones in current (SIC)	18,0	15,0
Stones out of current (SOOC)	12,0	12,0
Bedrock	3,0	2,0
Aquatic vegetation	1,0	2,5
Marginal vegetation in current	2,0	2,0

Biotope	Lower Foothills	Lowland River
Marginal vegetation out of current	2,0	2,0
Gravel	4,0	0,5
Sand	2,0	4,0
Mud	1,0	1,5

Table 15: Biotope availability at the sites (Rating 0-5)

Biotope	CROC1	CROC2	CROC3	CROC5	MAT1	MAT2
Stones in current (SIC)	3,5	3	1,5	2	0	0
Stones out of current (SOOC)	2	1	0	0,5	0	2
Bedrock	1	3	0	0	0	1
Aquatic vegetation	0	3	0	1	2	1
Marginal vegetation in current	2	2	3	2	0	0
Marginal vegetation out of current	2	2	2	3	3	3
Gravel	2	2	2	2	2	2
Sand	3	3	3	3	2	2
Mud	1	1	1	1	1	1
Biotope Score	16,5	20	12,5	14,5	10	12
Weighted Biotope Scores (%)	**45**	**41**	**21**	**28**	**9**	**21**
Biotope Category (Tate and Husted, 2015)	**D**	**D**	**F**	**F**	**F**	**F**

Habitat suitability ranged from class D at sites CROC1 and CROC2; to class F at site CROC3 and CROC5. The class D suitability was attributed to the low diversity of stones biotope within the systems and the decrease to class F at the lower sites was attributed to poor stones in and out of current diversity and abundance.

Habitat suitability within the Matlabas was rated as class F at both MAT1 and MAT2 sites. The poor habitat rating was attributed to low diversity of stones in and out of current, and low marginal and aquatic vegetation diversity. Furthermore, the low water levels within the system contributed to low biotope diversity.

The biotope results indicate that habitat availability would be a limiting factor to the macroinvertebrate assemblages within the Crocodile and Matlabas systems.

5.3.2 South African Scoring System

The aquatic macroinvertebrate results for the low flow survey are presented in Table 16. The SASS5 scores recorded in the Crocodile system during the low flow survey ranged from 113 at CROC1 to 79 at CROC3, with ASPT scores ranging from 5,1 at CROC1 and 4,4 at CROC2, indicating a semi intolerant macroinvertebrate assemblage at CROC1 (5-10 sensitivity score) to a tolerant assemblage at CROC2 (<5 sensitivity score).

Ecological classes decreased from the upstream CROC1 site (largely natural, class B), to the downstream systems which were rated as moderately to largely modified (CROC2 to CROC5). This can be attributed to variations in habitat suitability between the sites as presented in Table 15. Water quality within the reach remained stable, with minor fluctuations observed in pH and dissolved oxygen and solid levels, further indicating habitat availability as the limiting factor.

The total sensitivity scores within the Matlabas River ranged from 91 at the upstream MAT1 site, to 120 at the downstream MAT2 site. The ASPT scores of both sites indicated predominantly tolerant taxa occurring within the reach (<5 sensitivity score). Water quality within the reach decrease from the upstream to downstream sites, with an increase in habitat suitability observed between the upstream and downstream sites. Therefore, habitat diversity within the reach is the limiting factor within the reach assessed. Ecological category increased from largely modified at MAT1, to largely natural at MAT2.

Table 16: Macroinvertebrate assessment results recorded during the low flow season survey (June 2018)

Site	SASS Score	No. of Taxa	ASPT****	Category
CROC1*	113	22	5,1	**B**
CROC2*	96	22	4,4	**C**
CROC3*	79	15	5.3	**D**
CROC5*	98	19	5.2	**C**
MAT1**	91	19	4.8	**D**
MAT2**	120	26	4.6	**B**
*Bushveld basin **Limpopo Plain				

****ASPT: Average score per taxon**

5.3.3 Macroinvertebrate Response Assessment Index

The Macroinvertebrate Response Assessment Index (MIRAI) methodology was conducted according to Thirion, 2007. Data collected from the SASS5 method was applied to the MIRAI model. The MIRAI model provides a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community (assemblage) from the reference condition (unmodified river). Results for the reaches assessed are presented in Table 17 and Table 18.

The results for the Crocodile River reach assessed indicate that the macroinvertebrate integrity is moderately modified. Scores indicate that all three drivers (flow, habitat and water quality modifications) are responsible for the modifications to the macroinvertebrate community.

The results for the Matlabas River assessment indicate that the macroinvertebrate integrity is largely natural, with flow modifications within the reach being the predominant driver for the modified assemblage.

Table 17: MIRAI Score for the Crocodile River reach (2018)

Invertebrate Metric Group	Score
Flow Modifications	75,6
Habitat	76,1
Water Quality	77,7
Ecological Score	**76,5**
Category	**C**

Table 18: MIRAI Score for the Matlabas River reach (2018)

Invertebrate Metric Group	Score
Flow Modifications	75,3
Habitat	90,3
Water Quality	83,2
Ecological Score	**82,8**
Category	**B**

5.4 Fish Assessment

5.4.1 Expected Fish Species

The list of expected fish species is presented in Table 19 (Skelton, 2001; DWS, 2018). Based on this, a total of 18 fish species are expected to occur in Crocodile River, and 18 in the Matlabas River.

It should be noted that these expected species lists are compiled on an SQR basis and not on a site specific basis. It is therefore unlikely that all of the expected species will be present at every site in the SQR with habitat type and availability being the main driver of species present. Therefore, Table 19 should be viewed as a list of potential species rather than an expected species list.

Table 19: Expected species list for the Crocodile and Matlabas sub-quaternary catchments

Scientific name	Common name	IUCN Status	Crocodile	Matlabas
Anguilla mossambicus	Longfin eel	LC	✓	✓
Chetia flaviventris	Canary Kurper	LC		✓
Chiloglanis paratus	Sawfin Catlet	LC	✓	
Chiloglanis pretoriae	Shortspine catlet	LC	✓	
Clarias gariepinus	Sharptooth catfish	LC	✓	✓
Coptodon rendalli	Red-breasted Tilapia	LC		✓
Enteromius annectens	Broadstripe barb	LC		✓
Enteromius bifrenatus	Hyphen Barb	LC		✓

Enteromius rapax	Bushveld Papermouth	LC	✓	
Enteromius paludinosus	Straightfin Barb	LC	✓	✓
Enteromius trimaculatus	Threespot barb	LC	✓	✓
Enteromius unitaeniatus	Longbeard barb	LC	✓	✓
Labeo cylindricus	Redeyed labeo	LC	✓	✓
Labeo molybdinus	Leaden Labeo	LC	✓	✓
Labeobarbus marequensis	Lowveld Largescale Yellowfish	LC	✓	✓
Marcusenius macrolepidotus	Southern Bulldog	DD		✓
Mesobola brevianalis	River Sardine	LC	✓	✓
Micralestes acutidens	Elongated Robber	LC	✓	
Micropanchax johnstoni	Johnston's Topminnow	LC	✓	
Oreochromis mossambicus	Mozambique Tilapia	**NT**	✓	✓
Petrocephalus wesselsi	Southern Churchill	LC		
Pseudocrenilabrus philander	Southern mouthbrooder	LC	✓	✓
Schilbe intermedius	Butter Catfish	LC	✓	✓
Synodontis zambezensis	Plain squeeker	LC		✓
Tilapia sparrmanii	Banded tilapia	LC	✓	
Total			**18**	**18**

LC - Least Concern; NT - Near Threatened

5.4.2 Sampled Fish Species

During the dry season survey, 12 indigenous fish species were collected and a single exotic species (*Gambusia affinis*) within the Crocodile River reach. This included several sensitive species, including *Chiloglanis paratus*, *C. pretoriae*, *Labeo cylindricus*, *L. molybdinus*, and *Labeobarbus marequensis* (Table 20). The species most frequently collected within the Crocodile River includes *L. molybdinus*, *L. marequensis,* and *Oreochromis mossambicus.* The predominant cover features within the system included undercut banks with marginal vegetation (e.g. *Phragmites* sp.). Sites CROC1 and CROC2 presented stones and bedrock with fast flowing water biotopes, which are preferred habitat for several species collected during the survey including the *Labeo, Labeobarbus* and *Chiloglanis* species. The dominant biotope within the reach was moderately flowing waters over shallow sandy substrate, providing poor cover for fish species.

A total of nine species of indigenous fish were collected in the Matlabas River. Cover features within reaches sampled were limited due to poor connectivity within the reach and low water levels. Site MAT1 presented adequate vegetation and depth cover features, and limited stones and boulders. Site MAT2 presented good depth and stones cover features, with abundant juvenile fish collected in shallow pools with good aquatic vegetation. The most frequently collect fish was *Clarias gariepinus*, *Enteromius bifrenatus, E. trimaculatus, and O. mossambicus.* Several notable species were absent within the reach, including *L. marequensis*. The poor connectivity and low water levels contributes to the absence of the species; however, the species is likely to occur in upstream weirs. Illustration of selected fish species collected during the survey are presented in Table 21.

Table 20: Fish species collected during the survey, sensitivities and frequency of occurrence within each reach

Scientific name	Frequency of Occurrence		Sensitivity	
	Crocodile	Matlabas	No-flow	Phys-chem
Chiloglanis paratus	2,5	0	**3,2**	**3,1**
Chiloglanis pretoriae	1,25	0	**4,8**	**4,5**
Clarias gariepinus	3,75	5	**1,7**	**1,0**
Coptodon rendalli	0	2,5	**1,8**	**2,1**
Cyprinus carpio	Observed	0	**N/A**	**N/A**
Enteromius annectans	0	2,5	**2,8**	**3,0**
Enteromius bifrenatus	0	5	**2,5**	**3**
Enteromius paludinosus	1,25	0	**2,3**	**1,8**
Enteromius trimaculatus	2,5	5	**2,7**	**1,8**
Enteromius unitaeniatus	2,5	0	**2,3**	**2,2**
Gambusia affinis	1,25	0	**N/A**	**N/A**
Labeo cylindricus	3,75	5	**3,1**	**3,1**
Labeo molybdinus	5	0	**3,3**	**3,2**
Labeobarbus marequensis	5	0	**3,2**	**2,1**
Oreochromis mossambicus	5	5	**0,9**	**1,3**
Petrocephalus wesselsi	0	2,5	**N/A**	**N/A**
Pseudocrenilabrus philander	1,25	0	**1,0**	**1,4**
Schilbe intermedius	0	2,5	**1,3**	**1,8**
Tilapia sparrmanii	3,75	0	**0,9**	**1,4**

N/A- Data not available

Table 21: Illustration of selected fish species collected during the June 2018 survey

Chiloglanis paratus

Chiloglanis pretoriae

Enteromius annectens

Enteromius paludinosus

Enteromius trimaculatus

Enteromius unitaeniatus

Clarias gariepinus

Gambusia affinis

Labeobarbus marequensis

Labeo molybdinus

Labeo cylindricus

Oreochromis mossambicus

Pseudocrenilabrus philander

Tilapia sparrmanii

Petrocephalus wesselsi

5.4.3 Presence of Species of Conservation Concern

The conservation status of the indigenous fish species was assessed in terms of the IUCN Red List of Threatened Species (IUCN, 2016). Based on this assessment, a single species of special concern occur within the reach, *Oreochromis mossambicus*. *O. mossambicus* occurs in all but fast-flowing waters and thrives in standing waters. The species is threatened by hybridization with the rapidly spreading *Oreochromis niloticus*. Further south in its range it is most common in blind estuaries and coastal lakes where it tolerates brackish and marine environments. Feeds on algae, especially diatoms, and detritus, large individuals also take insects and other invertebrates. Breeds in summer, females raising multiple broods every 3 to 4 weeks during a season (IUCN, 2016).

5.4.4 Fish Response Assessment Index

The results of the FRAI assessment for the reaches assessed are presented in Table 22 and Table 23. The results indicate that the Crocodile River fish community was moderately modified during the survey. Several species were absent during the assessment; however, results are based on a single dry season survey. Should additional sampling be conducted within the reach, it is likely that additional species would be collected within the reach. A single exotic species was collected within he Crocodile River (G. affinis), and furthermore, according to anecdotal evidence from local residence, numerous *Cyprinus carpio* occur within the system.

The results for the Matlabas River fish community indicates a moderately modified fish assemblage. A total of nine of the expected 18 species were collected in the system, however, due to poor connectivity within the reach and low water levels, the fish community is expected to be modified. Should additional sampling be conducted during the high flow survey, more diverse cover features and velocity depth classes would be present, likely increasing the fish assemblage diversity. No exotic species were found within the system.

Table 22: Fish Response Assessment Index for the Crocodile River (June 2018)

FRAI% (Automated)	**69,51**
EC FRAI	**Class C**

Table 23: Fish Response Assessment Index for the Matlabas River (June 2018)

FRAI% (Automated)	**72,51**
EC FRAI	**Class C**

5.5 Present Ecological State

The Present Ecological State of each reach assessed for the study is presented in Table 24 and Table 25. The findings of the study were based on a single low flow survey, limiting spatial and temporal findings within the reaches, and therefore the confidence of the findings are low.

The results indicate that the Crocodile reach was in a moderately modified state during the survey (Table 24). This is attributed to the modifications to instream habitat, connectivity, flows, water quality, and riparian zone, resulting in a modified biotic integrity.

The results of the PES study indicate that the Matlabas system is in a moderately modified state. This is attributed to flow modifications within the reach, including weirs, as well as modifications to the riparian zone and instream habitat.

Table 24: The Present Ecological Status of the Crocodile River reach

Category	Score	Ecological Category
Riparian	56,1	**D**
Macroinvertebrate	76,5	**C**
Fish	69,51	**C**
EcoStatus	**C**	

Table 25: The Present Ecological Status of the Matlabas River reach

Category	Score	Ecological Category
Riparian	66,84	**C**
Macroinvertebrate	82,8	**B**
Fish	72,51	**C**
EcoStatus	**C**	

6 Buffer Zones

A buffer zone of 30m from the edge of the riparian zone is recommended. Considering that the proposed project is for an instream barrier and a water pipeline crossing the buffer derived is only applicable for associated construction activities such as mixing areas, stockpiles and laydown yards. Based on the proposed developments level of disturbance, a riverine buffer zone of 32 m from the delineated riparian zones, and NFEPA wetlands identified (Pans and floodplains) are recommended (Macfarlane et al. 2009).

7 Risk Assessment

The report considers the following components for the risk assessment:

- Abstraction works
    - Abstraction weir (Vlieëpoort Weir) (Figure 7-1);
    - River abstraction pump station;
    - Desilting works; and
    - Sediment return pipeline (into Crocodile River).
- Pipeline
    - Central pipeline; and
    - Alternatives.
- Gauging Weirs
    - Bierspruit;
    - Sandspruit; and
    - New Paul Hugo Weir.
- Borrow pits (23) (Section 7.2)

Figure 7-1: Overlay of proposed weir structure (±4 – 6 m high) over Crocodile River at site CROC4

7.1 Current Impacts (The No-Go Option)

According to DWS (2011), the Crocodile West River catchment is one of the most developed river catchments in the country with extensive urban developments and industrial areas of northern Johannesburg and Pretoria, and mining and extensive agricultural activities downstream of Hartbeespoort Dam. This has resulted in the Crocodile River becoming one of the most developed and influenced by human activities. Future surface water run-off from urban areas will increase flows within the system, however, water quality deterioration is likely to remain a modifying driver within the system. Increased water users downstream of the Hartbeespoort Dam will increase pressure on the Environmental Water Requirements of the system. Should the project not proceed, the system will likely persist in a stable PES of class C.

7.2 Potential Impacts Identified for the Borrow Pits

A desktop assessment was conducted to determine the spatial layout of the proposed 23 borrow pits for the MCWAP-2A. A single borrow pit was identified which has the potential to modify the instream channel, banks and flows within the Crocodile River (Figure 7-2). The risk assessment is presented in

Activities associated with the borrow pit operation include:

- Creating access for excavators;
- Creation of platform working areas;
- Excavation of the river bed (sand mining);
- Stockpiling of soil;
- Sand haulage;
- Storage of chemicals, fuels and oils; and
- Operation, refuelling and maintenance of equipment and vehicles.

Removal of river bed material often in volumes greater than natural replenishment rates though upstream aggradation can result in river bed degradation, increased suspended sediment content (increased turbidity/reduced light penetration/habitat and gill smothering) and the sand/gravel siltation of rapid/cobble areas. The removal of gravel and clay layers alters the physical morphology of the river channel and can create excessive scour and sediment movement resulting in further bed and channel modification.

Overall the abovementioned physical instream impacts can have a negative effect on aquatic ecology through the direct loss of habitat (cover), loss of spawning habitats (gravel) and loss of fine sediment sensitive taxa through gill smothering.

On a project specific scale, the project proposes to remove sediment from the current sand bank, and not from the active channel, However, should flows increase within the system, water diversion around the operational area is likely.

The sand mining operation can potentially degrade the marginal zone of the considered water course through the following processes. Direct loss of the marginal and riparian zones can occur through the direct loss of habitat during the construction of access routes and mining platforms. The destruction of the riparian zone can result in the destabilisation of the river banks, increased erosion, loss of cover and increased stream temperatures.

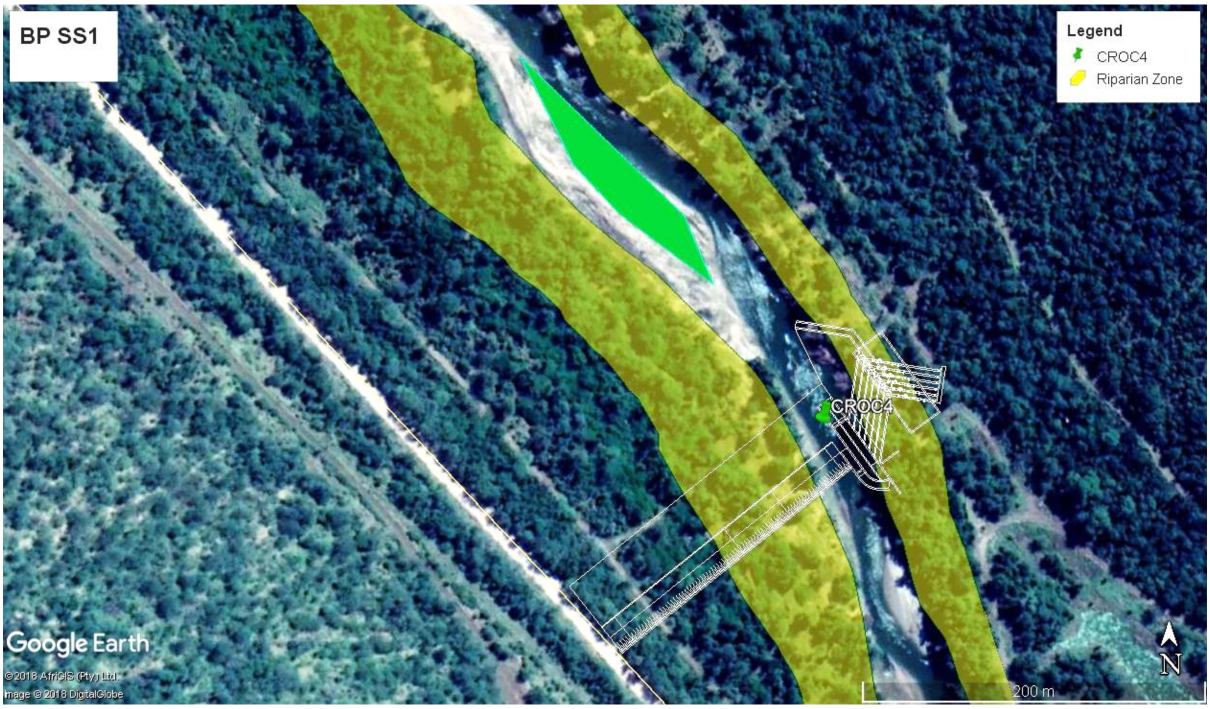


Figure 7-2: Illustration of borrow pit BP SS1 (green shading) within the Crocodile River

Table 26: Activity and Impact table for the proposed BP SS1 borrow pit

Phase	Activity	Aspect	Impact
Construction	Construction camps and associated infrastructure	Storage and use of hydrocarbons in proximity to the watercourse	• Alteration of site hydrology • Sewage contaminants from toilets • Solid waste inputs from the staff of the mining operation • Hydrocarbon related contamination • Erosion and sedimentation
		Staff ablutions	
	Creating access for excavators	Clearing of vegetation in order to access the mining resource (river sand)	• The loss/degradation of riparian areas • Alteration of natural hydrology
	Construction of resource stockpiles and processing equipment.	Stockpile runoff and seepage and hydrocarbon contamination	• Surface water contamination
Operation	Operation of office, toilets and workshop	Storage and use of hydrocarbons in proximity to the watercourse	• Alteration of site hydrology • Sewage contaminants from toilets • Solid waste inputs from the staff of the mining operation • Hydrocarbon related contamination
		Staff ablutions	
		Maintenance of vehicles & equipment	
		Storage of chemicals, fuel and oils	
	Excavation of the river bed	The removal of sediments	• Bed, flow and channel

Phase	Activity	Aspect	Impact
		Haulage of sand	modification • Altered hydro-dynamics • Lowering of the water table • Increased suspended solids • Surface water contamination
		Operation of machinery and equipment	
	Operation of resource stockpiles and processing equipment.	Stockpile runoff and seepage and hydrocarbon contamination	• Surface water contamination

Table 27: DWS Risk Impact Matrix for the proposed project

Aspect	Flow Regime	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Consequence
Construction Phase								
Construction of new infrastructure	1	1	1	1	1	1	2	4
Storage and use of hydrocarbons in proximity to the watercourse	0	2	0	2	1	2	2	5
Staff ablutions	0	2	0	2	1	2	2	5
Clearing of embankment vegetation in order to access the mining resource (river sand)	2	2	2	3	2.2	2	2	6.2
Stockpile runoff and seepage and hydrocarbon contamination	1	2	2	3	2	2	2	6
Operational Phase								
Storage and use of hydrocarbons in proximity to the watercourse	0	2	1	2	1.2	2	2	5.2
Staff ablutions	0	2	1	1	1	2	2	5
The removal of sediments	3	1	3	3	2,5	3	2	7,5
Operation of machinery and equipment	2	2	2	2	2	2	2	6
Stockpile runoff and seepage and hydrocarbon contamination	2	2	2	2	2	2	2	6

Table 28: DWS Risk Impact Matrix for the proposed project continued

Aspect	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Sig.	Without Mitigation	With Mitigation
Construction Phase								
Construction of new infrastructure	3	2	1	3	9	36	**Low**	**Low**
Storage and use of hydrocarbons in proximity to the watercourse	3	2	5	3	13	65	**Moderate***	**Low**
Staff ablutions	3	2	1	3	9	45	**Low**	**Low**
Clearing of embankment vegetation in order to access the mining resource (river sand)	4	5	5	1	15	93	**Moderate**	**Moderate**
Stockpile runoff and seepage and hydrocarbon contamination	3	3	1	3	10	60	**Moderate***	**Low**
Operational Phase								
Storage and use of hydrocarbons in proximity to the watercourse	3	3	5	3	14	73	**Moderate***	**Low**
Staff ablutions	3	3	1	3	10	50	**Low**	**Low**
The removal of sediments	2	4	5	2	13	97,5	**Moderate**	**Moderate**
Operation of machinery and equipment	3	3	1	3	10	60	**Moderate***	**Low**
Stockpile runoff and seepage and hydrocarbon contamination	3	3	1	3	10	60	**Moderate***	**Low**
(*) denotes-In accordance with General Notice 509 “Risk is determined after considering all listed control / mitigation measures. Borderline moderate risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80). This risk assessment was completed by Russell Tate (Pr. Sci. Nat: 400089/15)								

The risk of the removal of sediments from the active river channel are detailed below. Considering the criteria for the risk matrix the factors: Flow Regime, Water Quality, Habitat and overall effect on Biota, the proposed removal of sediments was rated as moderate. The spatial scale of the was rated as "regional" with the downstream river reaches being affected. The duration of the potential impact of the activity was determined to be "One month to one year" as recovery of the project area will likely take one to two seasons with seasonal flooding replenishing sediment.

The frequency of the removal of sediments activity was rated as "daily" as the activity will likely take place throughout the project duration. The frequency of impacts associated with the removal of sediments activity was determined to be "daily" with anticipated impacts stemming from daily activities for the duration of the project.

The removal of sediments from an river channel is a listed activity and requires governmental authorisation and therefore was rated as "fully covered by legislation". The detection of the impacts stemming from the removal of sediments was derived to be "without much effort" as alterations to the stream substrate will be clear in the project area, however, downstream impacts may need to be assessed with additional investigation.

As mentioned above, the results of the risk assessment determined low risks for activities occurring outside of the delineated watercourse areas. However, activities occurring within the instream and riparian zones were derived to be moderate risk activities despite mitigation. The reason for this classification even after mitigation was due to the location of the activities within the direct associated instream and riparian habitats.

7.3 Potential Impacts Identified for the Construction and Operation of the Weirs, Pipelines and Associated Infrastructure

According to the proposed activities for the MCWAP-2A and the current state of the local aquatic systems assessed, numerous potential impacts are expected for the project. The most direct impact expected to the Crocodile system is during the construction and operation of the Vlieëpoort and New Paul Hugo Weir. As the activity is for instream construction, direct impacts to water quality, flows, instream habitat and aquatic biota are expected. Furthermore, the inundation of the Crocodile River will impact instream and riparian habitat, and likely to modify aquatic biota due to modifications to flow regimes, from largely lotic system to lentic. Several fish and macroinvertebrate species with a high preference for well oxygenated fast flowing waters are likely to avoid the inundation zone. Furthermore, the potential for alien invasive species to proliferate is high, including fish species (*Micropterus salmoides* and *Cyprinus carpio*) which are likely to have adverse effects on indigenous aquatic biota and habitat; and alien invasive vegetation {e.g. *Eichhornia crassipes* (Water hyacinth)}. The instream connectivity of the Crocodile River is further to be fragmented due to the construction of the two proposed weirs, adversely affecting fish migration. A single true migratory species is expected within the region, *Anguilla mossambica*. The presence of the species in upstream reaches (DWS, 2018) indicates the ability of the species to circumnavigate low levels weirs. However, fish species found within the region have local migratory habits (< 5km) (Kleynhans and Louw, 2007). A provision for a fish way for the Vlieëpoort Abstraction Weir has been included in this report.

As part of the desilting work operation, it is proposed that sediment is discharged back into the Crocodile River during high flows. The discharge of sediment back into the system has the potential to modify banks and instream habitat at the discharge point, and sediment balance of downstream systems. During the dry season survey, a large amount of instream sedimentation was observed. The project has the potential to correct the sediment balance within the Crocodile River.

The potential impacts during the construction and operational phases for the Bierspruit and Sandspruit Gauging Weirs are expected to be minor should adequate mitigation measures be implemented. Both systems are ephemeral, allowing construction to take place during the dry season.

Potential impacts to the Matlabas system during the construction of the pipeline crossing include modifications to the riparian zone, instream habitat, water quality, and modifications to local aquatic biota. All associated infrastructure should respect recommended buffer during construction activities and reduce the footprint proximate to the Matlabas system. During the operational phase, risks to the Matlabas system include spillages and leaks, potentially modifying water quality, bank and instream habitat due to erosion, resulting in downstream sedimentation. Scouring of the pipeline at the Matlabas River crossing is proposed every five years. This has the potential to modify water quality and erode banks and instream habitat and modify the sediment balance within the system.

7.3.1 Pipeline Alternatives

Pipeline alternatives were assessed for the northern portion of the water transfer infrastructure (Figure 7-3). Several proposed pipeline routes run adjacent to pans identified within the project area. Pipeline Alternative D1 was identified as a preferential route, with the addition of Alternative D4, which by-passes two pans marked as A and B. The Alternative D4 route is in excess of 500 m of pans A and B, and no impacts to identified pans are anticipated.

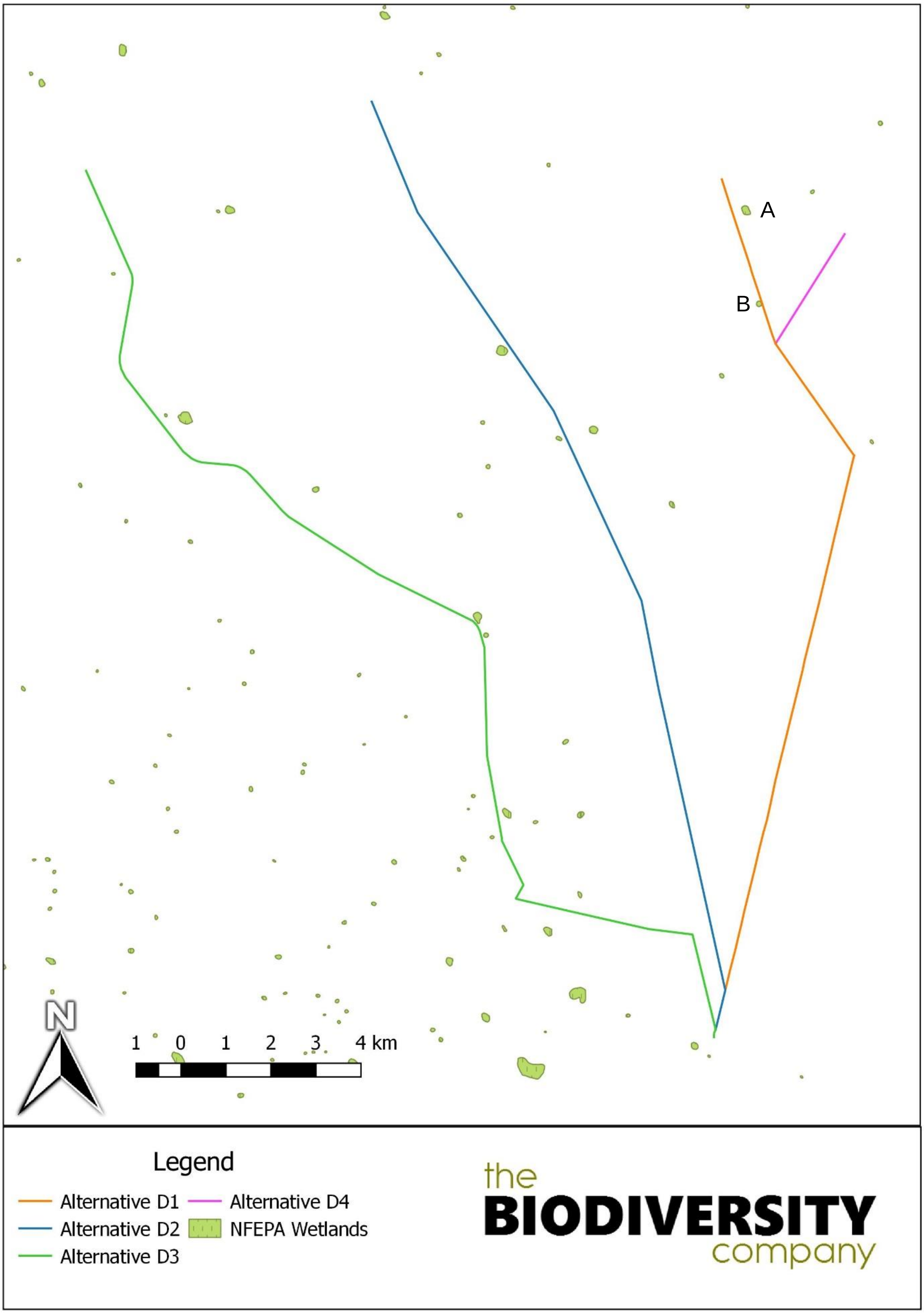


Figure 7-3: Pipeline alternatives assessed for the northern portion of the water transfer infrastructure (Points A and B- Pans along Alternative D1)

7.3.2 Risk Assessment

The potential impacts arising from the abovementioned activities are provided in Table 29. The risk assessment for the proposed project is presented in Table 30 and Table 31.

Table 29: Activity and Impact table for the proposed development

Phase	Activity	Aspect	Impact
Construction	Construction of road and pipeline crossing	Site clearing and compaction	The activity would result in the deterioration of water and habitat quality within the downstream river reaches
		Storage of construction materials	
		Alteration of catchment drainage	
	Weir construction and associated infrastructure	Physical construction of the structure including the excavation of the streambed and removal of bank vegetation	Direct instream habitat loss and up and downstream habitat deterioration. Water quality impacts may also be anticipated through increased nutrients, suspended and dissolved solids
		Diversion of river for construction activities	
		Temporary infrastructure including mixing areas and ablutions	
		Spills and leaks of hydrocarbons and the operation of machinery	
Operation	Operation of the weir	Initial flooding of the impoundment	The flooding of upstream aquatic habitat and loss of water quantity downstream
		Maintenance of the impoundment and presence of barrier	The barrier will alter the hydrology of the river system resulting in negative effects to the ecology of the river system. The barrier will serve to sever connectivity between up and downstream river reaches
		Physical abstraction of water	Loss of flow and floodplains in downstream sacrifice zone
	Operation of the roads and pipeline infrastructure	Runoff of contaminants and alteration of catchment hydrology	Water and habitat quality impacts to downstream river reaches
	Sediment return	Discharge of sediment into Crocodile River	Water and habitat quality impacts to downstream river reaches
	Scouring Pipeline in Matlabas	Release of water and sediment into the Matlabas	Water and habitat quality impacts to downstream river reaches

Table 30: DWS Risk Impact Matrix for the proposed project

Risk Matrix (Based on DWS 2015 publication: Section 21(c) and 21(i) water use Risk Assessment Protocol) This risk assessment was completed by Christian Fry (Pr. Sci. Nat: 119082)								
Aspect	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**
Construction Phase								
Site clearing and compaction	2	2	3	2	2,25	2	3	7,25
Storage of construction materials	0	3	2	3	2	2	3	7
Alteration of catchment drainage	3	1	3	2	2,25	2	3	7,25
Physical construction of the structure including the excavation of the streambed and removal of bank vegetation	2	2	4	3	2,75	3	3	8,75
Diversion of river for construction activities	3	2	3	2	2,5	2	3	7,5
Temporary infrastructure including mixing areas and ablutions	1	3	2	2	2	2	3	7
Spills and leaks of hydrocarbons and the operation of machinery	0	3	2	3	2	3	3	8
Operational Phase								
Initial flooding of the impoundment	4	2	4	4	3,5	3	4	10,5
Maintenance of the impoundment and presence of barrier	1	1	2	3	1,75	1	4	6,75
Physical abstraction of water	1	1	1	1	1	1	4	6
Runoff of contaminants and alteration of catchment hydrology	1	2	1	1	1,25	2	4	7,25
Discharge of sediment into Crocodile River	1	2	3	2	2	2	4	8
Release of water and sediment into the Matlabas	2	3	3	3	2,75	2	2	6,75

Table 31: DWS Risk Impact Matrix for the proposed project continued

Aspect	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Sig.	Without Mitigation	With Mitigation
Construction Phase								
Site clearing and compaction	2	4	5	1	12	87	**Moderate**	**Moderate**
Storage of construction materials	2	3	1	3	9	63	**Moderate**	**Low**
Alteration of catchment drainage	2	4	5	1	12	87	**Moderate**	**Moderate**
Physical construction of the structure including the excavation of the streambed and removal of bank vegetation	2	4	5	1	12	105	**Moderate**	**Moderate**
Diversion of river for construction activities	2	4	5	1	12	90	**Moderate**	**Moderate**
Temporary infrastructure including mixing areas and ablutions	2	3	1	3	9	63	**Moderate**	**Low**
Spills and leaks of hydrocarbons and the operation of machinery	2	1	1	3	7	56	**Moderate**	**Low**
Operational Phase								
Initial flooding of the impoundment	1	5	5	1	12	126	**Moderate**	**Moderate**
Maintenance of the impoundment and presence of barrier	4	5	5	1	15	101,25	**Moderate**	**Moderate**
Physical abstraction of water	5	4	5	3	17	102	**Moderate**	**Moderate**
Runoff of contaminants and alteration of catchment hydrology	3	3	1	3	10	72,5	**Moderate**	**Low**
Discharge of sediment into Crocodile River	2	2	5	2	11	88	**Moderate**	**Moderate**
Release of water and sediment into the Matlabas	1	2	5	2	10	67,5	**Moderate**	**Low**
(*) denotes - In accordance with General Notice 509 "Risk is determined after considering all listed control / mitigation measures. Borderline Low / Moderate risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to listing of additional mitigation measures detailed below."								

The construction of the Vlieëpoort Weir poses several moderate risks to the Crocodile River, with mitigation measures not being able to lower the risk status. This is due to the nature of the activity and proximity to sensitive areas. The physical construction of the weir poses the highest risk to the system, with additional moderate risks associated with river diversion, and clearing of the riparian areas for infrastructure. The initial flooding of the weir post construction poses the highest initial risk to the Crocodile River, as this will inundate instream habitat, and modify downstream flows. Based on data provided to the specialist, an estimated 7,3 km of the Crocodile will be inundated, and an additional 1,5 km of the Bierspruit. This will result in permanent impacts to upstream areas of the weir. The construction of the Sandspruit and Bierspruit gauging weirs will pose a lower risk to the systems, as these systems are ephemeral, and should be constructed during the dry season.

The abstraction of water from the Crocodile River is rated as moderate. The moderate rating remains high due to the duration of the activity, however, due to the increase in expected runoff from upstream reaches, the flow modifications within the reach are expected to be improved and base flows within the lower reaches of the Crocodile be maintained. The discharge of sediment into the Crocodile poses a moderate risk. This is due to the potential of altered sediment balance, modifications to downstream instream habitat, bank and channel erosion.

The construction of the central pipeline across the Matlabas system poses a moderate risk to the riparian and instream habitats. Furthermore, during the scouring of the pipeline into the system, risks were rated as moderate due to the potential modifications to water quality and instream habitat.

7.4 Recommendations and Mitigation

The mitigation actions provided below are important to consider with other specialist assessments (e.g. Wetland Assessment). These mitigation measures should be implemented in the Environmental Management Plan (EMP) should the project go-ahead. The mitigation hierarchy proposed by Macfarlane *et al.,* (2016) was considered for this study.

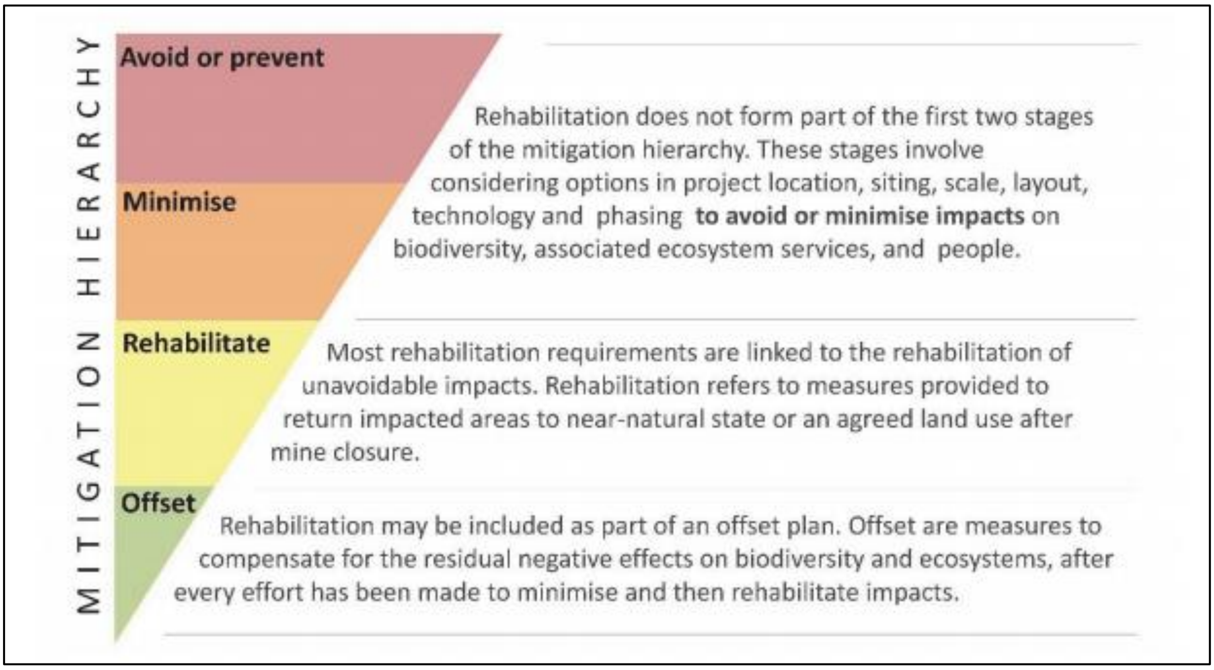


Figure 7-4: The Mitigation Hierarchy (Macfarlane et al. 2016)

As observed above, avoiding and the prevention of loss of sensitive landscapes are the first stage of the mitigation hierarchy. Considering this, no riverine areas can be avoided by the proposed project due to the activity taking place directly within the instream channel.

7.4.1 Buffer Zones

The recommended buffer zones should be strictly adhered to during the construction phase of the project, with exception of the activities and structures required to traverse a watercourse. This includes structures such as culverts for drainage lines and the weir structure itself. Any supporting aspects and activities, such as laydown and mixing yards, not required to be within the buffer area should adhere to the buffer zone. These buffer zones apply to the activities related to the BP BSS1 borrow pit, with activities including access roads and infrastructure respecting buffer zones where riparian zones are avoidable.

7.4.2 Borrow Pit Mitigation Measures

Recommended mitigation measures for the BP BS1 borrow pit follow best practice guidelines, and are presented in Sections 7.4.4 (Altered Hydrology), 7.4.5 (Impaired Water Quality), 7.4.6 (Erosion and Sedimentation), and 7.4.8 (Alien Invasive Plants). A rehabilitation plan for the borrow pit should be established and implemented post-operation, with emphasis on establishing natural vegetation within the riparian zones and ensuring bank stabilisation within the reach to mitigate against further erosion.

7.4.3 Weir Construction Mitigation Measures

The following further mitigation measures are prescribed for other infrastructure and weir construction:

- A water bar (e.g. Earth Berm Water Bars) diverts water flowing down a surface (e.g. road) to one side. This reduces the volume of water that flows down the surface and the subsequent erosion that occurs;

- During the excavation of watercourses, flows should be diverted around active work areas where required. Water diversion must be temporary and re-directed flow must not be diverted towards any stream banks that could cause erosion;
- Construction areas should be demarcated and watercourses marked as "restricted" in order to prevent the unnecessary impact too and loss of these systems;
- Storm water channels and preferential flow paths should be filled with aggregate and/or logs (branches included) to dissipate and slow flows limiting erosion;
- Prevent uncontrolled access of vehicles through the wetlands that can cause a significant adverse impact on the hydrology and alluvial soil structure of these areas;
- All removed soil and material must not be stockpiled within the system. Stockpiling should take place outside of the water resources. All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds; and
- Any exposed earth should be rehabilitated promptly by planting suitable vegetation (vigorous indigenous grasses) to protect the exposed soil.

7.4.4 Mitigation for Altered Hydrology

The minimum flows for the Environmental Water Requirements (EWR) stipulated in the "Preliminary Reserve Determination and Ecological Categorisation for selected Rivers and Wetlands in the Crocodile (West) Catchment (A20)" is recommended for implementation e through the operational phase of the proposed project.

7.4.5 Mitigation for Impaired Water Quality Protection

The following mitigation measures are prescribed:

- Storm water channels and preferential flow paths should be filled with aggregate and/or logs (branches included) to dissipate and slow flows limiting erosion;
- Laydown yards, camps and storage areas must be beyond the water resource areas and associated buffers where applicable;
- During construction contractors used for the project must have spill kits available to ensure that any fuel or oil spills are clean-up and discarded correctly;
- As much material must be pre-fabricated and then transported to site to avoid the risks of contamination associated with mixing, pouring and the storage of chemicals and compounds on site;
- All contractors and employees should undergo induction which is to include a component of environmental awareness. The induction is to include aspects such as the need to avoid littering, the reporting and cleaning of spills and leaks and general good "housekeeping";
- All chemicals and toxicants during construction must be stored in bunded areas;
- All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced off-site;
- Cofferdams are temporary structures used to displace water and provide dry access to usually submerged areas (such instream construction and maintenance of bridges etc.). They can also be built to prevent water coming into contact with high impact zones (e.g. construction and mining sites) and reduce the amount of sedimentation and pollution;

- Adequate sanitary facilities and ablutions on the servitude must be provided for all personnel throughout the project area. Use of these facilities must be enforced (these facilities must be kept clean so that they are a desired alternative to the surrounding vegetation);
- Have action plans on site, and training for contactors and employees in the event of spills, leaks and other impacts to the aquatic systems;
- No dumping of construction material on-site may take place; and
- All waste generated on-site during construction must be adequately managed. Separation and recycling of different waste materials should be supported.

7.4.6 Mitigation for Erosion and Sedimentation

The following mitigation measures are prescribed:

- Storm water channels and preferential flow paths should be filled with aggregate and/or logs (branches included) to dissipate and slow flows limiting erosion;
- During the excavation of watercourses, flows should be diverted around active work areas where required. Water diversion must be temporary and re-directed flow must not be diverted towards any stream banks that could cause erosion;
- All removed soil and material must not be stockpiled within the system. Stockpiling should take place outside of the water resources. All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds;
- A water bar (e.g. Earth Berm Water Bars) diverts water flowing down a surface (e.g. road) to one side. This reduces the volume of water that flows down the surface and the subsequent erosion that occurs;
- The placement of culverts in drainage lines should not encourage erosion through increasing water velocity. Energy dissipation must be installed downstream of culverts in drainage lines.
- Temporary and permanent erosion control methods may include silt fences, flotation silt curtains, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed embankments, erosion mats, and mulching;
- Any exposed earth should be rehabilitated promptly by planting suitable vegetation (vigorous indigenous grasses) to protect the exposed soil; and
- Riverine sediment management must occur in a manner which replicates natural sediment movements.

7.4.7 Pipeline Trench Rehabilitation Measures

The following measures are required for excavation within the watercourses:

- Trench must be side dug (where possible) from the access routes, or already disturbed areas;
- Trenches must be dug on-line (where applicable) creating narrower trenches;
- Where trench breakers are required, these must be imported appropriately and installed by the backfill crew, ahead of backfilling;
- Careful separation of soil types/ strata as identified;
- The soils must be removed in such a way that they can be easily reinstated in the reverse order;

- To ensure correct backfilling, the soil that is removed from the trench at its deepest point must be laid closest to the trench. The first layer of topsoil must be laid furthest away from the trench;
- Excess spoil must be temporarily windrowed over the trench to permit natural settling of the material prior to the reinstatement phase;
- Stripping must be demarcated to avoid unnecessary removals (survey pegs). Keep stripping areas to a minimum footprint area;
- Trenches within watercourses must be in excess of 1m to enable interflow within the system;
- Vegetation should be stripped / removed in a phased manner. Where possible, store vegetation for re-planting. Impacted areas can be re-vegetated using sods from removed vegetation;
- To avoid compaction of the backfilled trench, ripping should be done to a maximum depth of 300 mm in two directions at right angles;
- Ripping should be conducted during the drier period;
- After construction, compacted top soil should be ripped and vegetation re-planted or seeds dispersed; and
- Should project timeline allow, the construction of the weir and pipeline should be undertaken in the dry season.

7.4.8 Mitigation for Alien Invasive Plants

The following mitigation measures are prescribed:

- Quarterly vegetation rehabilitation surveys need to be conducted of the vegetation within the project footprint; and
- An alien invasive plant management plan needs to be compiled and implemented prior to construction to control and prevent the spread of invasive aliens.

7.4.9 Maintenance of Connectivity

The loss of connectivity between areas up- and downstream of the weir are anticipated to have the largest ecological impact, especially when considering the listed Near Threatened species. It is anticipated that the weir will act as a barrier. Therefore, to facilitate the movement of fish species, a fish ladder is recommended as the mitigation action. A fish ladder has been included in the initial proposed weir design options. However, the option considered from an aquatic ecology perspective should pose the least risk to fish migration.

Detailed fish ladder designs should implement the established protocols found in Water Research Commission (WRC) report No 1270/2/04 and WRC report No 1310/1/05. Essentially, four types of fishways should be considered namely: Pool and weir, vertical-slot, pool and slot, and natural by-pass channels.

Considering this literature, the following fishway concepts should be adhered to in the preferred option:

- The fishway should have water passing through it during both high flows and low flows to encourage fish to make use of the fishway no matter the flow levels;

- The fishway should cater for both rheophilic (fastmoving water) and anti-rheophilic (slow moving water) fish species. This can be achieved through having several different flow velocity areas across the fishway;
- It is recommended that a rough stone surface be cast into the fishway channel floor to cater for climbing and crawling species;
- Rocks used for the fishway should have flat sides with rounded edges (typical of quarried rock) rather than rounded rocks, as they provide a variety of water velocity and depths that easy for fish to navigate;
- Pools or depressions of varying sizes and depths should be created at random throughout the length and width of the fishway and should be placed behind large rocks to create lower velocity resting areas (eddies) for fish. The more pools incorporated in the design, the more successful the fishway will be; and
- Additional guidelines for fishway design include:
    - **Channel slope (gradients)** – between 1/8 and 1/10 is recommended for South African fish;
    - **Fishway entrance** – furthest point upstream that the fish can penetrate, usually in a suitable pool (low turbulence with sufficient depth) located at the base of the low level weir;
    - **Fishway exit –** located in a quiet area, sheltered, low velocity to prevent fish from being swept downstream and to afford protection from predators;

      - the invert level of the exit (i.e. water inflow) should be lower than that of the weir overflow to ensure the low flows are directed down the fishway;
    - **Depth of pool** - small fish (20 to 200 mm in length: at least 300 mm to reduce predation and limit turbulence;

      - Larger fish (>200 mm): at least 500 mm can be deeper to reduce turbulence, if necessary;
    - **Length of pool** – at least 2.5 times the length of the largest fish catered for;
    - **Drop height between pools/rock levels –** maximum of 100 mm to cater for small fish.

7.5 Cumulative Impact Assessment

Limited cumulative level impacts are anticipated in the Matlabas, Sandspruit and Bierspruit watercourses. The spatial framework for the cumulative impact assessment included the A24J-438 SQR of the Crocodile River system. The construction of the Vlieëpoort abstraction works will result in approximately 9 km of instream aquatic habitat to be flooded. Based on the inundation delineation provided by the EAP, limited upper zone riparian impacts can be anticipated. Considering this, the proposed project will therefore directly affect approximately 9 km of the A24J-438 SQR which represents approximately 20% of the SQR.

Downstream of the proposed abstraction point, limited large (>5m) impoundments could be observed. Thus, the cumulative impact of flooding instream habitats will be limited to approximately 20% of the instream habitat. It is however noted that the impacts posed by the inundation zone are reversible.

Overall, there will be a reduced PES of the aquatic ecosystems directly associated with the proposed project. The magnitude of the impact is considered moderate, as habitats will be altered but not completely lost. The scale of the anticipated impact will be limited to the immediate river reaches and is therefore considered a local impact. The impact is reversible should the weir structure be removed and rehabilitated. However, the impact will occur through the life of the project which is considered a long-term impact. Overall the cumulative impact of the proposed project was derived to be moderate.

It is noted that should mitigation actions be implemented, and the calculated EWR allocated, limited changes to riverine PES will be anticipated downstream of the proposed project after the completion of the construction phase.

7.6 Monitoring Programme

Considering the potential negative impacts to aquatic ecology arising from the proposed project, an aquatic monitoring programme has been recommended. Details pertaining to this monitoring programme are provided Table 32.

Table 32: Aquatic Biomonitoring Programme

Component	Details
Survey Period	Bi-annual monitoring during the construction period and into the operational phase. During scouring of the central pipeline into the Matlabas River (Every 5 years).
Survey Location	Sites assessed during the baseline assessment should be monitored, including the Crocodile River, Bierspruit, Sandspruit, and Matlabas River.
Survey Method	The techniques applied in the baseline study should be utilised.

8 Conclusions

The results from the aquatic baseline study indicates that the Crocodile River reach assessed in in a moderately modified state (class C), and the Matlabas River reach assessed in in a moderately modified state (class C). Due to the ephemeral nature of the Sandspruit and the Bierspruit, an ecological class for the reaches could not be determined. According to desktop data, the Crocodile River reach associated with the proposed development ranges from a largely modified state to a largely natural state. The Matlabas reach assessed ranged from largely modified to moderately modified, aligning with the results from the baseline survey.

Pipeline Alternatives D1 and D4 for the northern section of the water transfer infrastructure were identified as preferential routes, with pans occurring in excess of 500 m of the proposed route. Therefore, no impacts to identified pans are anticipated.

The construction of the Vlieëpoort Weir poses several moderate risks to the Crocodile River, with mitigation measures not being able to lower the risk status. This is due to the nature of the activity and proximity to sensitive areas. The physical construction of the weir poses the highest risk to the system, with additional moderate risks associated with river diversion, and clearing of the riparian areas for infrastructure. The flooding of the weir poses the highest initial risk to the Crocodile River, as this will inundate instream habitat, and modify downstream flows. Based on data provided to the specialist, an estimated 7,3 km of the Crocodile will be inundated, and an additional 1,5 km of the Bierspruit. This will result in permanent impacts to upstream areas of the weir. The construction of the Sandspruit and Bierspruit gauging weirs will pose a lower risk to the systems, as these systems are ephemeral, and should be constructed during the dry season.

The abstraction of water from the Crocodile River is rated as moderate. The moderate rating remains high due to the duration of the activity, however, due to the increase in expected runoff from upstream reaches, the flow modifications within the reach are expected to be improved and base flows within the lower reaches of the Crocodile be maintained. The discharge of sediment into the Crocodile poses a moderate risk. This is due to the potential of altered sediment balance, modifications to downstream instream habitat, bank and channel erosion.

The construction of the central pipeline across the Matlabas system poses a moderate risk to the riparian and instream habitats. Furthermore, during the scouring of the pipeline into the system, risks were rated as moderate due to the potential modifications to water quality and instream habitat.

Overall, there will be a reduced PES of the aquatic ecosystems directly associated with the proposed project. The magnitude of the impact is considered moderate, as habitats will be altered but not completely lost. The scale of the anticipated impact will be limited to the immediate river reaches and is therefore considered a local impact. The impact is reversible should the weir structure be removed and rehabilitated. However, the impact will occur through the life of the project which is considered a long-term impact. Overall the cumulative impact of the proposed project was derived to be moderate.

A buffer zone of 30 m from the edge of the delineated riparian zone is recommended. Considering that the proposed project is for an instream barrier and a water pipeline crossing the buffer derived is only applicable for associated construction activities such as mixing areas, stockpiles and laydown yards. Based on the proposed developments level of disturbance, a riverine buffer zone of 32 m from the delineated riparian zones, and NFEPA wetlands identified (Pans and floodplains) are recommended.

The ecological status of the Matlabas River needs to be determined during the high-flow period, prior to construction. The high flow survey needs to address potential impacts of the valve scouring on water quality, erosion and sedimentation of the Matlabas. Furthermore, a study of the potential introduction of nuisance and invasive species into the Matlasbas should be conducted. This should include a diatom assessment of the Crocodile and Matlabas Rivers to determine risk during valve scouring and leaks. This will determine the requirements for crossing the watercourse (i.e. open trench), as well as for scouring (i.e. draining water from the pipeline, typically during maintenance). A high flow baseline assessment of the Bierspruit and Sandspruit is recommended as no surface water was available during the low flow survey.

Provision for a fishway at the Vlieëpoort abstraction weir should be included based on the considerations mentioned under maintenance of connectivity.

It is recommended that a sediment study be conducted by a fluvial-geomorphologist to determine the baseline sediment balance of the Crocodile River, and the potential risks and benefits of sediment abstraction and return during the operational phase of the MCWAP project.

A single borrow pit (BP BSS1) was identified which has the potential to modify the instream channel, banks and flows within the Crocodile River. The results of the risk assessment determined low risks for activities occurring outside of the delineated watercourse areas. However, activities occurring within the instream and riparian zones were derived to be moderate risk activities despite mitigation. The reason for this classification even after mitigation was due to the location of the activities within the direct associated instream and riparian habitats.

A rehabilitation plan for the borrow pit BP BSS1 should be established and implemented post-operation, with emphasis on establishing natural vegetation within the riparian zones and ensuring bank stabilisation within the reach to mitigate against further erosion.

It is the opinion of the specialist that according to the bassline conditions of the Crocodile and Matlabas Rivers, and the proposed activities for the MCWAP-2A project, no fatal flaws have been identified for the project.

9 References

Barbour, M.T., Gerritsen, J. & White, J.S. 1996. Development of a stream condition index (SCI) for Florida. Prepared for Florida Department of Environmental Protection: Tallahassee, Florida.

Dallas, H.F. 1997. A preliminary evaluation of aspects of SASS (South African Scoring System) or the rapid bioassessment of water in rivers with particular reference to the incorporation of SASS in a national biomonitoring programme. South African Journal of Aquatic Science, 23: 79-94.

Dallas, H.F. 2007. River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Institute of Natural Resources.

Darwall, W.R.T., Smith, K.G., Tweddle, D. and Skelton, P. (eds) 2009. The Status and Distribution of Freshwater Biodiversity in Southern Africa. Gland, Switzerland: IUCN and Grahamstown, South Africa: SAIAB. viii+120pp.

Department of Water Affairs and Forestry (DWS). 1996. South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.

Department of Water Affairs and Forestry (DWS). 2005b. River Ecoclassification: Manual for Ecostatus Determination. First Draft for Training Purposes. Department of Water Affairs and Forestry.

Department of Water Affairs (DWS) 2011. Strategy Steering Committee Of The Crocodile West Water Supply System: Maintenance And Implementation Of The Reconciliation Strategy. Progress Report.

DWS (Department of Water and Sanitation) 2018. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Draft. Compiled by RQS-RDM.

Dickens, C. W. S. and Graham, P.M. 2002. The South African Scoring System (SASS) Version 5: Rapid bioassessment method for rivers. African Journal of Aquatic Science. 27 (1): 1 -10.

Doudoroff, P. & Shumway, D. L., 1970. Dissolved Oxygen Requirements of Freshwater Fish. In: Food and Agricultural Organisation of the United Nations. Rome: FAO Fisheries Technical Paper No.86.

Driver, A., J.L. Nel, K. Snaddon, K. Murray, D.J. Roux, L. Hill, E.R. Swartz, J. Manual, and N. Funke. 2011. Implementation manual for freshwater ecosystem priority areas. WRC Report No. 1801/1/11. Pretoria: Water Research Commission.

Gerber, A. & Gabriel, M.J.M. 2002. Aquatic Invertebrates of South African Rivers Field Guide. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 150pp

Hellawell, J.M. 1977. Biological Surveillance and Water Quality Monitoring. In: JS Alabaster (Ed). Biological monitoring of inland fisheries. Applied Science, London. Pp 69-88.

Kleynhans, C.J., M.D. Louw, and J. Moolman. 2007. Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans CJ, Louw MD. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans CJ, Thirion C and Moolman J. 2005. A Level 1 Ecoregion Classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria.

Land Type Survey Staff. (1972 - 2006). Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases. Pretoria: ARC-Institute for Soil, Climate, and Water.

Limpopo Provincial Government. Department of Economic Development, Environment, and Tourism (LEDET). 2016. Limpopo Environmental Outlook Report.

McMillan, P.H. 1998. An Invertebrate Habitat Assessment System (IHASv2), for the Rapid Biological Assessment of Rivers and Streams. A CSIR research project, number ENV – P-I 98132 for the Water Resource Management Program, CSIR. Ii + 44p.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L and Nienaber S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross S.K., Hughes, R.M., 1989. Rapid Bio-assessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. U.S. Environmental Protection Agency.

International Union for Conservation of Nature and Natural Resources (IUCN). 2015.3. Red list of threatened species. www.iucnredlist.org. Accessed 16th June 2018

South African National Biodiversty Institute (SANBI). 2014c. Species Status Database. http://www.speciesstatus.sanbi.org/default.aspx

Skelton, P.H. 2001. A complete guide to the freshwater fishes of southern Africa. Struik Publishers, South Africa.

Statistics South Africa (StatsSA). 2010. Water Management Areas in South Africa. http://www.statssa.gov.za/publications/d04058/d04058.pdf. Accessed 20th February 2015.

Tate RB, Husted A. 2015. Aquatic macroinvertebrate responses to pollution of the Boesmanspruit river system above Carolina, South Africa. *African Journal of Aquatic Science*. 1-11.

Thirion, C.A., Mocke, A. & Woest, R. 1995. Biological monitoring of streams and rivers using SASS4. A User's Manual. Internal Report No. N 000/00REQ/1195. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 46