Elandsfontein Aquatic Biomonitoring Assessment

Low Flow 2019

Clewer, Mpumalanga

September 2019

Client

Prepared for:

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Submitted to	
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Photograph of the impoundment within the project area, taken September 2019 at site E2

Executive Summary

The Biodiversity Company was commissioned to conduct an aquatic biomonitoring programme for the Elandsfontein Colliery, Anker Coal (Pty) Ltd.

A single low flow aquatic assessment was conducted of the tributary of the Saalboomspruit system and the Elandsfontein tributary west of the town of Clewer on the 18th of September 2019. This study represents an update to aquatic assessments conducted by Digby Wells Environmental in 2014 (Digby, 2017) for the proposed Elandsfontein coal mining developments. The Digby (2017) document was used as a baseline. No additional data was available for trend analysis.

The watercourses associated with Elandsfontein Colliery are predominantly located in the B20G quaternary catchment and to a lesser extent the B11K quaternary catchment, within the Olifants Water Management Area (WMA) (NWA, 2016) and the Highveld - Lower ecoregion. The relevant Sub-Quaternary Reach (SQR) is the B20G-1099, which is a reach of the Saalboomspruit, which flows north and eventuates in the Wilge River. The reach assessed represents a tributary the headwaters of the Saalboomspruit. The area is marked by extensive agricultural and mining activities.

An aquatic assessment was conducted to establish baseline conditions associated with the Elandsfontein Colliery. The low flow survey established critically modified conditions of the aquatic systems within the Elandsfontein project area, and further, the largely modified conditions of the tributary of the Saalboomspruit. The study further indicated that a deterioration of water quality was occurring between the upstream T1 site, and the T2, and T3 sites, as indicated by a decrease in pH, resulting acidic conditions, and elevated dissolved solids. The results further indicated contaminated water stemming from the Elandsfontein tributary, as indicated by results from the upstream E Dam, E1 and E2, and E3 sites, which contributed to the deteriorated water quality conditions of the tributary of the Saalboomspruit, and likely downstream catchments. Further, extensive stands of alien invasive species occur within the Elandsfontein project area, reducing riparian habitat integrity. A high flow survey is to be conducted as part of the biomonitoring programme. A comprehensive report with spatial and temporal trends will be included.

Table of Contents

Tables

Figures

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 work relevant to this application, including knowledge of the Act (NEMA), 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

Aquatic Specialist

The Biodiversity Company

25 September 2019

1 Introduction

The Biodiversity Company was commissioned to conduct an aquatic biomonitoring programme for the Elandsfontein Colliery, Anker Coal (Pty) Ltd.

This study represents an update to aquatic assessments conducted by Digby Wells Environmental in 2014 (Digby, 2017) for the proposed Elandsfontein coal mining developments. The Digby (2017) document was used as a baseline. No additional data was available for trend analysis.

This report provides the preliminary findings of the low flow study. A high flow survey is proposed to be conducted as part of this study.

2 Project Area and Background

The watercourses associated with Elandsfontein Colliery are predominantly located in the B20G quaternary catchment and to a lesser extent the B11K quaternary catchment, within the Olifants Water Management Area (WMA) (NWA, 2016) and the Highveld - Lower ecoregion (Dallas, 2007). The relevant Sub-Quaternary Reach (SQR) is the B20G-1099, which is a reach of the Saalboomspruit, which flows north and eventuates in the Wilge River (Figure 2-1). The reach assessed represents a tributary the headwaters of the Saalboomspruit. The area is marked by extensive agricultural and mining activities. A total of eight sites were selected for the study (Figure 2-2), including two water quality sites at E Seep and E Dam. Site photographs and GPS coordinates for the sampling points are presented in Table 2-1.

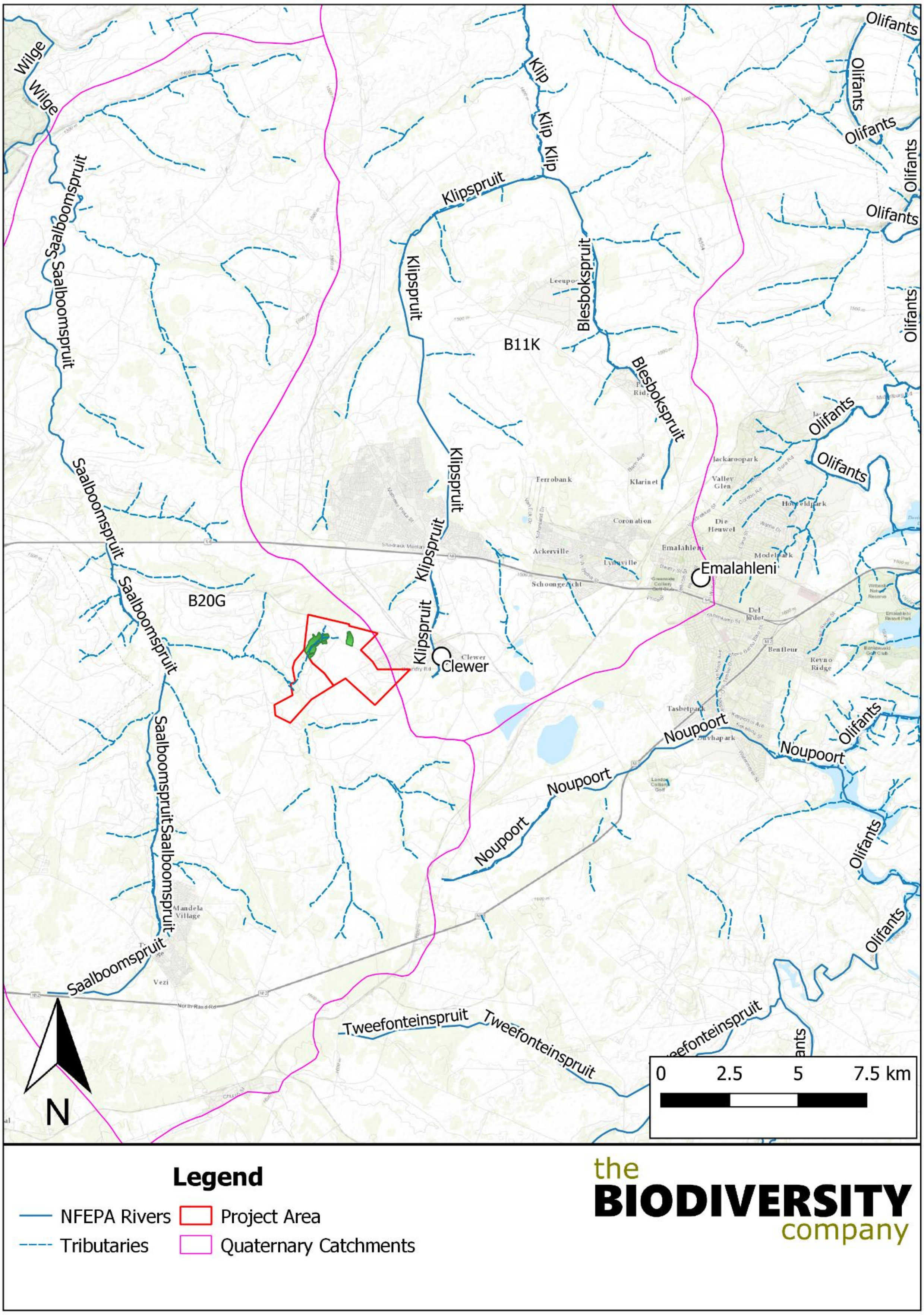

Figure 2-1: Elandsfontein Colliery project locality map (green presenting wetland areas)

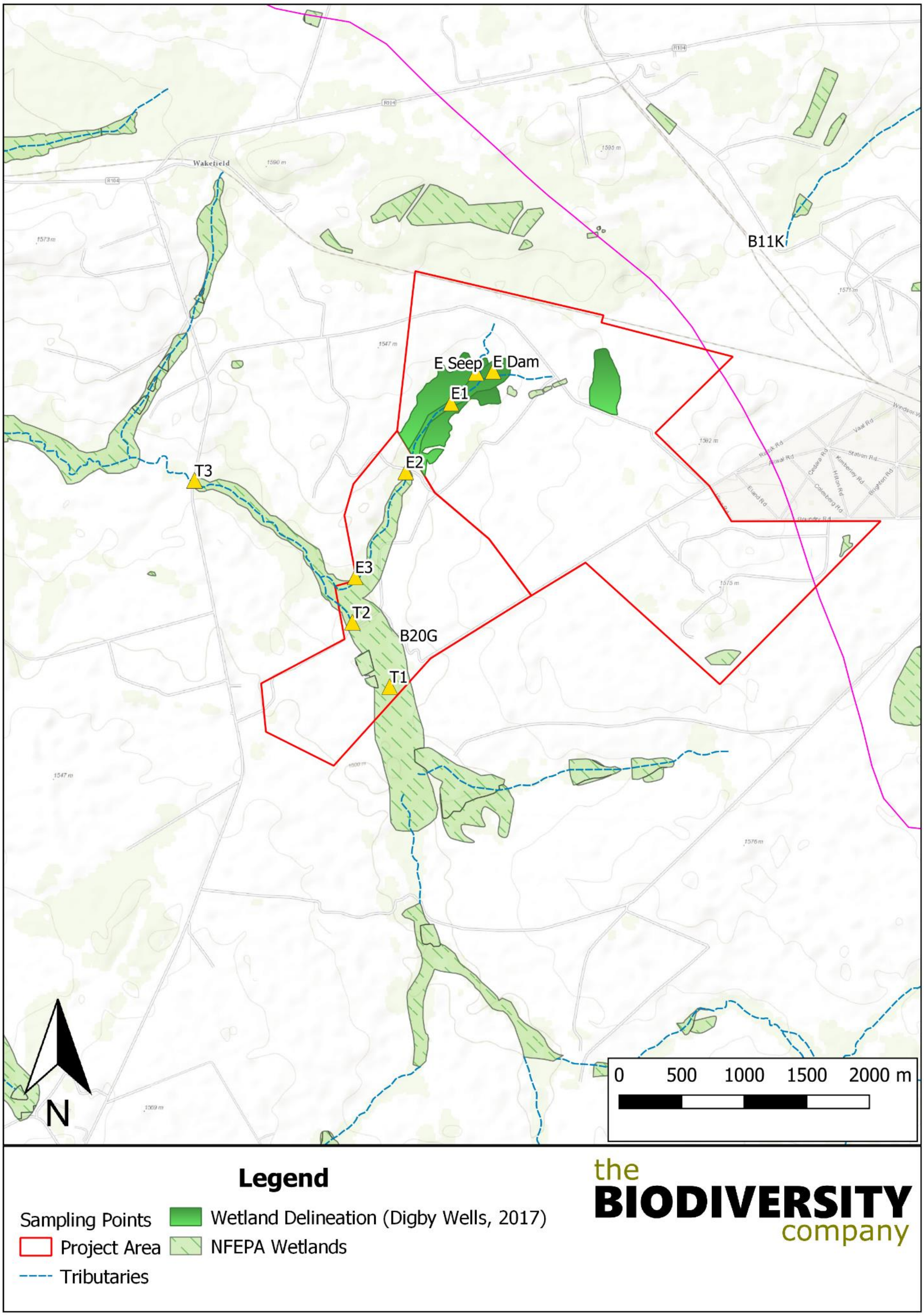

Figure 2-2: Aquatic sampling points for the Elandsfontein Colliery

Table 2-1: Photos and co-ordinates for the sites sampled (photos taken September 2019)

Site	Upstream	Downstream
T1		
GPS	25°55'24.64"S 29° 4'51.59"E	
T2		
GPS	25°55'7.92"S 29° 4'40.85"E	
T3		
GPS	25°54'31.10"S 29° 3'55.50"E	
E1		
GPS	25°54'10.97"S 29° 5'9.14"E	

Site	Upstream	Downstream
E2		
GPS	25°54'28.87"S 29° 4'56.15"E	
E3		
GPS	25°54'56.17"S 29° 4'41.66"E	
E Seep		
GPS	25°54'3.11"S 29° 5'16.34"E	
E Dam		
GPS	25°54'2.70"S 29° 5'21.21"E	

3 Methodology

A summary of assessments conducted during the survey are presented in Table 3-1. Full methodologies applied during the study are presented in Appendix B.

Table 3-1: Methodologies applied during the 2019 study

Aspect	Analyses
Water Quality	*In situ* (DWAF, 1996)
Habitat	Intermediate Habitat Integrity Assessment (Kleynhans, 1998) Integrated Habitat Assessment System (McMillan, 1998) Biotope assessment (Tate and Husted, 2015)
Biotic indices	SASS5 (Dickens and Graham, 2002); The Average Score Per Taxon (ASPT); Macroinvertebrate Response Assessment Index (MIRAI); (Thirion,2007)

3.1 Reference Conditions

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the Highveld - Lower Ecoregions were obtained from Dallas (2007). The biological bands for the Highveld - Lower Ecoregion are presented in Figure 3-1. Ecological categories based on biological banding are presented in Table 3-2.

Table 3-2: Biological Bands / Ecological categories for interpreting SASS data (adapted from Dallas, 2007)

Class	Ecological Category	Description
A	Natural	Unimpaired. High diversity of taxa with numerous sensitive taxa.
B	Largely natural	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
C	Moderately modified	Moderately impaired. Moderate diversity of taxa.
D	Largely modified	Considerably impaired. Mostly tolerant taxa present.
E/F	Seriously Modified	Severely impaired. Only tolerant taxa present.

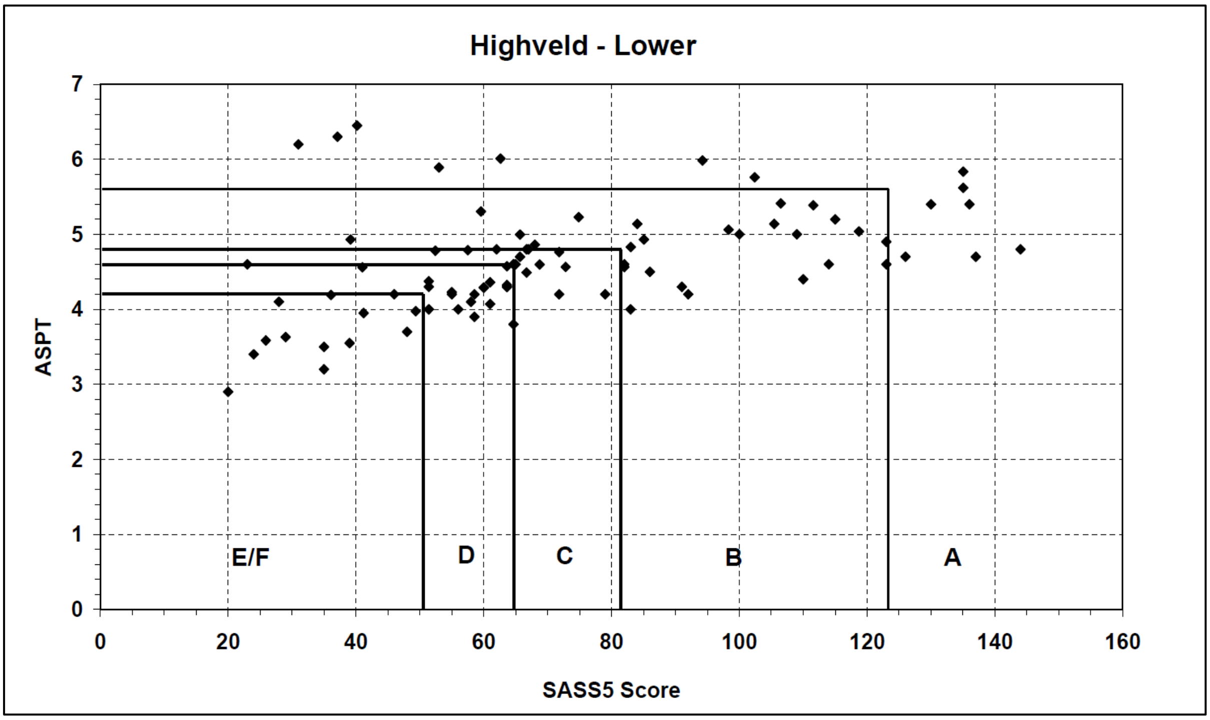

Figure 3-1: Biological Bands for the Highveld – Lower Ecoregion, calculated using percentiles (Dallas, 2007)

3.2 Resource Quality Objectives

Results from the riverine assessment are compared to the Resource Quality Objectives (RQO) for the Olifants WMA, Integrated Unit of Analysis II, biophysical node HN28 (Saalboomspruit Quaternary Catchment B20G) (DWS, 2016).

4 Results and Discussion

4.1 Desktop Assessment

4.1.1 National Freshwater Ecosystem Priority Area Status

The National Freshwater Ecosystem Priority Areas (NFEPA) database forms part of a comprehensive approach for 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 NWA. This directly applies to the NWA, 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 (Act No.10 of 2004) (NEM:BA), informing both the listing of threatened freshwater ecosystems and the process of bioregional planning provided for by this Act (Nel *et al*., 2011). According to Nel *et al.* (2011), no river FEPAs are listed for the B20G-1099 SQR (Figure 4-1). However, as presented in Table 4-1, numerous NFEPA wetlands are present within the reach.

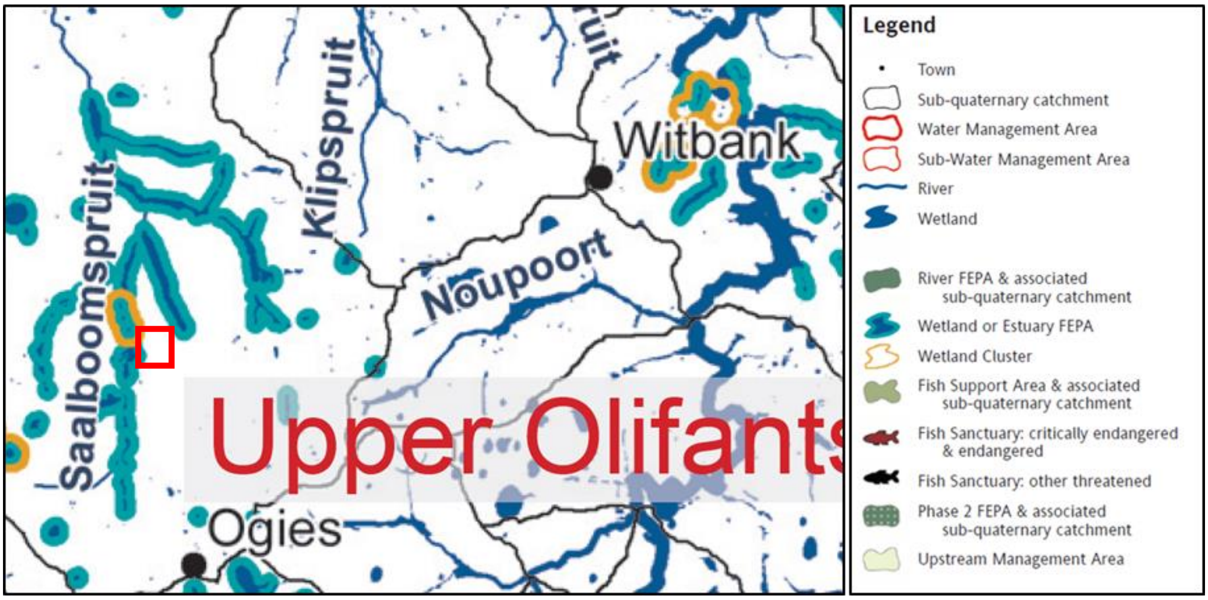

Figure 4-1: Illustration of absence of NFEPAs within the project area (indicated by a red square)

Table 4-1: NFEPAs listed for the B20G-1099 SQR

Type of FEPA map category	Biodiversity features
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Channelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Depression
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Flat
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Seep
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Unchannelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Valleyhead seep

4.1.2 Desktop Present Ecological State

Desktop information was obtained from DWS (2019) for the Saalboomspruit SQR and is summarised in Table 4-2. The desktop PES of the reach of the Saalboomspruit associated with the Elandsfontein Colliery area is a class C or moderately modified. The confidence in this classification is low due to the long distance of the considered SQR (42 km). The ecological importance and sensitivity of the river reach was rated as high. The defined Default Ecological Category for the river was class B or largely natural, and according to the RQOs for the reach, the Ecological Category to be maintained is a class C. The gradient of the considered river reach in proximity to the project area was found to be a class E geoclass. This places the river as a lowland river reach.

Table 4-2: The desktop information pertaining to the B20G-1099 Sub Quaternary Reach

Component/Catchment	Saalboomspruit
Present Ecological Status	Moderately Modified (class C)
Ecological Importance Class	High
Ecological Sensitivity	High
Default Ecological Category (DWS, 2019)	Largely Natural (class B)
Resource Quality Objectives (DWS, 2016)	Moderately Modified (class C)

4.2 *In situ* Water Quality

In situ water quality analyses was conducted at all sites with adequate surface water during the September 2019 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 4-3. Results were compared to Target Water Quality Range (TWQR) for aquatic ecosystems (DWS, 1996).

Table 4-3: In situ water quality results (September 2019)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR*	**6.5-9.0**	**-**	**>5.00**	**5-30**
Tributary of Saalboomspruit				
T1	7.06	308	5.46	20.0
T2	**3.53**	941	**3.93**	22.1
T3	**4.71**	**2280**	**3.34**	15.5
Elandsfontein tributary				
E1	7.35	**3030**	6.05	23.2
E2	7.36	**3280**	7.54	21.2
E3	7.78	**2290**	6.6	21.1
E Seep	6.59	**2580**	**1.62**	24.0
E Dam	7.08	**3180**	5.80	21.0

Levels exceeding recommended guideline levels are indicated in red
***TWQR – Target Water Quality Range**

Findings from the *in situ* water quality results indicate a marked decrease in pH levels between site T1 and T2, and persists to downstream reaches at site T3 (Table 4-3). The change in pH and acidic levels would present adverse conditions to local aquatic biota and limit the diversity and abundances of sensitive biota. The pH levels stemming from the Elandsfontein tributary fell within the TWQR. Slight acidity was observed from E Seep; however, the pH normalises at site E1.

The *in situ* water quality results further indicated marked changes in dissolved solid concentrations between sites T1, T2, and T3. The marked increases indicate that an influx of pollutants enter the system between T1 and T2, and a large influx of dissolved solids arising from the Elandsfontein project area as indicated by elevated levels at site E3. Elevated dissolved solid levels were observed throughout the Elandsfontein project area (Table 4-3). The marked change in dissolved solids observed between sites T1, T2, and T3 would negatively affect local aquatic biota, and be considered limiting factors to local aquatic biota.

Low Dissolved Oxygen (DO) levels were observed at sites T2, T3, and E Seep. Sites T2 and T3 were characterised as wetlands, and some degree of supressed DO would be expected. However, site T1 presented similar conditions, and therefore, an increase in chemical oxygen demand contributes to low DO levels. Chronically low DO levels would present adverse conditions, and limit aquatic biota diversity and abundances. The water temperature levels observed throughout the project area fell within recommended levels for the ecoregion, and no marked fluctuations were observed. The *in situ* water quality results indicate deteriorated water conditions in the aquatic systems assessed during the survey, and further, the poor water quality conditions would negatively impacts on local aquatic biota.

Comparative water quality results for the 2014 and 2019 surveys are presented in Table 4-4. Historical trends indicate a a deterioration of water quality from the 2014 to 2019 survey, as indicated by a decrease in pH levels at sites T2 and T3, which is attributed to an increase in acid mine drainage in the area. Further, an increase in dissolved solid levels within the reach was observed at all sites assessed during the study. Chronically elevated dissolved solid levels were observed from the Elandsfontein tributary, as observed by the E1 and E3 results. A decrease in dissolved oxygen levels was observed from the 2014 study at sites T2 and T3. The results indicate a deterioration in water quality from the 2014 study, particularly below site T1, indicating an influx of pollutants between sites T1 and T3.

Table 4-4: Temporal In situ water quality results (TBC 2019 and Digby 2014)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
TWQR* RQOs**	**6.5-9.0**	**550****	**>5.00**	**5-30**
		T1		
2019	7.06	308	5.46	20.0
2017 (E01)	7.0	165	7.03	22.1
		T2		
2019	**3.53**	941	**3.93**	22.1
2017 (E02)	6.6	500	6.95	20.2
		T3		
2019	**4.71**	**2280**	**3.34**	15.5
2017 (E04)	6.7	**2150**	7.48	27.1
		E1		

2019	7.35	**3030**	6.05	23.2
2017 (E05)	6.5	**3020**	6.51	27.1
		E3		
2019	7.36	**3280**	7.54	21.2
2017 (E03)	8.2	**2620**	9.6	22.5

4.3 Riverine Habitat

4.3.1 Intermediate Habitat Integrity Assessment

The results for the instream and riparian habitat integrity assessment for the tributary of the Saalboomspruit and the Elandsfontein tributary are presented in Table 4-5. The reach includes 10 km of the aquatic systems assessed during the study and integrated into the IHIA assessment.

Table 4-5: Results for the habitat integrity assessment

Instream Habitat	**Tributary of the Saalboomspruit**	**Elandsfontein Tributary**	**Total Score**
Water abstraction	14	8	6,16
Flow modification	16	18	8,84
Bed modification	13	20	8,58
Channel modification	10	20	7,8
Water quality	18	18	10,08
Inundation	12	13	5
Exotic macrophytes	8	8	2,88
Exotic fauna	5	0	0,8
Solid waste disposal	6	3	1,08
Total Instream		**48,8**	
Category		**D**	
Riparian Habitat	**Tributary of the Saalboomspruit**	**Elandsfontein Tributary**	**Total Score**
Indigenous vegetation removal	15	14	7,54
Exotic vegetation encroachment	16	17	7,92
Bank erosion	11	11	6,16
Channel modification	8	13	5,04
Water abstraction	9	7	4,16
Inundation	9	9	3,96
Flow modification	12	10	5,28
Water quality	12	9	5,46
Total Riparian		**54.5**	
Category		**D**	
***Red highlighted blocks indicate predominant modifying drivers in the reaches assessed**			

The results of the instream integrity assessment derived a class D (largely modified) status for the reach, indicating a large loss of natural habitat, biota and basic ecosystem functions has occurred. The predominant factor negatively influencing the habitats are attributed to flow modification within the reach. Several impoundments and low water crossings occur within he reach (Figure 4-2 and Figure 4-3). These have further resulted in bed and channel modification, resulting in instream sedimentation and a loss of marginal habitat due to channel erosion and inundation. Several alien invasive vegetation species were observed within the reach, including extensive *Populus alba* stands (Figure 4-4 and Figure 4-5). Direct channel modifications within the Elandsfontein reach due to a river diversion has resulted in extensive instream and riparian modifications within the reach Figure 4-4.

Figure 4-2: Instream impoundments and low water crossing within the tributary of Saalboomspruit (Google Earth Imagery, 2019)

Figure 4-3: Low water crossings and indigenous vegetation clearing (Google Earth, 2019)

Figure 4-4: Additional modifications within the Elandsfontein tributary (Google Earth Imagery, 2017)

Figure 4-5: Populas alba stands within the Elandsfontein project area (September 2019)

4.3.2 Macroinvertebrate Habitat and Biotope Assessments

A biotope rating of available habitat was conducted at each site assessed to determine the suitability of habitat to macroinvertebrate communities. The Saalboomspruit system within the project area was classed as lower foothills. Sites E3 and M5 were classified as wetland systems and typical riverine characteristics were not present. Each geoclass has different weightings for the various biotopes according to importance value (Table 4-6). The categories were calculated according to the biotope rating assessment as applied in Tate and Husted (2015). The results of the biotope assessment are presented in Table 4-6. A rating system of 0 to 5 was applied, 0 being not available and 5 being abundant and diverse.

Table 4-6: Biotope weightings for lower foothill geoclass

Biotope	Lower Foothills
Stones in current (SIC)	18.0
Stones out of current (SOOC)	12.0
Bedrock	3.0
Aquatic vegetation	1.0
Marginal vegetation in current	2.0
Marginal vegetation out of current	2.0
Gravel	4.0
Sand	2.0

Mud	1.0

Table 4-7: Biotope scores at each site during the survey (September 2019)

Biotope	T1	T2	T3	E1	E2	E3
Stones in current	1	0.5	0	0	0	0
Stones out of current	0	0	0	0	0	0
Bedrock	0	0	0	0	0	0
Aquatic Vegetation	3	3	2	0	2	1.5
Marginal Vegetation in Current	1	1	2	2	0	1
Marginal Vegetation Out of Current	3.5	2.5	3	2	3	2.5
Gravel	2	2	1	1	0	1
Sand	2	1	2	0	0	1
Mud	3	2.5	2	1	1	2.5
Biotope Score	15,5	12,5	12	6	6	9,5
Weighted Biotope Score (%)	20	14	10	6	4	8
Biotope Category (Tate and Husted, 2015)	F	F	F	F	F	F

Biotope diversity at all sites assessed during the study were assigned a class F, indicating limited habitat diversity within the systems assessed and that habitat diversity was a limiting factor to the macroinvertebrate community. Further, macroinvertebrate diversity with a preference for flow and stones in current was expected to be limited during the study. The low habitat diversity was expected for the system due to the wetland nature of sites, bar site E2 which was an impoundment, and site E3 which is artificial and within the river diversion.

4.4 Macroinvertebrate Assessment

4.4.1 South African Scoring System (version 5)

The aquatic macroinvertebrate results for the study are presented in Table 4-8.

Table 4-8: Macroinvertebrate assessment results (September 2019)

Site	T1	T2	T3	E1	E2	E3
SASS Score	97	42	39	15	55	40
No. of Taxa	20	8	7	2	9	9
ASPT*	4.9	5.2	5.6	7.5	6.1	4.4
Category (Dallas, 2007)**	B	E/F	E/F	E/F	D	D
Category Digby 2014	B	N/A	B	N/A	N/A	B

*ASPT: Average score per taxon
**Highveld-Lower Ecoregion

Based on the Average Score Per Taxon (ASPT) the aquatic macroinvertebrate communities within the tributary of the Saalboomspruit ranged from 4.9 to 5.6 at sites T1 and T3 respectively. A marked decrease in total sensitivity score was observed from site T1 to sites T2 and T3, and a corresponding decrease in number of taxa. The marked decrease in macroinvertebrates community is attributed to water quality deterioration, as habitat diversity within the reach was comparative at all sites.

The macroinvertebrate community within the Elandsfontein tributary were considered modified, as indicated by the low number of taxa collected at site E1, E2 and E3. The habitat within the reach was able to sustain Hemiptera, Odonata, and Coleoptera, however, many of these taxa were absent during the study. Comparative results to the Digby 2014 study indicated a decrease in ecological category at sites T3 and E3, however, the upstream site remained stable at a class B (largely natural). The decrease in ecological categories is attributed to water quality deterioration within the reach.

4.4.2 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. Data from sites T1, T2 and T3 on the tributary of the Saalboomspruit was used to determine the ecological category, and E1, E2 and E3 for the Elandsfontein tributary. 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 tributary of the Saalboomspruit reach assessed are presented in Table 4-9, and for the Elandsfontein tributary in Table 4-10. It should be noted that the reference conditions generated for the ecoregion were adapted for Highveld ecoregion source zone, with the absence of typical instream riverine features.

The MIRAI results indicates a largely modified state (class D) for the tributary of the Saalboomspruit reach assessed. The driver predominantly contributing to the modified state is flow and water quality impairment within the reach. The limited habitat diversity and sedimentation within the reach was likely driving the decrease in the habitat metric.

The MIRAI results indicates a largely modified state (class D) for the Elandsfontein tributary. The driver predominantly contributing to the modified state is water quality impairment within the reach, and further, flow modifications contribute to the modified macroinvertebrate community.

Table 4-9: MIRAI Score for the reach (September 2019)

Invertebrate Metric Group	Tributary of Saalboomspruit
Flow Modifications	38,2
Habitat	61,1
Water Quality	47,7
Ecological Score	48,8
Category	**D**

Table 4-10: MIRAI Score for the reach (September 2019)

Invertebrate Metric Group	Elandsfontein Tributary
Flow Modifications	33,0
Habitat	53,4
Water Quality	23,6
Ecological Score	36,1
Category	**E**

4.5 Fish Assessment

No fish were collected within the reach. It is expected that should additional sampling be conducted that fish would be collected. No species of conservational concern are expected for the reach (Skelton, 2011; IUCN, 2019)

4.6 Present Ecological State

The PES of the tributary of the Saalboomspruit reach assessed for the study is presented in Table 4-11. The findings of the study were based on a single low flow survey.

The results indicate that the reach considered in the study was in a largely modified state during the 2019 study (Table 4-11). This was attributed to modifications to drivers within the system, predominantly flow modification and water quality deterioration, and modifications to the riparian zones due to livestock, mining and agricultural activities. Instream habitat modifications were observed during the study, predominantly due to erosion in the reach, resulting in instream sedimentation, and the presence of instream impoundments which reduced instream and marginal habitat diversity. Furthermore, alien invasive vegetation encroachment has decreased the ecological integrity of the tributary of the Saalboomspruit and the Elandsfontein tributary. The modifications to drivers within the reach was reflected in the modified local aquatic biota observed during the study.

Table 4-11: The PES of the Saalboomspruit reach (September 2019)

Category	Score	Ecological Category
Instream Assessment	48,8	**D**
Riparian Assessment	54.4	**D**
Macroinvertebrate Response Assessment Index	48.8	**D**
EcoStatus	**D**	
Recommended Ecological Category (RQOs)	Moderately Modified (class C)	

5 Conclusion

An aquatic assessment was conducted to establish current ecological status associated with the Elandsfontein Colliery. The low flow survey established critically modified conditions of the aquatic systems within the Elandsfontein project area, and further, the largely modified conditions of the tributary of the Saalboomspruit. The study further indicated that a deterioration of water quality was occurring between the upstream T1 site, and the T2, and T3 sites, as indicated by a decrease in pH, resulting acidic conditions, and elevated dissolved solids. The results further indicated contaminated water stemming from the Elandsfontein tributary, as indicated by results from the upstream E Dam, E1 and E2, and E3 sites, which contributed to the deteriorated water quality conditions of the tributary of the Saalboomspruit, and likely downstream catchments. Further, extensive stands of alien invasive species occur within the Elandsfontein project area, reducing riparian habitat integrity.

A high flow survey is to be conducted as part of the biomonitoring programme. A comprehensive report with spatial and temporal trends will be included. Recommendations will be provided in the final biomonitoring once trends and the Present Ecological State has been established and ecological indicators identified.

6 References

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7 Appendix A

7.1 *In Situ* Water Quality

During the survey a portable Exstick 2 multimeter was used to measure the following parameters *in situ*:

- pH;
- Conductivity;
- Dissolved Oxygen (DO); and
- Water Temperature.

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

7.2 Habitat Assessment

Habitat availability and diversity are major attributes for the biota found in a specific ecosystem, and thus knowledge of the quality of habitats is important in an overall assessment of ecosystem health. Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al*. 1996). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities (USEPA, 1998). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason, habitat evaluation is conducted simultaneously with biological evaluations to facilitate the interpretation of results.

7.2.1 Intermediate Habitat Integrity Assessment

The aim of the Intermediate Habitat Integrity Assessment (IHIA) is to make an intermediate assessment of the habitat integrity of rivers according to a modified Habitat Integrity approach which can be applied in intermediate determination of the ecological Reserve for rivers in South Africa (DWS, 1999). The methodology is based on the qualitative assessment of a number of pre-weighted criteria which indicate the integrity of the in-stream and riparian habitats available for use by riverine biota.

The criteria considered indicative of the habitat integrity of the river were selected on the basis that anthropogenic modification of their characteristics can generally be regarded as the primary causes of degradation of the integrity of the river (Table 7-1) (DWS, 1999). The study assessed 5 km of the Saalboomspruit and its tributary.

Table 7-1: Criteria used in the assessment of habitat integrity (from Kleynhans, 1996).

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an

	increase in duration of high 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 (Gordon *et al*., 1993 in: DWS, 1999). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993 in: DWS, 1999) 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 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 (Gordon *et al*., 1992 in DWS, 1999)).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

The assessment of the severity of impact of modifications is based on six descriptive categories which are described in Table 7-2.

Table 7-2: Descriptive classes for the assessment of modifications to habitat integrity (from Kleynhans, 1996).

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

Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	**21 - 25**

The habitat integrity assessment takes into account the riparian zone and the instream channel of the river. Assessments are made separately for both aspects, but data for the riparian zone are primarily interpreted in terms of the potential impact on the instream component (Table 7-3). The relative weighting of criteria remain the same as for the assessment of habitat integrity (DWS, 1999).

Table 7-3: Criteria and weights used for the assessment of habitat integrity and habitat integrity (from Kleynhans, 1996).

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

The negative weights are added for the instream and riparian facets respectively and the total additional negative weight subtracted from the provisionally determined intermediate integrity to arrive at a final intermediate habitat integrity estimate. The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific intermediate habitat integrity category (DWS, 1999). These categories are indicated in Table 7-4.

Table 7-4: Intermediate habitat integrity categories (From Kleynhans, 1996)

Category	**Description**	**Score (% of Total)**
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39

F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

7.3 Aquatic Macroinvertebrates

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream 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.

7.3.1 South African Scoring System version 5

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).

7.3.2 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.

7.4 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 ecoclassification manual by Kleynhans and Louw (2007).

8 Accreditation of the Specialist

Water and Sanitation
Environment Affairs

Water Research Commission

CERTIFICATE OF ACCREDITATION

This is to certify that

Christian Fry

has met the requirements of the
River Health Programme as a SASS5 Practitioner

COMPETENCY IN THE FOLLOWING AREAS HAVE BEEN DEMONSTRATED:

UNDERSTANDING OF THE SCOPE AND APPLICATION OF THE SASS5 METHOD.
DEMONSTRATION OF THE CORRECT SAMPLING PROTOCOLS
DEMONSTRATION OF THE CORRECT SAMPLE PREPARATION PROTOCOLS
IDENTIFICATION OF AQUATIC MACROINVERTEBRATES

COMPETENCY IS VALID FOR 3 YEARS FROM CERTIFICATE DATE

NATIONAL SASS5 AUDITOR

26 December 2017
DATE