

**AQUATIC ECOLOGICAL ASSESSMENT AS PART OF THE
ENVIRONMENTAL ASSESSMENT AND AUTHORIZATION
PROCESS FOR THE PROPOSED CONSTRUCTION OF A
FERROCHROME SMELTER, LIMPOPO PROVINCE**

Prepared for

SLR Consulting (Africa) (Pty) Ltd.

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MANAGEMENT SUMMARY

A biomonitoring field assessment was conducted on the 24th of November 2015. During this site visit an aquatic ecological assessment was conducted in order to define the Present Ecological State (PES) and Ecstatus of the aquatic ecosystem. This report includes an assessment of biota specific water quality, a survey of the habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate integrity and riparian vegetation conditions of the associated water resources. This report will also highlight measures deemed necessary to minimise impacts on the receiving environment. The protocols of applying the indices were strictly adhered to and all work was carried out by an accredited assessor. Key results are presented below:

Only one out of the six sites (SC4) was subjected to further detailed aquatic assessment since this site was the only monitoring point to contain surface water at the time of the assessment and even at this point the conditions in the system were highly marginal and not ideal for applying the assessment indices. Temporal analysis could therefore only be applied to site SC4 and no spatial comparison of data could take place.

Site SC4 is located on the Phufane stream and will be crossed by the proposed powerline.		
Water Quality		
pH	7.45	
Conductivity (mS/m)	16.0	
Temperature (° C)	20.7	
DO (mg/L)	6.19	
Aquatic Macro-invertebrate community assessment		
Dickens & Graham (2001)	Class F	
Dallas (2007)	Class E/F	
SASS5 Score	23	
ASPT Score	3.8	
MIRAI score	37.9 (Class E)	
Habitat Integrity Assessment		
IHAS Score	33 (Inadequate)	
IHIA Score	57.6 (Class D)	
VEGRAI Score	45.7 (Class D)	
Current impacts and comments		
Reduced instream flow due to impoundments and water abstraction within the system along with a nationwide drought experienced at the time of the assessment.		

Invertebrate Habitat Integrity Assessment:

The Invertebrate Habitat Integrity Assessment (IHIA) was applied to each of the aquatic systems (Phufane, upstream and downstream Brakspruit). Moderate, large and serious impacts were recorded for each system.

The Phufane, upstream and downstream Brakspruit systems all achieved a Class C (moderately impaired) classification for instream conditions, while all three systems can be classified as Class D (largely modified) conditions for riparian habitat integrity.

Overall, for habitat integrity the upstream Brakspruit scored 58.2% (Class D), the Phufane scored 57.6% (Class D), and the downstream Brakspruit scored 61.3% (Class C). Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic / wetland / riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained.

Riparian Vegetation Response Assessment:

Because the riparian vegetation was very similar along all sites assessed on the various drainage systems, VEGRAI was applied to each system as a whole and not to individual sites. The scores attained for the VEGRAI assessment indicate that the riparian systems along the study area fall within



a PES Class D for the upstream Brakspruit and Phufane systems while the downstream Brakspruit system can be classified as a borderline Class C/D. The Class D attained within the upstream Brakspruit and Phufane systems, and the borderline Class C/D attained within the downstream Brakspruit system indicate that the riparian vegetation has undergone large modifications, with a large loss of natural habitat, biota and basic ecosystem functions. This is due to the significant erosion and modification of water flow within all three systems.

The following recommendations were made upon completion of the aquatic assessment:

- On-going aquatic ecological monitoring must take place on an annual basis in the high flow season by a suitably qualified assessor focusing on aquatic macro-invertebrates, habitat integrity and biota specific water quality;
- Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic / wetland / riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained;
- Due to the ephemeral nature of the water resources in the vicinity of the study area, it is recommended to rather apply the diatom community analysis due to the decreasing aquatic community integrity over time. This will aid in the definition of the lower range classes specified in the RHP methodology;
- Results should be compared spatially and temporally to the results of this document. If it is observed through biomonitoring information that significant negative changes are taking place in ecological integrity (Change of Class), it should be taken as an indication that the system is suffering stress and mitigatory actions should be identified and where possible implemented.



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GLOSSARY OR TERMS

ASPT	Average Score Per Taxon	The average sensitivity of the aquatic community obtained by determining the sum of the sensitivity scores for each aquatic macro-invertebrate family observed and then dividing by the number of families present.
DO	Dissolved Oxygen	Dissolved Oxygen is the amount of oxygen that is present in the water. It is measured in milligrams per litre (mg/L).
% DO sat	Dissolved Oxygen Saturation	In aquatic environments, oxygen saturation is a ratio of the concentration of dissolved oxygen in the water to the maximum amount of oxygen that will dissolve in the water at that temperature and pressure under stable equilibrium.
DWAF	Department of Water Affairs and Forestry	
DWS	Department of Water and Sanitation	
EC	Electrical Conductivity	Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge.
ECat	Ecological Category	
EIS	Ecological Importance and Sensitivity	Ecological importance refers to the diversity, rarity or uniqueness of the habitats and biota. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts.
EMP	Environmental Management Plan	An EMP is a site-specific plan developed to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislation.
EWR	Ecological Water Requirements	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
IHAS	Invertebrate Habitat Assessment System	An assessment index to determine the suitability of the habitat at any assessment point for colonisation by aquatic macro-invertebrates.
IHIA	Intermediate Habitat Integrity Assessment	The habitat integrity assessment is based on two perspectives of the river, the riparian zone and the instream channel. 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.
MIRAI	Macro-invertebrate Response Assessment Index	MIRAI integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions presented as Ecostatus Categories.
NA	Not Applicable	
NEMA	National Environmental Management Act	
NWA	National Water Act	
PES	Present Ecological State	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses viz. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.
Ref	Reference	
RQIS	Resource Quality Information Services	RQIS provides national water resource managers with aquatic resource data, technical information, guidelines and procedures that support the strategic and operational requirements for assessment and protection of water resource quality.



SA RHP	South African River Health Programme	The RHP serves as a source of information regarding the overall ecological status of river ecosystems in South Africa. For this reason, the RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterise the response of the aquatic environment to multiple disturbances.
SASS5	South African Scoring System	An index to determine the integrity of the aquatic macro-invertebrate community at any given assessment point.
SQR	Sub-quaternary Reach	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments).
TWQR	Target Water Quality Requirement	Guidelines set by the South African Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF), for various physico-chemical and biological parameters for various uses as well as ecosystem functioning.
Var	Variation	
VEGRAI	Riparian Vegetation Response Assessment Index	VEGRAI is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results presented as Ecostatus Categories.
WMS	Water Management System	WMS is a suite of computer programmes developed for the Department of Water and Sanitation to provide information for water resource monitoring and management in South Africa.
WUL	Water Use License	The National Water Act (Act 36 of 1998) gives the Department of Water and Sanitation the tools to gather the information that we need for the optimal management of South Africa's water resources. The registration of water use is one of these tools.



1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to conduct a faunal, floral, wetland and aquatic ecological assessment as part of the environmental assessment and authorisation process for the proposed construction of a new ferrochrome (FeCr) Smelter located immediately adjacent to the existing Union Section Mine on Portion 3 of the farm Grootkuil 409 KQ, in the Thabazimbi Local Municipality, Limpopo Province. The proposed Siyanda ferrochrome smelter (hereafter referred to as the 'Project Infrastructure Area'), which will in broad terms comprise a railway siding, a raw materials offloading area, two 70 MW DC furnaces, crushing and screening plant, slag dump and baghouse slurry dam, as well as related facilities such as material stockpiles, workshops, stores and various support infrastructure and services, is located within the western portion of Portion 3 of the farm Grootkuil 409 KQ. In addition, an overhead powerline as well as one access road is proposed, with two access road alternatives, namely Access Road Corridor Option 2 and Access Road Option 3, being considered for development. The proposed powerline will originate from the Spitzkop substation to the southeast of Portion 3 of the farm Grootkuil 409 KQ, run north towards the southeastern corner of Portion 3 of the farm Grootkuil 409 KQ and from there extend along the southern boundary of the property towards the Project Infrastructure Area. The proposed Project Infrastructure Area, together with the proposed powerline and the two access road alternatives, of which only one will be developed, are hereafter referred to as the 'project site' (Figures 1 & 2). As part of the ecological assessment, the remainder of Portion 3 of the farm Grootkuil 409 KQ was also assessed, and, together with the project site, is hereafter referred to as the 'study area'.

The Project Infrastructure Area is situated approximately 10km to the west of the R510 regional road and 8km to the northwest of the town of Northam, and approximately 1,5km to the south of the Brits Road. The Swartklip Mine Village (developed as part of the Union Section Mine) is located immediately to the southwest of the Project Infrastructure Area.

A biomonitoring field assessment was conducted on the 24th of November 2015. During this site visit an aquatic ecological assessment was conducted in order to define the PES and Ecstatus of the aquatic ecosystem. This report includes an assessment of biota specific water quality, a survey of the habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate integrity and riparian vegetation conditions of the associated water resources.



This report will also highlight measures deemed necessary to minimise impacts on the receiving environment.

1.2 Project Scope

Specific outcomes in terms of this report are outlined below:

- To define the PES and Ecological Importance and Sensitivity (EIS) of the aquatic resources and aquatic ecosystems in the vicinity of the study area;
- To monitor spatial and temporal trends in aquatic resource integrity in the vicinity of the study area;
- To define the habitat conditions prevalent in the area as well as natural constraints posed to the system along with anthropogenic impacts on these systems;
- To report any emerging issues;
- To develop a database of biological integrity for streams in the region; and
- To define the required management, mitigation and monitoring measures required in order to minimise the impact of the proposed development on the receiving aquatic environment.

Table 1 below presents geographic information with regards to the monitoring points selected. Figure 1 visually presents the locations of the various points assessed.

Table 1: Location of the biomonitoring points with co-ordinates

Site	Site Description	GPS coordinates	
		South	East
SC1	Located in an area in which livestock grazing and crop cultivation are the dominant activities in the landscape. This site will be crossed by the proposed powerline and will be representative of the system for future monitoring.	24°55'47.17"S	27°10'53.80"E
SC2	Located in a remote area with little surrounding activities. The site is located on the upstream Brakspruit system and will serve as an upstream reference point to site SC5.	24°57'20.69"S	27°12'18.58"E
SC3	Located in a remote area with little surrounding activities. The site is located on the Phufane system and will serve as an upstream reference point to site SC4. The site will be crossed by the proposed powerline.	24°57'11.66"S	27°13'46.66"E
SC4	Located in a remote area with little surrounding activities. The site is located on the Phufane system and will serve as downstream reference point to site SC3. The site will be crossed by the proposed powerline.	24°56'31.48"S	27°13'10.62"E
SC5	Located in a remote area with little surrounding activities. The site is located on the downstream Brakspruit system and will serve as downstream reference point to site SC2. The site will be crossed by the proposed powerline.	24°56'19.22"S	27°12'33.22"E
SC6	This site is located on the Brakspruit, downstream of the confluence with the Phufane system. The site is located at a bridge crossing on Brits Road to the west of the town of Northam.	24°55'0.12"S	27°12'53.46"E



Six sites were assessed, namely SC1 – SC6, located on the unnamed tributary, Phufane, and Brakspruit streams. Only one out of the six sites (SC4) was subjected to further detailed aquatic assessment since this site was the only monitoring point to contain surface water at the time of the assessment and even at this point the conditions in the system were highly marginal and not ideal for applying the assessment indices. Temporal analysis could therefore only be applied to site SC4 and no spatial comparison of data could take place.

Factors investigated included the visual conditions of the site, including an identification of any impacts on the streams at each point. Physico-chemical water quality variables at each site. Intermediate Habitat Integrity Assessment (IHIA) and habitat suitability for aquatic macro-invertebrates was determined using the Invertebrate Habitat Assessment System (IHAS) method. The integrity of the aquatic macro-invertebrate community was assessed using the South African Scoring System version 5 (SASS5).

The sampling points are presented in Figure 1 which indicate the area under investigation.



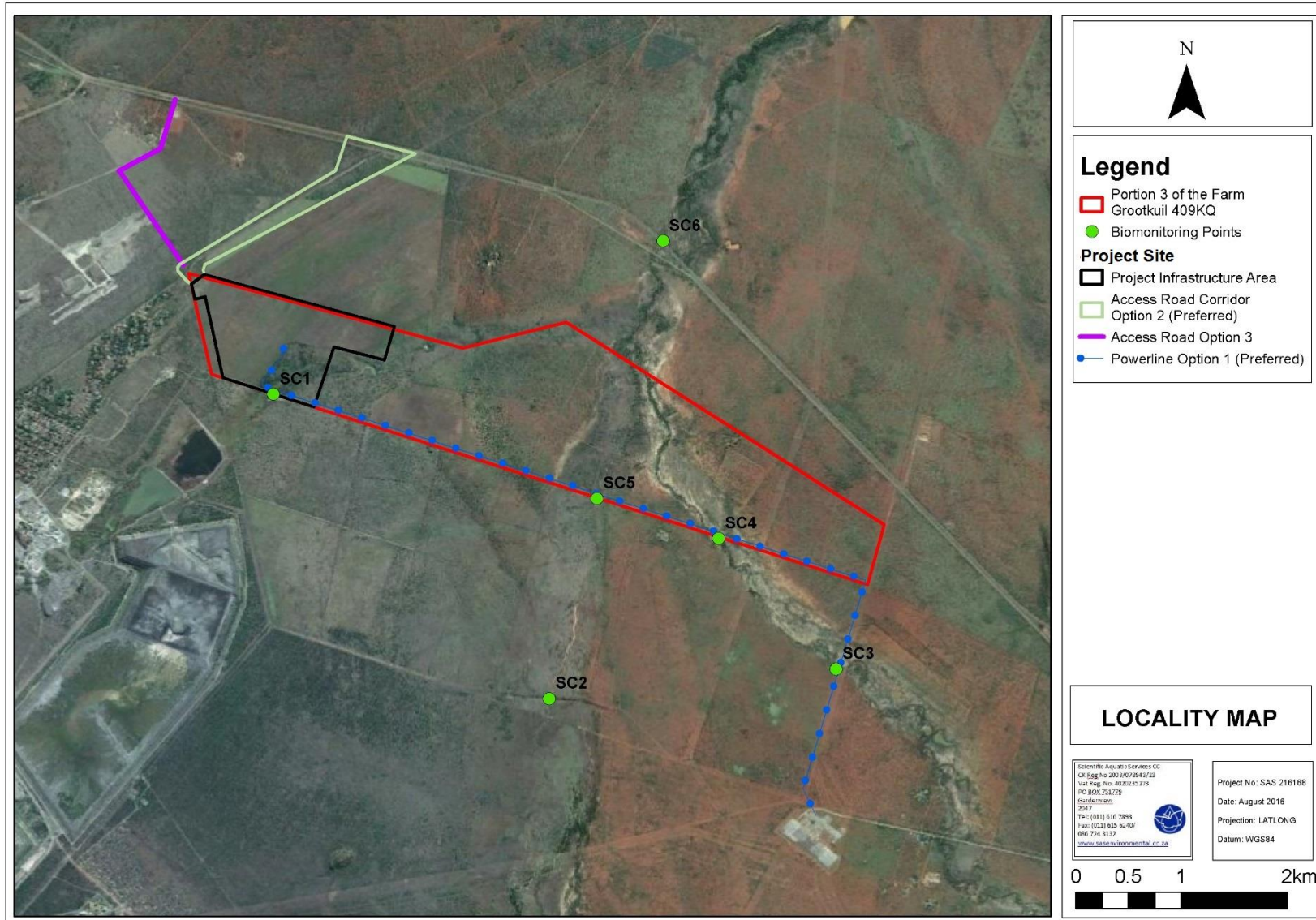


Figure 1: Aerial view of the study area to show the location of the biomonitoring points.



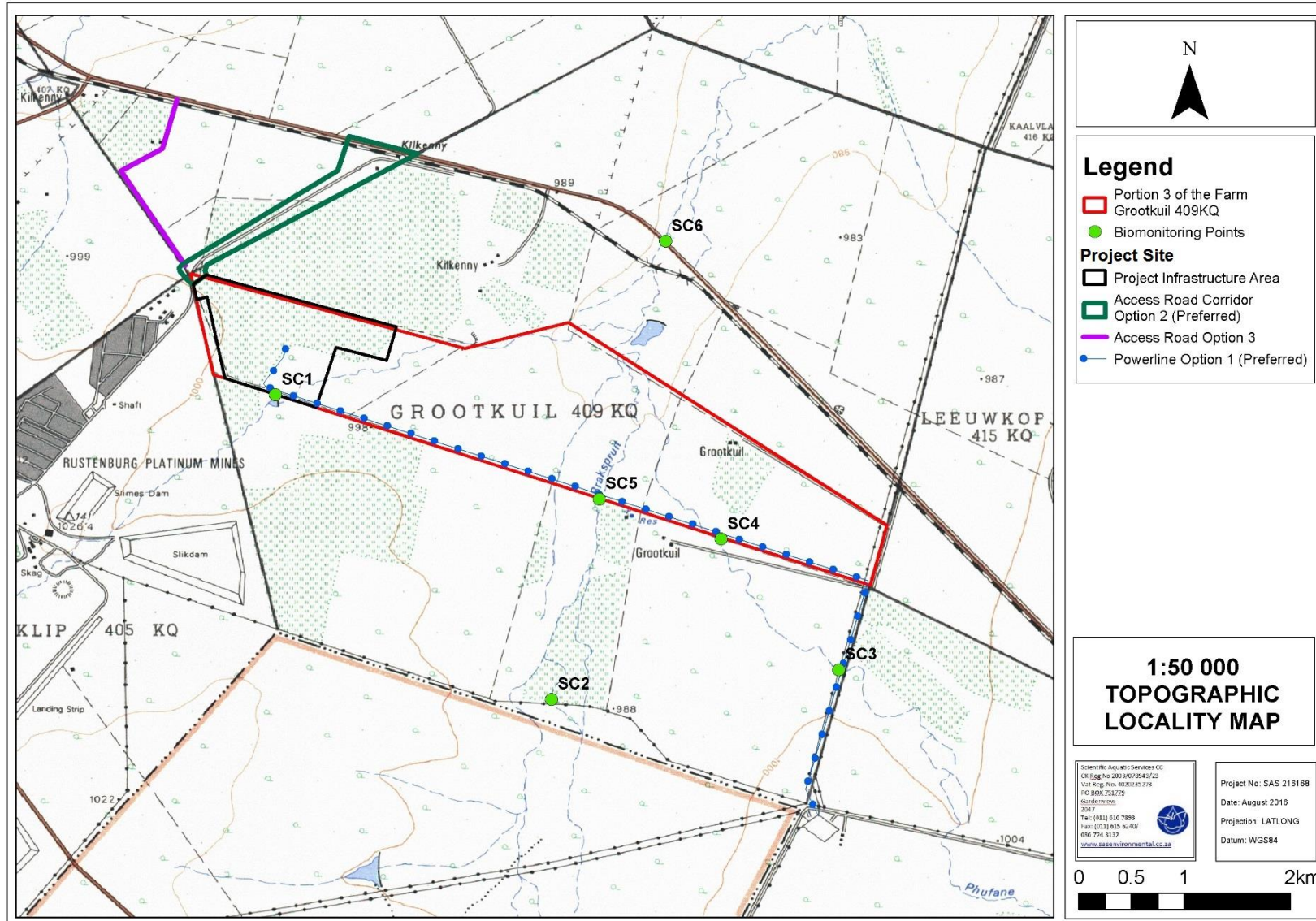


Figure 2: A topographic map showing the location of the study area and biomonitors.



1.3 Assumptions and limitations

The following points serve to indicate the assumptions and limitations of this aquatic ecological assessment:

- **Reference conditions are unknown:** The composition of aquatic biota in the Brakspruit area, prior to major disturbance, is unknown. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from limited data available. It is however deemed essential that an aquatic biomonitoring program be implemented to define the seasonal community composition of the aquatic resources;
- **Lack of strong flowing water:** The presence of various impoundments in the system has led to reduced instream flow, along with the nationwide drought experienced at the time of the assessment will limit the diversity and sensitivity of the macro-invertebrate communities expected at these sites;
- **Application of indices and ecostatus tools:** Six sites (SC1 – SC6) were visually assessed of which only one out of the six sites (SC4) was subjected to further detailed aquatic assessment since this site was the only monitoring point to contain surface water at the time of the assessment and even at this point the conditions in the system were highly marginal and not ideal for applying the assessment indices. Temporal analysis could therefore only be applied to site SC4 and no spatial comparison of data could take place.

1.4 Legislative Requirements

The following legislative requirements were considered during the assessment:

- **The National Water Act (NWA; Act 36 of 1998);**
 - Chapter 3: Protection of Water Resources:
 - Part 2: Determination of class of water resources and resource quality objectives.
 - Chapter 14: Monitoring, Assessment and Information:
 - Part 1: Establishment of National Monitoring Systems.
 - Part 2: National information systems on water resources.
- **The National Environmental Management Act (NEMA; Act 107 of 1998);**
 - Chapter 5: Integrated Environmental Management.
 - Chapter 7: Compliance, Enforcement and Protection:
 - Part 2: Information, enforcement and compliance



2 METHOD OF INVESTIGATION

Best practice methodologies (detailed methodologies to be provided on request) were used to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity. All work was undertaken by a South African River Health Program (SA RHP) accredited assessor. Factors investigated included the following where conditions at the time of assessment allowed:

- Visual conditions of the site, including an assessment of impacts on the stream, at each point;
- On-site testing of biota specific water quality parameters including pH, Electrical Conductivity (EC), Dissolved Oxygen concentration (DO) and temperature. The results aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems developed by the Department of Water and Sanitation (DWS) formerly known as the Department of Water Affairs and Forestry (DWAf 1996 vol. 7).
- The Riparian Vegetation Response Assessment Index (VEGRAI) was applied according to the protocol of Kleynhans *et al.* (2007) in order to define the Ecostatus of the riparian vegetation.
- The general habitat integrity of the site was assessed based on the application of the Intermediate Habitat Integrity Assessment (IHIA) based on the protocol of Kemper (1999).
- Habitat suitability for aquatic macro-invertebrates was determined using the IHAS (Invertebrate Habitat Assessment System) method and was applied according to the protocol of McMillan (1998);
- The integrity of the aquatic macro-invertebrate community was assessed using the SASS5 (South African Scoring System version 5) as defined by Dickens & Graham (2001) as well as the application of the MIRAI (Macro-Invertebrate Response Assessment Index) ecostatus tool as described by Thirion (2007);
- Interpretation of the results, in relation to reference scores, was made according to the classification of SASS5 scores presented in the SASS5 methodology, published by Dickens & Graham (2001) as well as according to the SASS5 data interpretation guidelines (Dallas 2007). Aquatic macro-invertebrates expected within the system were derived from the (DWS) Resource Quality Information Services (RQIS) PES/EIS database.




3 RESULTS AND INTERPRETATION

Six sites (SC1 – SC6) were visually assessed of which only one out of the six sites (SC4) was subjected to further detailed aquatic assessment since this site was the only monitoring point to contain surface water at the time of the assessment and even at this point the conditions in the system were highly marginal and not ideal for applying the assessment indices. Temporal analysis could therefore only be applied to site SC4 and no spatial comparison of data could take place.

Results are presented as “dashboard” reports (Tables 2 and 3). These dashboard reports aim to present concise summaries of the data on as few pages as possible in order to allow for integration of results by the reader to take place. Where required, further discussion and interpretation is provided.



Table 2: Results of the assessment at site SC4

Site SC4		In situ physico-chemical water quality		Aquatic macro-invertebrate community integrity		Habitat Integrity																																																	
	pH	7.45	SASS5 score	23	Instream Category 66.5 Moderately Modified Riparian Zone Category 48.7 Largely Modified Overall Category 57.6 Largely Modified (Class D)																																																		
	EC (mS/m)	16.0	Number of taxa	6																																																			
	DO (mg/L)	6.19	ASPT score	3.8																																																			
	DO (% sat)	72.6	MIRAI score	37.9																																																			
	Temp (°C)	20.7	IHAS score	33 (Inadequate)																																																			
Site specific temporal water quality variations (% var)		Site specific temporal aquatic invertebrate community variations (% var)																																																					
Parameter	% Var from baseline data	Parameter	% Var from ref ecoregion data (SASS5)	% Var from baseline data																																																			
pH	-5.9	SASS5	-80.8	-11.5																																																			
EC	-33.3	ASPT	-32.1	-23.3																																																			
DO	+9.9	IHAS	NA	-8.3																																																			
Temp	+2.0																																																						
Figure 3: General view of the SC4 site at the time of the assessment.																																																							
Algal proliferation	None observed.	Riparian Vegetation Assessment																																																					
Depth profiles	Very shallow. Generally < 1/2 m.	<table border="1"> <thead> <tr> <th colspan="6">LEVEL 3 ASSESSMENT</th> </tr> <tr> <th>METRIC GROUP</th> <th>CALCULATED RATING</th> <th>WEIGHTED RATING</th> <th>CONFIDENCE</th> <th>RANK</th> <th>% WEIGHT</th> </tr> </thead> <tbody> <tr> <td>MARGINAL</td> <td>37.1</td> <td>23.2</td> <td>2.5</td> <td>1</td> <td>100.0</td> </tr> <tr> <td>NON MARGINAL</td> <td>60.0</td> <td>22.5</td> <td>0.0</td> <td>2</td> <td>60.0</td> </tr> <tr> <td colspan="5"></td> <td>160.0</td> </tr> <tr> <td colspan="4">LEVEL 3 VEGRAI (%)</td> <td>45.7</td> <td></td> </tr> <tr> <td colspan="4">VEGRAI EC</td> <td>D</td> <td></td> </tr> <tr> <td colspan="4">AVERAGE CONFIDENCE</td> <td>1.3</td> <td></td> </tr> </tbody> </table>					LEVEL 3 ASSESSMENT						METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT	MARGINAL	37.1	23.2	2.5	1	100.0	NON MARGINAL	60.0	22.5	0.0	2	60.0						160.0	LEVEL 3 VEGRAI (%)				45.7		VEGRAI EC				D		AVERAGE CONFIDENCE				1.3		Riparian vegetation is considered to be largely modified. Large impacts from vegetation removal and erosion is evident along the Phufane system.
LEVEL 3 ASSESSMENT																																																							
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT																																																		
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LEVEL 3 VEGRAI (%)				45.7																																																			
VEGRAI EC				D																																																			
AVERAGE CONFIDENCE				1.3																																																			
Flow condition	Small isolated stagnant pool at the time of the assessment.																																																						
Riparian zone characteristics	Narrow due to the incised nature of the stream. Significant erosion and shear banks. Riparian zone dominated by trees.																																																						
Water clarity and odour	Water is highly turbid and silty due to the dominant muddy substrate present at the site and trampling by animals. .																																																						
Site Ecostatus Category Dickens & Graham Dallas MIRAI IHIA VEGRAI	Category F Category E/F Category E Category D Category D	Key Drivers of System Change ➤ Reduced instream flow due to impoundments and water abstraction within the system along with a nationwide drought experienced at the time of the assessment, limits habitat availability at this point, thus limiting the diversity and sensitivity of the aquatic community likely to occur at this point.																																																					

NA = Not Applicable, SASS reference score = 120, ASPT reference score = 5.6, var = variation, ref = reference



Table 3: Temporal variations observed at the SC4 site since the baseline assessment in April 2015.

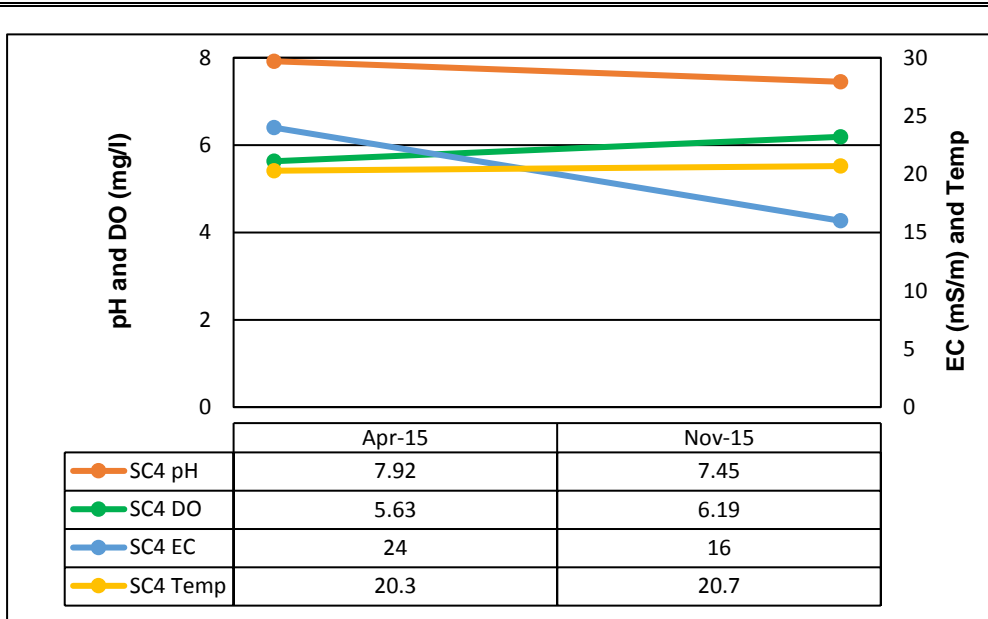


Figure 4: Site specific temporal water quality variation at site SC4.

Comment:

- Electrical conductivity (EC) variation over time, exceeds the DWS target water quality guidelines (DWAF, 1996) (Table 2), which advocates that seasonal and temporal changes should not exceed 15%;
- EC has decreased significantly when compared to the baseline assessment and can be seen as an improvement in the system;
- When compared to the baseline assessment, pH has decreased slightly and exceeds the DWS target water quality guidelines (DWAF, 1996) (Table 2), which advocates that seasonal and temporal changes should not exceed 5%. No impact on the aquatic community is likely at the time of the assessment as the absolute value is considered as largely natural;
- Dissolved oxygen (DO) saturation can be considered as inadequate in supporting a diverse and sensitive aquatic community, and falls below the 80% saturation requirement (DWAF, 1996);
- DO concentrations are relatively low over time, and can be attributed to the lack of flowing water and the high turbidity due to the dominant muddy substrate at the site;
- The temperature can be regarded as natural for the time of year and time of day during which sampling took place;
- Ongoing monitoring at this point will need to continue to establish any trends.

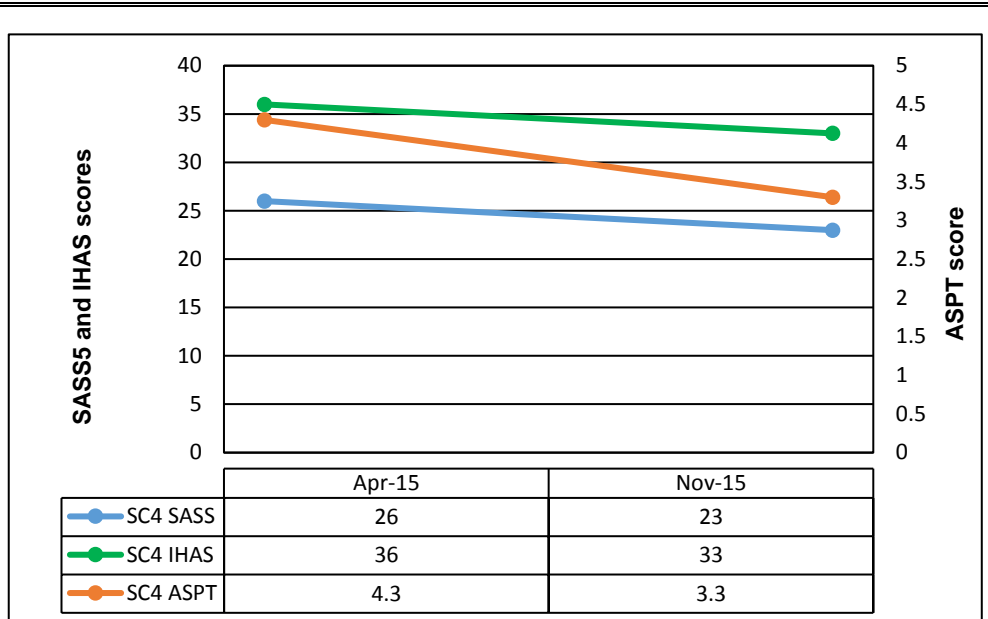


Figure 5: Site specific temporal macro-invertebrate community integrity at site SC4.

Comment:

- When compared to the baseline assessment the SASS5 score has decreased by 11.5%, the ASPT score has decreased by 23.3% and the IHAS score has decreased by 8.3% (Table 2);
- The decrease in SASS5 and ASPT scores are likely related to the change in IHAS score along with the nationwide drought experienced at the time of the assessment;
- Ongoing monitoring at this point will need to continue to establish any trends.



3.1 Habitat Assessment

3.1.1 Invertebrate Habitat Integrity Assessment (IHIA)

An Invertebrate Habitat Integrity Assessment was applied to each of the aquatic systems (Phufane, upstream and downstream Brakspruit). Moderate, large and serious impacts were recorded for each system (Appendix 4).

Large instream impacts included water abstraction, bed modification and channel modification within all three systems. Flow modification was considered as a serious impact within all three aquatic resources. The Phufane, upstream and downstream Brakspruit systems achieved Class C (moderately impaired) instream conditions.

Moderate riparian zone impacts within the aquatic resources included exotic vegetation encroachment along with water abstraction. Large impacts recorded at the sites include indigenous vegetation removal along with channel modification. Serious riparian zone impacts included flow modification and erosion. The sites all achieved a class D (largely modified) classification for riparian habitat integrity.

Overall, for habitat integrity the upstream Brakspruit scored 58.2% (Class D), the Phufane scored 57.6% (Class D), and the downstream Brakspruit scored 61.3% (Class C). Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic / wetland / riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained.

3.1.2 Riparian Vegetation Response Assessment Index: VEGRAI

Tables 4 to 6 below present the overall VEGRAI results of the assessment sites.

Table 4: Results of the VEGRAI assessment for the upstream Brakspruit.

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	46.7	29.2	3.3	1	100.0
NON MARGINAL	46.7	17.5	0.0	2	60.0
					160
LEVEL 3 VEGRAI (%)				46.7	
VEGRAI EC				D	
AVERAGE CONFIDENCE				1.7	



Table 5: Results of the VEGRAI assessment for the Phufane system.

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	37.1	23.2	2.5	1	100.0
NON MARGINAL	60.0	22.5	0.0	2	60.0
					160.0
LEVEL 3 VEGRAI (%)				45.7	
VEGRAI EC				D	
AVERAGE CONFIDENCE				1.3	

Table 6: Results of the VEGRAI assessment for the downstream Brakspruit.

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	56.2	35.1	3.3	1.0	100.0
NON MARGINAL	60.0	22.5	0.0	2.0	60.0
					160.0
LEVEL 3 VEGRAI (%)				57.6	
VEGRAI EC				C/D	
AVERAGE CONFIDENCE				1.7	

Because the riparian vegetation was very similar along all sites assessed on the various drainage systems, VEGRAI was applied to each system as a whole and not to individual sites. The scores attained for the VEGRAI assessment indicate that the riparian systems in the vicinity of the study area fall within a PES category D for the upstream Brakspruit and Phufane systems while the downstream Brakspruit system can be classified as a borderline category C/D. The ecological category D attained within the upstream Brakspruit and Phufane systems, and the borderline category C/D attained within the downstream Brakspruit system indicate that the riparian vegetation has undergone large modifications, with a large loss of natural habitat, biota and basic ecosystem functions. This is due to the significant erosion and modification of water flow within all three systems.



4 RECOMMENDATIONS

The following recommendations were drawn upon completion of the aquatic assessment:

- On-going aquatic ecological monitoring must take place on an annual basis in the high flow season by a suitably qualified assessor focusing on aquatic macro-invertebrates, habitat integrity and biota specific water quality;
- Future development planning should ensure that activities do not lead to a reduction of stream flow or dewatering of any aquatic / wetland / riparian areas and connectivity of the aquatic features in the vicinity of the study area should be maintained;
- Due to the ephemeral nature of the water resources in the vicinity of the study area, it is recommended to rather apply the diatom community analysis due to the decreasing aquatic community integrity over time. This will aid in the definition of the lower range classes specified in the RHP methodology;
- Results should be compared spatially and temporally to the results of this document. If it is observed through biomonitoring information that significant negative changes are taking place in ecological integrity (Change of Class), it should be taken as an indication that the system is suffering stress and mitigatory actions should be identified and where possible implemented.



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APPENDIX 1: System Characterisation



Ecoregion

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the study area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The study area falls within the Bushveld Basin Aquatic Ecoregion and is located within is located within two quaternary catchments, A24F and A24E, with only the A24E quaternary catchment being applicable to the biomonitoring sites. The main attributes of the Bushveld Basin Aquatic Ecoregion are presented in Table 1 below:

Table 1: Main attributes of the Bushveld Basin Ecoregion.

MAIN ATTRIBUTES	BUSHVELD BASIN
Terrain Morphology: Broad division (dominant types in bold) (Primary)	Plains; Low Relief; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld; Clay Thorn Bushveld; Waterberg Moist Mountain Bushveld (limited)
Altitude (m a.m.s.l.) (modifying)	700-1700 (1700-1900 very limited)
MAP (mm) (Secondary)	400 to 600
Coefficient of Variation (% of annual precipitation)	25 to 35
Rainfall concentration index	55 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp. (°C)	14 to 22
Mean daily max. temp. (°C): February	22 to 32
Mean daily max. temp. (°C): July	14 to 24
Mean daily min. temp. (°C): February	12 to 20
Mean daily min temp. (°C): July	0 to 6
Median annual simulated runoff (mm) for quaternary catchment	20 to 100

Quaternary Catchment

Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database

The PES/EIS database, as developed by the DWS Resource Quality Information Services (RQIS) department, was utilised to obtain additional background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014.

The information from this database is based on information at a sub-quaternary catchment reach (subquat reach) level with the descriptions of the aquatic ecology based on the



information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, Ecological Water Requirements (EWR) sites and Hydro Water Management System (WMS) sites.

The results obtained serve to summarise this information as a background to the conditions within the study area:

Table 2: Summary of the ecological status of quaternary catchment A24E.

SQ REACH	SQR NAME	PES ASSESSED BY EXPERTS? (IF TRUE="Y")	PES CATEGORY MEDIAN	MEAN EI CLASS	MEAN ES CLASS	Length km	STREAM ORDER	DEFAULT EC (BASED ON MEDIAN PES AND HIGHEST OF EI OR ES MEANS)
A24E-00642	Sefathlane (Brakspruit)	Y	C	Moderate	Low	13.56	2	C
A24E-00652	Phufane	Y	C	Moderate	Very Low	36.08	1	C
A24E-00623	Brakspruit	Y	C	Moderate	Moderate	7.26	2	C
A24E-00696	Sefathlane (Brakspruit)	Y	C	Moderate	Low	35.03	1	C

From the assessment of the PES/EIS data, the following points are highlighted which summarise the data:

The **invertebrate data list** which is available for the Brakspruit (A24E-00623) is considered to be representative of the larger study area. However, this SQR specifically represents the larger Brakspruit. Because some of the assessed sites are located on smaller rivers which are tributaries of the Brakspruit, all the families listed below may not necessarily occur there due to natural limitations caused by lack of flowing water and limited habitat:

- Aeshnidae
- Atyidae
- Baetidae 1 sp.
- Belostomatidae
- Caenidae
- Ceratopogonidae
- Chironomidae
- Coenagrionidae
- Corixidae
- Culicidae
- Dytiscidae
- Gerridae
- Gomphidae
- Gyrinidae
- Hirudinea
- Hydrophilidae
- Hydracarina
- Hydrometridae
- Leptoceridae
- Libellulidae
- Muscidae
- Naucoridae
- Nepidae
- Notonectidae
- Oligochaeta
- Pleidae
- Potamanautidae
- Tabanidae
- Tipulidae
- Vellidae/Mesovellidae



Fish data is available for the Brakspruit (A24E-00623) in the larger study area and is considered to be representative of what may be expected in the study area:

- *Aplocheilichthys johnstoni* Günther, 1893
- *Labeobarbus marequensis* Smith, 1841
- *Barbus paludinosus* Peters, 1852
- *Barbus trimaculatus* Peters, 1852
- *Barbus unitaeniatus* Günther, 1866
- *Chetia flaviventris* Trewavas, 1961
- *Clarias gariepinus* Burchell, 1822
- *Labeo cylindricus* Peters, 1852
- *Labeo molybdinus* Du Plessis, 1963
- *Mesobola brevianalis* Boulenger, 1908
- *Oreochromis mossambicus* Peters, 1852
- *Pseudocrenilabrus philander* Weber, 1897
- *Tilapia sparrmanii* Smith, 1840

Table 3: Summary of the ecological status of the sub-quaternary catchment reach (SQR) A24E-00623 (Brakspruit) based on the DWS RQS PES/EIS database

Synopsis (SQ reach A24E-00623 Brakspruit)					
PES ¹ category median	Mean EI ² class	Mean ES ³ class	Length (km)	Stream order	Default EC ⁴
C	Moderate	Moderate	7.26	2.0	C
PES details					
Instream habitat continuity MOD		Small	Riparian/wetland zone MOD		Moderate
RIP/wetland zone continuity MOD		Small	Potential flow MOD activities		Moderate
Potential instream habitat MOD activities		Moderate	Potential physico-chemical MOD activities		Large
EI details					
Invertebrate taxa/SQ		30.00	Invertebrate average confidence		3.0
Invertebrate representivity per secondary class		Moderate	Invertebrate rarity per secondary class		Moderate
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		Low	Habitat diversity class		Very Low
Habitat size (length) class		Very Low	Instream migration link class		Very High
Riparian-wetland zone migration link		Very High	Riparian-wetland zone habitat integrity class		High
Instream habitat integrity class		High	Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m		Very High



Riparian-wetland natural vegetation rating based on expert rating			High
Fish spp./SQ	13.00	Fish: Average confidence	1.00
Fish representivity per secondary per secondary class	Moderate	Fish rarity per secondary per secondary class	Moderate
ES details			
Fish physical-chemical sensitivity description	High	Fish no-flow sensitivity description	High
Invertebrates physical-chemical sensitivity description	Moderate	Invertebrates velocity sensitivity	High
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description			Very Low
Stream size sensitivity to modified flow/water level changes description			Low
Riparian-wetland vegetation intolerance to water level changes description			Low

¹ PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;

² EI = Ecological Importance;

³ ES = Ecological Sensitivity

⁴ EC = Ecological Category; default based on median PES and highest of EI or ES means.

Table 4: Quaternary Catchment information

Catchment	Resource	EIS	PESC	DEMC
A24E	Bierspruit	Low/Marginal	Class B	Class D (Resilient Systems)

The Institute for Water Quality Studies (IWQS) quaternary catchment database was used as reference for the catchment of concern, in order to define the EIS, Present Ecological Management Class (PEMC) and Default Ecological Management Class (DEMC). The sections that follow indicate the aquatic ecoregion and quaternary catchment in which the study area falls and the characteristics of the ecology of the major drainage system in this quaternary catchment. It must be noted that the Phufane and Brakspruit systems are tributaries of the Bierspruit located north of the study area.

According to the ecological importance classification for the quaternary catchment, the Bierspruit can be classified as a resilient system, which, in its present state, can be considered a Class B (Largely natural) stream.

The points that follow summarise the impacts on the aquatic resources in A24E quaternary catchment (Kleynhans, 1999):

- The aquatic resources within this quaternary catchment have not been significantly affected by bed modification;
- Low/marginal impacts have occurred as a result of flow modifications;



- Low impacts from introduced instream biota;
- Low/marginal impacts from inundation are present within the catchment;
- Moderate impacts of riparian and bank conditions;
- Low impacts from water quality modification.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- The riparian systems in this catchment have a marginal/low diversity of habitat types;
- Very low importance in terms of conservation areas and conservation of biodiversity;
- The riparian resources have a low intolerance to changes in flow and flow related water quality;
- Low importance in terms of faunal migration;
- No importance in terms of rare and endangered species conservation;
- Marginal/low importance as a source of refugia for aquatic species;
- The catchment has a low sensitivity to changes in water quality and water flow;
- The catchment has low species/taxon richness;
- The catchment has no importance in terms of unique species conservation.



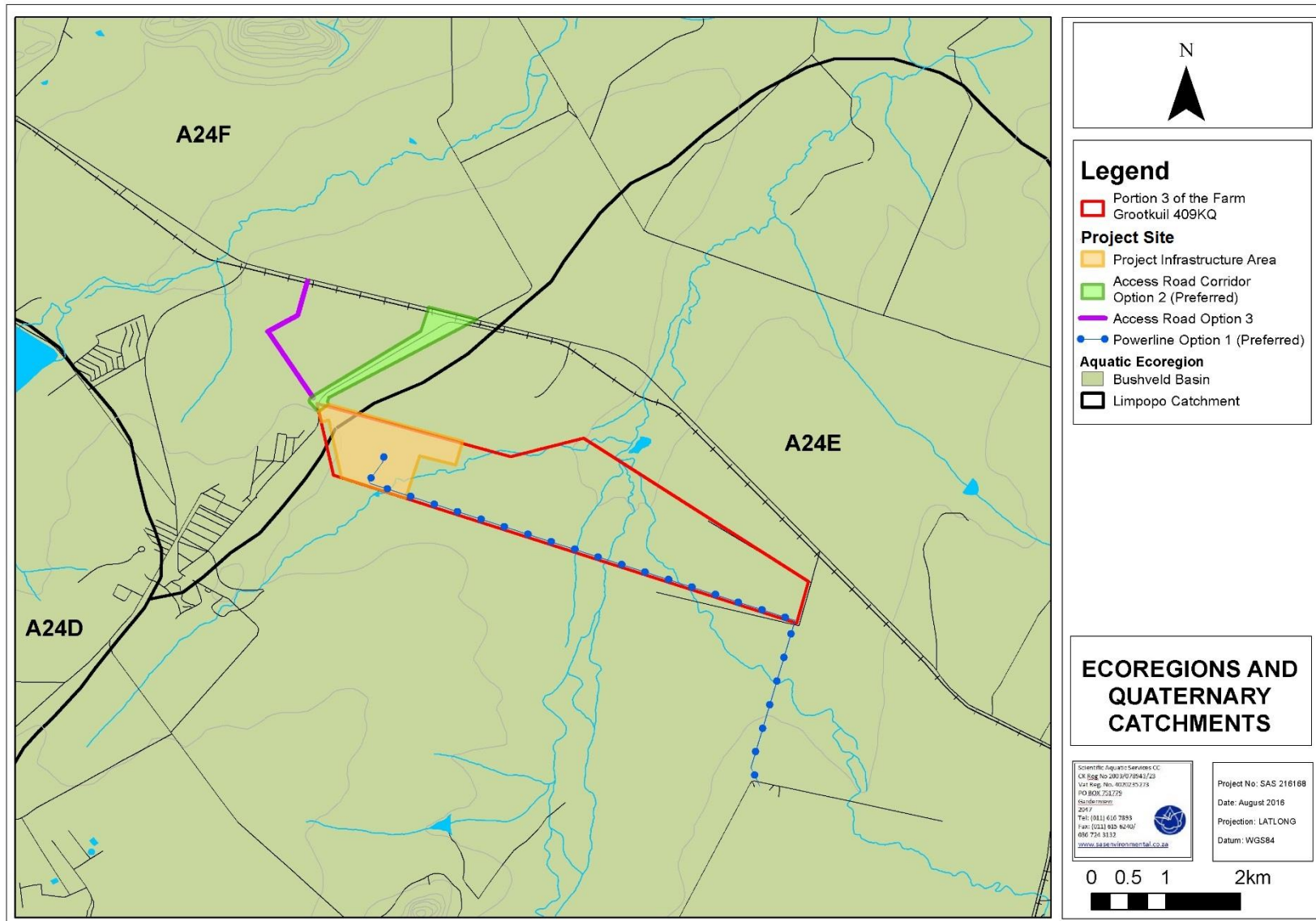


Figure 1: The Ecoregion and Quaternary Catchment applicable to the study area.



APPENDIX 2: SASS5 Scoresheets



RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/11/2015	TAXON	S	VG	GSM	TOT	TAXON	S	VG	GSM	TOT	TAXON	S	VG	GSM	TOT	
GRID REFERENCE:	PORIFERA	5				HEMIPTERA:					DIPTERA:					
S:°	COELENTERATA	1				Belostomatidae*	3				Athericidae	10				
E:°	TURBELLARIA	3				Corixidae*	3		A	A	Blepharoceridae	15				
SITE CODE: SC4	ANNELIDA:					Gerridae*	5				Ceratopogonidae	5				
RIVER:	Oligochaeta	1				Hydrometridae*	6				Chironomidae	2				
SITE DESCRIPTION:	Leeches	3				Naucoridae*	7				Culicidae*	1		A	A	
WEATHER CONDITION:	CRUSTACEA:					Nepidae*	3				Dixidae*	10				
TEMP: 20.7 °C	Amphipoda	13				Notonectidae*	3				Empididae	6				
Ph: 7.45	Potamonautidae*	3				Pleidae*	4				Ephydriidae	3				
DO: 6.19 mg/l	Atyidae	8				Veliidae/M...veliidae*	5				Muscidae	1		A	A	
Cond: 16.0 mS/m	Palaemonidae	10				MEGALOPTERA:					Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8				Cordalidae	8				Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:					Sialidae	6				Syrphidae*	1				
SOOC:	Notonemouridae	14				TRICHOPTERA					Tabanidae	5				
BEDROCK:	Perlidae	12				Dipseudopsidae	10				Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA					Ecnomidae	8				GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4				Hydropsychidae 1sp	4				Ancyliidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6				Hydropsychidae 2 sp	6				Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12				Hydropsychidae >2 sp	12				Hydrobiidae*	3				
SAND:	Caenidae	6				Philopotamidae	10				Lymnaeidae*	3				
MUD:	Ephemeridae	15				Polycentropodidae	12				Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13				Psychomyiidae/Xiphocen.	8				Planorbidae*	3				
FLOW:	Leptophlebiidae	9				CASED CADDIS:					Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15				Barbarochthonidae SWC	13				Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10				Calamoceratidae ST	11				PELECYPODA					
	Prosoptomatidae	15				Glossosomatidae SWC	11				Corbiculidae	5				
	Teloganodidae SWC	12				Hydroptilidae	6				Sphaeriidae	3				
	Tricothyridae	9				Hydrosalpingidae SWC	15				Unionidae	6				
	ODONATA:					Lepidostomatidae	10				SASS SCORE:		0	0	23	23
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10				Leptoceridae	6				NO OF TAXA:		0	0	6	6
	Chlorocyphidae	10				Petrothrincidae SWC	11				ASPT:		0.00	0.00	3.83	3.83
	Chlorolestidae	8				Pisuliidae	10				IHAS:		33%			
	Coenagrionidae	4				Sericostomatidae SWC	13				OTHER BIOTA:					
	Lestidae	8				COLEOPTERA:					COMMENTS:					
SIGNS OF POLLUTION:	Platycnemidae	10				Dytiscidae*	5		A	A	* = airbreathers					
	Protoneuridae	8				Elmidae/Dryopidae*	8				SWC = South Western Cape					
	Zygoptera juvs.	6				Gyrinidae*	5				T = Tropical					
	Aeshnidae	8				Halipidae*	5				ST = Sub-tropical					
	Corduliidae	8				Heloidea	12				S = Stone & rock					
OTHER OBSERVATIONS:	Gomphidae	6				Hydraenidae*	8		1	1	ST = Sub-tropical					
	Libellulidae	4				Hydrophilidae*	5		1	1	S = Stone & rock					
	LEPIDOPTERA:					Limnichidae	10				VG = all vegetation					
	Pyralidae	12				Psephenidae	10				GSM = gravel, sand & mud					
											f=1, A=2-10, B=10-100, C=100-1000, D=>1000					



APPENDIX 3: IHAS Scoresheets



INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: SC4	Date: 24/11/2015					
SAMPLING HABITAT						
	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	>15
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	>6
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	21-30	>30
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	>80
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min) (* NOTE: up to 25% of stone is usually embedded in the stream bottom)	0	<1	>1-2	2	>2-3	>3
SIC Score (max 20):						0
VEGETATION						
	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1	>2	>3
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none	run	pool	mix	>1	>2
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	1-25	26-50	51-75	>75	>80
Vegetation Score (max 15):						0
OTHER HABITAT/GENERAL						
	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	>2
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	>1
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**	>1	>2
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some	all**	>1	>2	>3
Algae present: ('+2m ² ' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m ²	rocks	1-2m ²	<1m ²	isol	none
Tray identification: (PROTOCOL - using time: 'corr' = correct time) (** NOTE: you must still fill in the SIC section)	under	corr	over	>1	>2	>3
Other Habitat Score (max 20):						20
HABITAT TOTAL (MAX 55):						20
STREAM CONDITION						
	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool	run	rapid	2mix	3mix	>3
Average width of stream: (in meters)	>10	>5-10	<1	1-2	>2-5	>5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med	mix	>1
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque	disc	clear	>1	>2
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other	none	>1
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none	grass	shrubs	mix	>1	>2
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other	open	>1
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95	>1	>2
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95	>1	>2
STREAM CONDITIONS TOTAL (MAX 13)						13
TOTAL IHAS SCORE (%):						33



APPENDIX 4: IHIA Scoresheets



Instream Zone Habitat Integrity

Weights		14	13	13	13	14	10	9	8	6	N/A	N/A
Reach	DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
Upstream Brakspruit	Nov 2015	10	15	10	10	0	0	0	0	0	67.6	Class C (Moderately modified)
Phufane		10	15	10	10	2	0	0	0	0	66.5	Class C (Moderately modified)
Downstream Brakspruit		10	15	10	10	0	0	0	0	2	67.1	Class C (Moderately modified)
None	Small	Moderate				Large				Serious		Critical

Riparian Zone Habitat Integrity

Weights		13	12	14	12	13	11	12	13	N/A	N/A
Reach	DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
Upstream Brakspruit	Nov 2015	10	8	15	8	15	10	0	0	48.7	Class D (Largely modified)
Phufane		10	8	15	8	15	10	0	0	48.7	Class D (Largely modified)
Downstream Brakspruit		8	8	13	8	15	10	0	0	55.5	Class D (Largely modified)
None	Small	Moderate			Large				Serious		Critical
REACH	ASSESSMENT DATE	INSTREAM HABITAT			RIPARIAN ZONE			IHI SCORE		CLASS	
Upstream Brakspruit	November 2015	67.6			48.7			58.2		Class D (Largely modified)	
Phufane		66.5			48.7			57.6		Class D (Largely modified)	
Downstream Brakspruit		67.1			55.5			61.3		Class C (Moderately modified)	

