WETLAND AND AQUATIC ECOLOGICAL ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE GREATER SOUTPANSBERG MOPANE PROJECT, LIMPOPO PROVINCE

Prepared for

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FINAL REPORT

Declaration Of Independance

This report has been prepared according to the requirements of Section 32 (3b) of the Environmental Impact Assessments Regulations, 2010 (GNR 543). We (the undersigned) declare the findings of this report free from influence or prejudice.

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EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to undertake a Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) analysis of the wetland, aquatic and riparian resources as part of the environmental assessment and authorisation process for the proposed Greater Soutpansberg Mopane project, located approximately 30km to the south of Musina within the Limpopo Province hereafter referred to as the 'study area'.

Specific outcomes required from this report in terms of the wetland assessment include the following:

- Compile a desktop study with all relevant information as presented by the South African National Biodiversity Institutes (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org) as well as location of Freshwater Ecosystem Priority Areas (FEPAs) in relation to the study area;
- Delineation of the wetland temporary zones by means of "Department of Water Affairs (DWA), 2005: A practical Guideline Procedure for the Identification and Delineation of Wetlands and Riparian Zones" and through the use of aerial photography;
- Define wetland functional units based on observed characteristics;
- Map functional units and apply applicable assessment methods to each functional unit;
- Assess the wetland services provided by the resources on the study area according to the method of Kotze *et al* (2005) in which services to the ecology of the site are defined and services to the people of the area are defined;
- Assess the wetland PES according to the resource directed measures guideline as advocated by DWA 1999;
- Compile a detailed impact assessment on all identified significant impacts including cumulative impacts on wetland resources in the region; and
- Provide recommendations on management and mitigation measures (including opportunities and constraints) with regards to mining related activities within the study area in order to improve, manage and mitigate impacts on the wetland ecology of the area.

Specific outcomes required from this report in terms of the aquatic assessment include the following:

- Define the ecostatus of the river systems;
- Define the ecological importance and sensitivity of the systems based on stressor and receptor assessments, including habitat assessments;
- Biota specific water quality assessment;
- Aquatic community integrity assessments;
- Define impacts on the systems;
- Provide an opinion based on the study form and aquatic ecological point of view; and
- Present required mitigation measures.

The following general conclusions were drawn upon completion of the literature review:

- The Greater Soutpansberg Mopane Project falls within the Limpopo Plain Ecoregion and is located within the A71J, A71K and A72B quaternary catchments. The bullets below presents the findings for each of the quaternary catchments based on Kleynhans (1999):
  - A71J - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Resilient* system which, in its present state, can be considered a Class B (largely natural) stream;
  - A71K - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Moderately Sensitive* system which, in its present state, can be considered a Class B (largely natural) stream; and
  - A72B - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Resilient* system which, in its present state, can be considered a Class B (largely natural) stream.
- The SANBI Wetland Inventory (2006) and NFEPA (2011) databases were consulted to define the ecology of the wetland or river systems within the Mopane Project Area that may be of ecological importance. Key findings are listed below:
  - The sub-Water Management Area is not regarded important in terms of fish sanctuaries, rehabilitation or corridors, translocation and relocation zones for fish;
  - The Sand River is a perennial system classified as a Class B (largely natural) river and is not indicated as a free flowing or flagship river. However, the northern portion of the Sand River is indicated as a FEPA river and the southern portion of the Sand River is indicated as an Upstream Management Area;

- River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. Although FEPA status applies to the actual river reach within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and smaller stream network need to be managed in a way that maintains the good condition (A or B ecological category) of the river reach;
- Upstream Management Areas are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas.

<u>The following general conclusions were drawn upon completion of the wetland assessment:</u>

- Sites selected with the use of desktop methods, were investigated during the field survey undertaken in July 2013. For the purposes of this investigation, use was made of distinguishing factors as either defined by DWA (2005) for ‘wetland habitat’ or defined in the National Water Act (NWA; Act No 36 of 1998) for ‘riparian habitat’. Due to the ephemeral nature of many features within the study area they could not be considered true wetland or riparian habitat and was consequently not assessed with the methods used below;
- Wetland and riparian features within the study area were categorised with the use of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, 2013). After the field assessment it can be concluded that three main feature groups are present within the study area, namely depressions (pans and wetland depressions), rivers (Sand River, Tokwespruit, Banff Stream and Voorburg Stream) and smaller drainage lines;
- These groups were then assessed to determine importance in terms of function and service provision as well as PES. The bullets below summarise the key findings:
  - The results obtained indicate that the Sand River can be considered the most important in terms of function and service provision, with the highest scores calculated for water supply, biodiversity and tourism and recreation. The next highest average scores calculated was for the Voorburg Stream, Banff Stream and wetland depressions;
  - Wet-Health was used to determine the PES of smaller drainage lines including wetland depressions and pans. Pans calculated average scores for vegetation, hydrology and geohydrology that fall within a very high PES (unmodified, natural), mainly as a result of their remoteness. Smaller drainage lines calculated the same impact score for vegetation, however hydrology and geohydrology impact scores are lower as a result of impact from earth works due to the construction of the impoundments (wetland depressions) as well as abstraction of water;
  - Riparian Vegetation Response Assessment Index (VEGRAI) was used to assess the response of riparian vegetation to impacts within rivers as well as smaller drainage lines. The mean average scores calculated for the Sand River and Tokwespruit both fall within Class C (moderately modified) and mean average scores calculated for the smaller drainage lines, Banff and Voorburg Streams fall within Class B (largely natural); and
  - The Index of Habitat integrity (IHI) was used to assess the vegetation, hydrology and geomorphology of the different river systems and drainage lines. All three aspects were used to determine the average PES category for each feature assessed. The smaller drainage lines calculated the highest PES score falling within a Class A (unmodified), followed by the Banff Stream, Voorburg Stream and the Tokwespruit all calculating scores falling between Class A and B (largely natural). The Sand River calculated the lowest score falling between Class B and Class C (moderately modified).
- All features were delineated on a desktop level with the use of aerial photographs, digital satellite imagery and topographical maps. Portions of the features were verified during the field survey according to the guidelines advocated by DWA (2005). To comply with legislative requirements as well as to aid with conservation of habitat within the study area, during the proposed mining activities, 100m buffer zones are recommended for all features (refer to figures below);
- Legislative requirements were used to determine the extent of buffer zone required for each group depending on whether a group is considered wetland/riparian habitat or not:

- The Sand River, Tokwespruit, Banff Stream and Voorburg Stream as well as smaller drainage lines with riparian zones are defined as watercourses. If any activities are to take place within 100 meters or the 1:100 year flood lines exemption terms of Regulation General Notice (GN) 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as GN no. 1199 of 2009 as it relates to the NWA will also apply and therefore a Water Use Licence (WUL) will be required;
- Smaller drainage lines *without* riparian zones are not considered wetlands but are still defined as watercourses. If any activities are to take place with the 1:100 year flood line exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained, however Section 21 of the NWA (Act 36 of 1998) as well as GN no. 1199 of 2009 as it relates to the NWA does not apply and therefore no WUL will be required;
- Wetland depressions form part of smaller drainage lines with riparian zones and as a result are already included within the legislative requirements defined for the smaller drainage lines above; and
- Pans are considered wetland habitat, therefore a WUL in terms of section 21 c and i of the NWA will be required, and the 500 m zone of applicability of GN no. 1199 of 2009 as it relates to the NWA will also apply.
- According to GN 704 no mining activities may take place within 100m from a water course or within the 1:100 year floodline, whichever is the greatest. Given the fact that the 1:100 year floodline is much wider than the 100m (in most cases), the determining factor will for the project has been defined as the 1:100 year floodline (for the Sand River). Based on the findings of this aquatic assessment recommended a 100m buffer zone from the edge of the riparian zone (wetlands), and therefore the project will be run on the basis that no mining activities should take place within 100m from the edge of the 1:100 year floodline.

<u>The following general conclusions were drawn upon completion of the aquatic assessment:</u>

- Increased concentrations of dissolved salts were observed in a downstream direction, resulting from low flow conditions compounded by water abstraction from the system for agricultural purposes);
- pH values also increased in a downstream direction;
- The most significant impacts (instream habitat) are from water abstraction, flow modification and water quality modifications. Both sites obtained a “D” (“Largely modified”) classification with regard to instream habitat integrity;
- In the riparian zone the system has been affected by vegetation removal, alien encroachment and bank erosion;
- With regard to riparian zone habitat integrity, site GSP3 was classified as “D” (largely modified), whilst site GSP1 was classified as “C” (moderately modified);
- Overall scores of 55.9 % (GSP3) and 56.5% (GSP1) were calculated, placing both sites GSP3 and GSP1 in class D (largely modified);
- Habitat diversity and structure was considered inadequate for supporting a diversity of aquatic macro-invertebrate communities at all three downstream sites (GSP1, GSP3 and GSP4);
- Habitat conditions seem to deteriorate in a downstream direction with impacts from farming and construction evident;
- Conditions (macro-invertebrate community) in the Sand River have deteriorated in a downstream direction according to both the Dallas (2007) and the Dickens & Graham (2001) classification systems;
- At site GSP6, the stream may be considered to be in a class C (moderately impaired) condition according to the Dickens & Graham (2001) classification system and in a class D (largely impaired) condition according to the Dallas (2007) classification system;
- In comparison the downstream sites vary between class C (moderately impaired) and class E (severely impaired) conditions according to the Dickens & Graham (2001) classification system. With the Dallas (2007) classification system conditions vary between class D and class and in a class E/F for the three downstream sites (GDP4, GSP3 and GSP1);
- The MIRAI results in terms of (ecological category classification) follow the same trends as that obtained using the SASS class classifications (C for GSP6, E for GSP4, D for GSP3 and F for GSP1);
- The (ecostatus) EC classification obtained are in congruence with previous studies performed in the same system;

- The automated EC calculated for the FRAI (C/D for GSP6, E for GSP4, E for GSP3, D for GSP1 and F for the system as a whole) largely corresponds to that obtained for the MIRAI.

The impact assessment of the project highlighted that the potential impacts on the envisaged Voorburg section of the project are very high to high and with very careful mitigation can be reduced to high to moderately high levels while impacts on the Jutland section are moderately low and can be slightly reduced to lower levels. The most significant impact in the area is the impact of the proposed project on instream flow and streamflow reduction, especially on the Sand River system.

On a larger scale there is likely to be a very significant cumulative impact on the Sand River system from both the Chapudi and the Mopane projects with both systems likely to have similar types of impacts on the Sand River system. The combined impact of both these projects is likely to significantly affect the water supply and possibly the water quality in the Sand River which in turn will affect the habitat available in the system as well as the availability of refuge pools in periods of low flow and an impact on aquatic and riparian community diversity sensitivity and abundance is likely to occur. In addition these projects have the potential to affect downstream socio-cultural service provision of the Sand River system.

For these reasons extreme caution and care should take place throughout the entire life cycle of these two projects, should they proceed, in order to ensure that the impact on the Sand River system and other ephemeral systems in the area with riparian vegetation is minimised to levels which would ensure an ongoing acceptable level of functioning and biodiversity in these systems. The mitigation measures highlighted in this report are considered extremely important and all effort to implement these measures should take place in order to minimise the impacts to levels that will ensure the sustainability of the ecology of the local area and downstream areas.

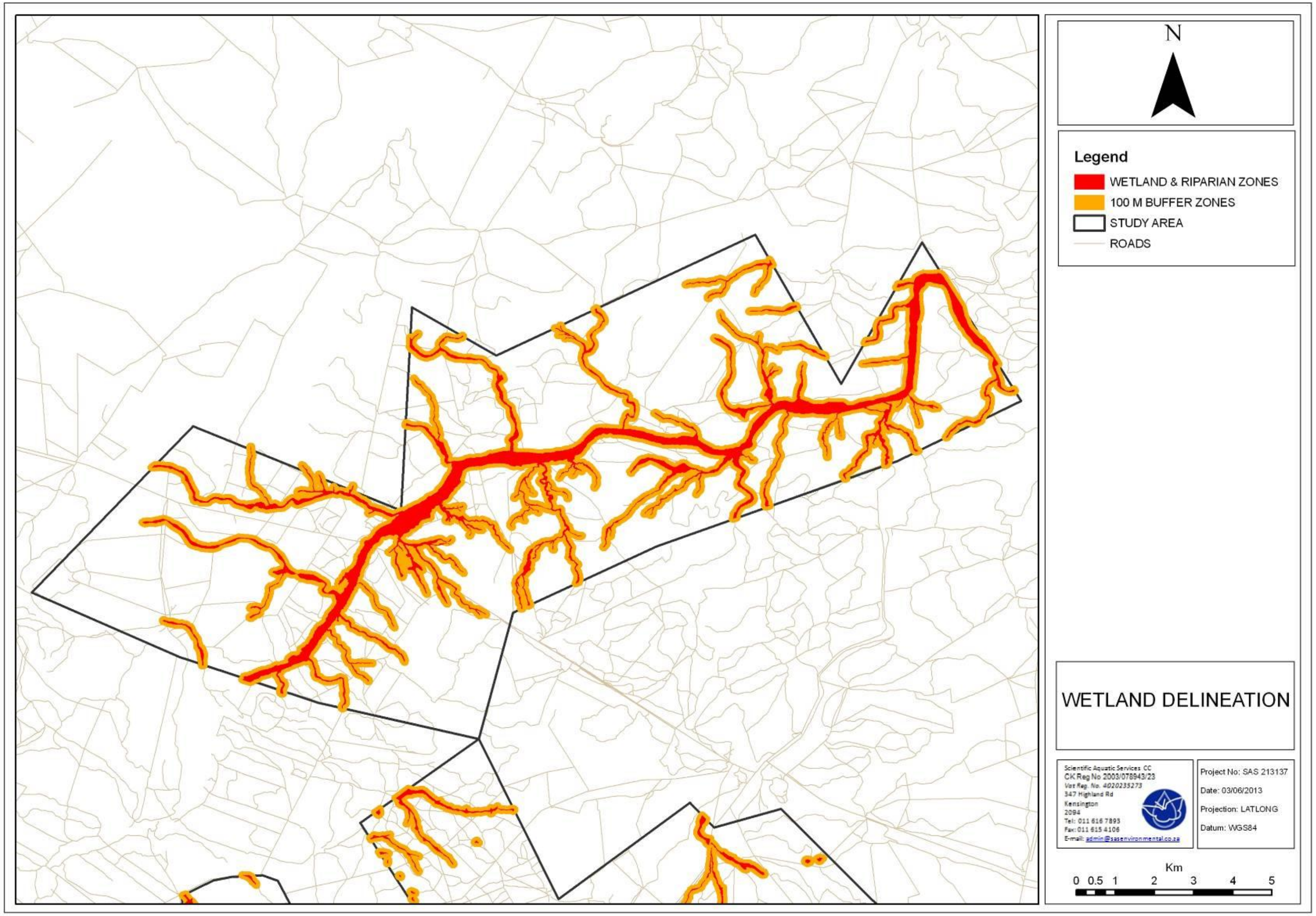

Figure B: **Allocated 100m buffer zones in relation to the Voorburg section.**

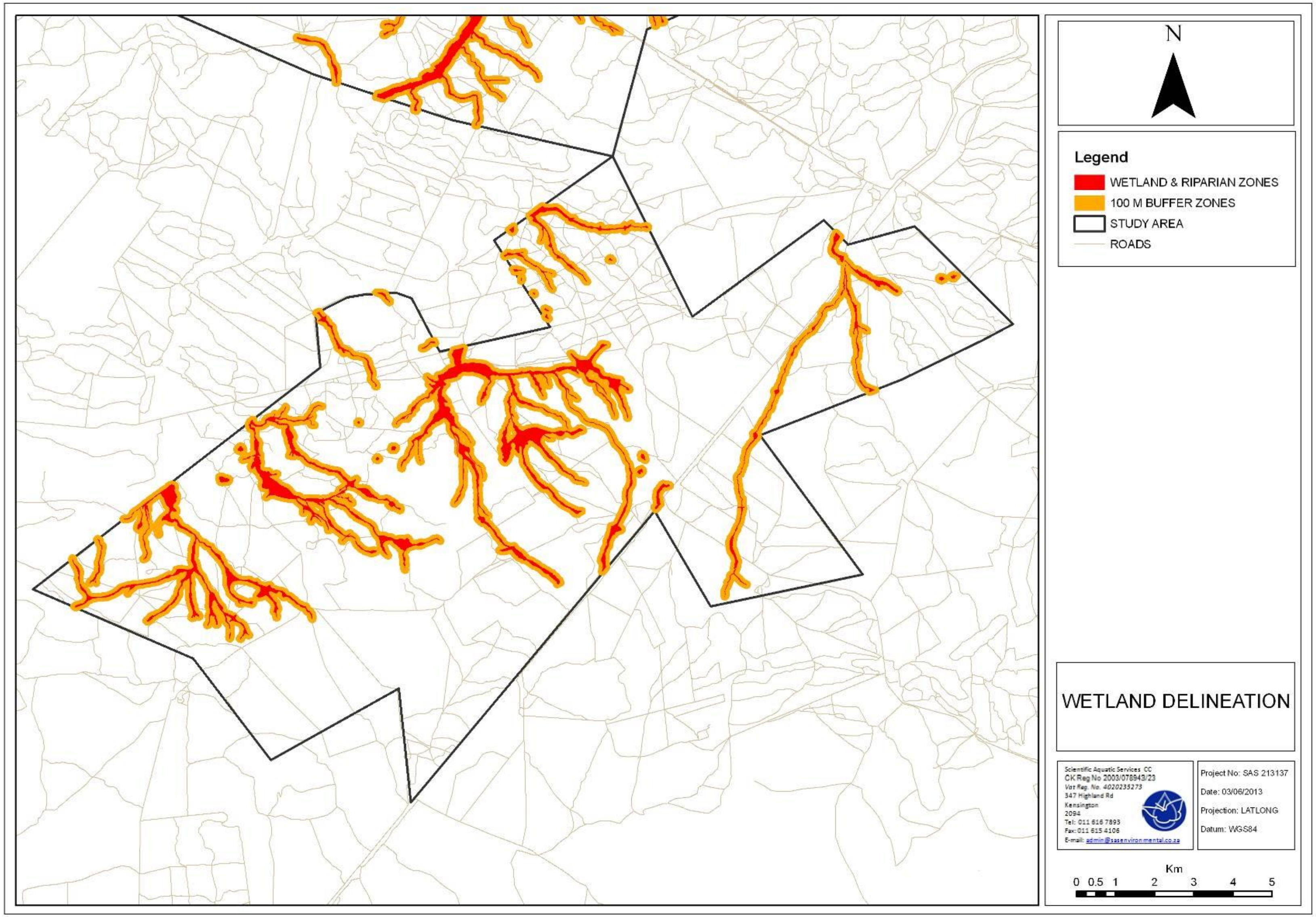

Figure C: Allocated 100m buffer zones in relation to the Jutland section.

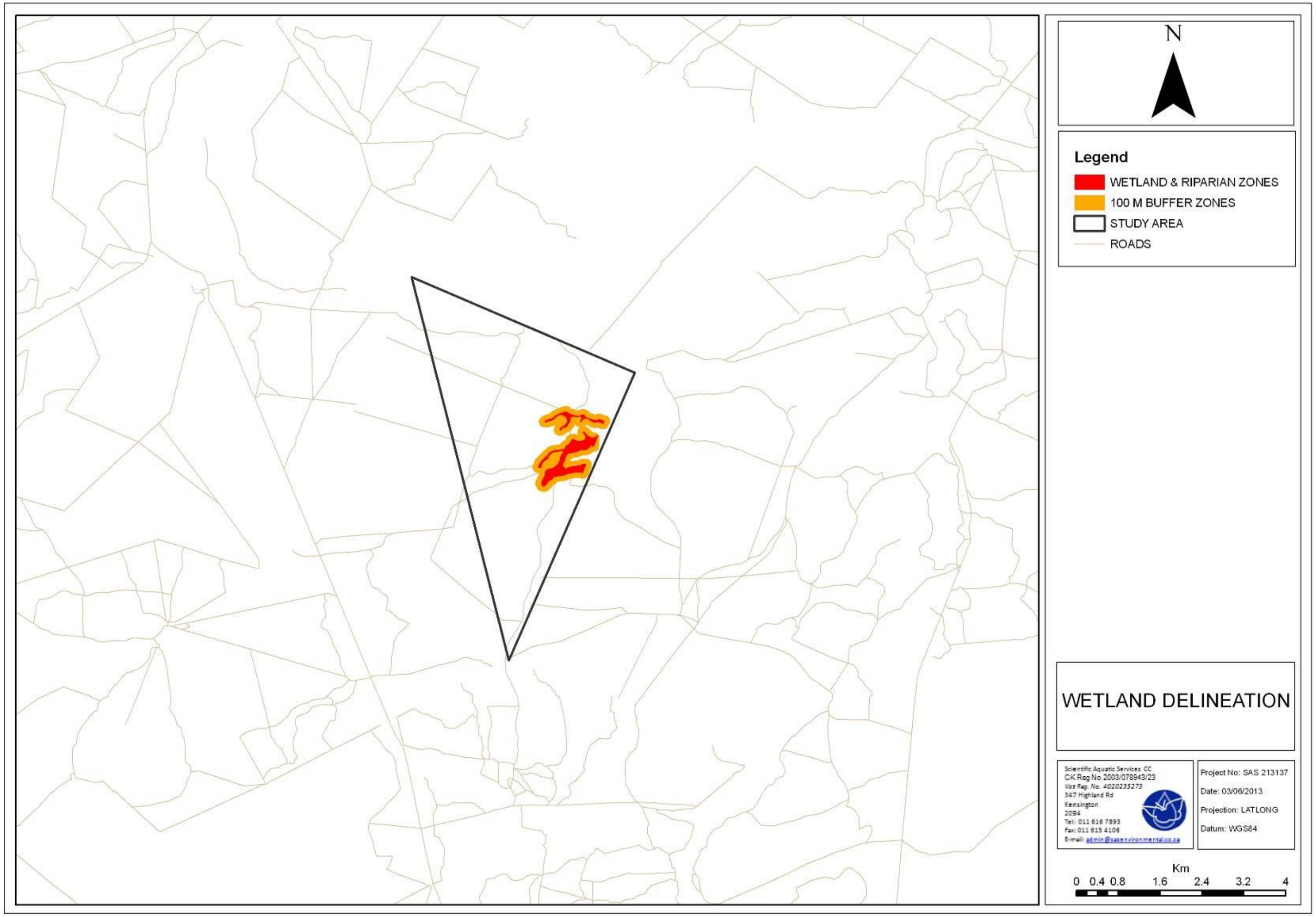

Figure D: **Allocated 100m buffer zones in relation to the Ursa Minor section.**

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Acronyms

BGIS - Biodiversity Geographic Information Systems

°C – Degrees Celsius.

DEMC -Desired Ecological Management Class

DWA – DWA

EAP - Environmental Assessment Practitioner

EIA- -Environmental Impact Assessment

EIS - EIS

EMC - Ecological Management Class

GIS – Geographic Information System

HGM – Hydrogeomorphic Units

IHI - Index of Habitat Integrity

m - meter

NAEHMP - National Aquatic Ecosystem Health Monitoring Programme

NBA – National Biodiversity Assessment

NFEPA – National Freshwater Ecosystem Priority Areas

NSBA - National Spatial Biodiversity Assessment

NWCS - National Wetland Classification System

PEMC - Present Ecological Management Class

REC - Recommended Ecological Category

RHP - River Health Program

SAS – SAS

1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to undertake a Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) analysis of the wetland, aquatic and riparian resources as part of the environmental assessment and authorisation process for the proposed Greater Soutpansberg Mopane project, located approximately 30km to the south of Musina within the Limpopo Province hereafter referred to as the 'study area'. Farms included as part of the study area are listed in the table below and extend over approximately 16 000ha (depicted in Figure 1 and Figure 2 below).

Similar applications for New Order Mining Rights (NOMRs) in terms of Section 22 of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) have been submitted by Coal of Africa Limited (CoAL), Chapudi Coal (Pty) Ltd (Chapudi), Kwezi Mining Exploration (Pty) Ltd (Kwezi) and Regulus Investment Holdings (Pty) Ltd (Regulus) based on the prospecting rights held by them in the Mopane Project area. The objective is to have a consolidated project with economically minable blocks which are contiguous.

CoAL is a shareholder of MbeuYashu (Pty) Ltd, with a shareholding of 74%. The remaining 26% is held by Rothe Investments (Pty) Ltd, a Black Economic Empowerment company as contemplated in the Mining Charter. MbeuYashu in turn holds a 100% shareholding in Chapudi and Kwezi. CoAL is also the holder of 100% of the issued shares in Regulus.

Table 1: Farms included as part of the study area.

Farm Name	Portion
Mons	All
Bierman	All
Cohen	All
Jutland	All
Stubbs	All
Honeymoon	All
Schalk	All
Verdun	RE
Faure	All
Du Toit	RE
Hermanus	All

Farm Name	Portion
Cavan	RE
Banff	All
Ancaster	RE
Ancaster	1, 2, 3
Scheveningen	All
Delft	RE
Delft	1
Delft	2
Krige	All
Vera	All
Ursa Minor	All

Pretorius	RE
Pretorius	1
Voorburg	All

van der Bijl	All
Goosen	RE and 1

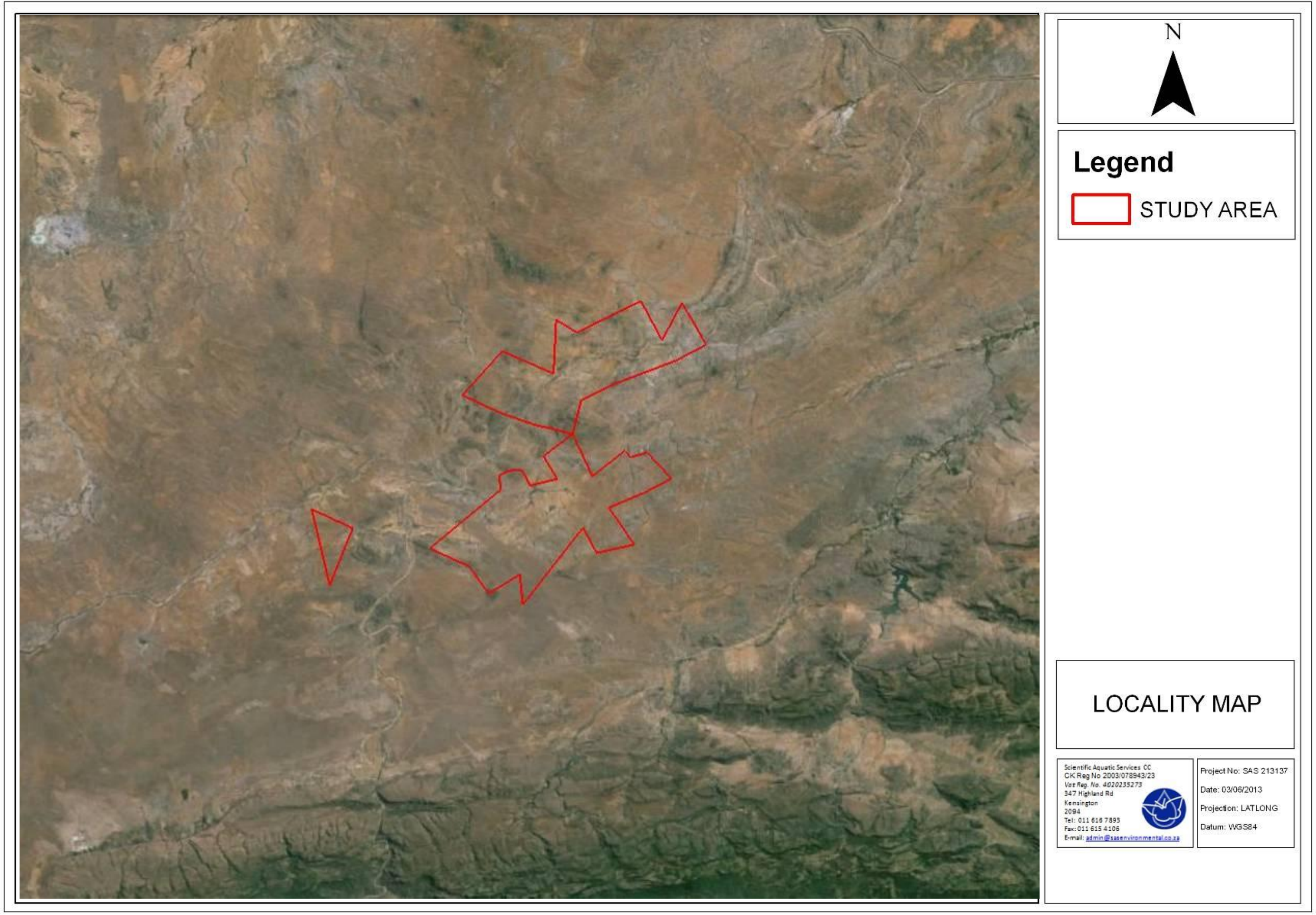

Figure 1: Location of the study area depicted on an aerial photograph in relation to surrounding areas.

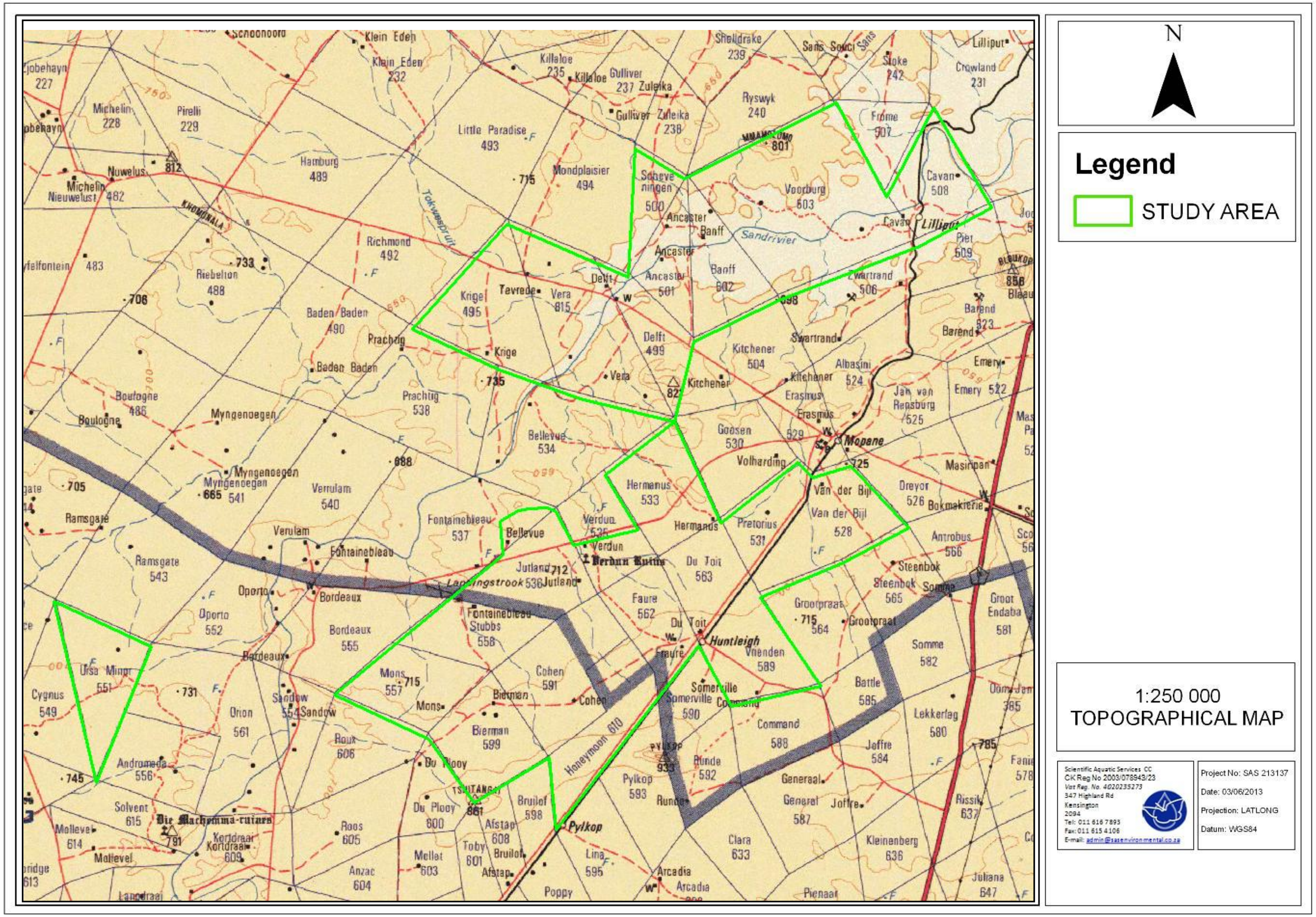

Figure 2: 1:250 000 Topographic map depicting the location of the study area in relation to surrounding areas.

1.2 Project Key Staff

Stephen van Staden

SACNASP REG.NO: **400134/05**

Stephen van Staden completed an undergraduate degree in Zoology, Geography and Environmental Management at RAU. On completion of this degree, he undertook an honours course in Aquatic health through the Zoology department at RAU. In 2002 he began a Masters degree in environmental management, where he did his mini dissertation in the field of aquatic resource management, also undertaken at RAU. At the same time, Stephen began building a career by first working at an environmental consultancy specialising in town planning developments, after which he moved to a larger firm in late 2002. From 2002 to the end of 2003, he managed the monitoring division and acted as a specialist consultant on water resource management issues and other environmental processes and applications. In late 2003, Stephen started consulting as an independent environmental scientist, specialising in water resource management under the banner of Scientific Aquatic Services. In addition to aquatic ecological assessments, clients started enquiring about terrestrial ecological assessments and biodiversity assessments. Stephen, in conjunction with other qualified ecologists, began facilitating these studies as well as highly specialised studies on specific endangered species, including grass owls and arachnids and invertebrates and various vegetation species. Scientific Aquatic Services soon became recognised as a company capable of producing high quality terrestrial ecological assessments. Stephen soon began diversifying into other fields, including the development of EIA process, EMPR activities and mine closure studies.

Stephen has experience on well over 1000 environmental assessment projects with specific mention of aquatic and wetland ecological studies as well as terrestrial ecological assessments and project management of environmental studies. Stephen has a professional career spanning more than 10 years, of which almost ten years have been as the owner and Managing member of Scientific Aquatic Services and the project manager on most projects undertaken by the company.

Stephen is registered by the SA RHP as an accredited aquatic biomonitoring specialist and is also registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) in the field of ecology. Stephen is also a member of the Gauteng Wetland Forum and South African Soil Surveyors Association (SASSO).

Natasha van de Haar

SACNASP REG.NO: **400229/11**

Natasha obtained a Masters Degree in Science (M.Sc.) in the field Botany with specialisation in Molecular Biology and Biotechnology, which was conferred in 2008. Prior to the M.Sc., she obtained an Honours Degree (B.Sc. Hons.) (Botany). Her undergraduate studies took place in the science faculty (Natural and Environmental Sciences) majoring in Botany and Zoology. All degrees were obtained from the University of Johannesburg, formerly known as the Rand Afrikaans University (RAU). Natasha initiated her professional career as a micro technologist at Le-Sel Researchers. She then went on to become a researcher and Laboratory Technician for the department of Botany and Plant Biotechnology at the University of Johannesburg. The research she undertook during this time entailed the identification of micro organisms and the role they play in the breakdown of diesel spillages. Natasha then went on to become a Laboratory Manager for Rapula Flora specialising in *Zantedeschia* tissue culture.

Natasha then joined Scientific Aquatic Services in 2009, where she began undertaking studies as a field ecologist focusing on floral biodiversity and ecological functioning, with special mention of wetland ecology and functioning within South Africa (all provinces), Lesotho and Ghana. Since then she has initiated a branch of Scientific Aquatic Services in Cape Town servicing the Western Cape, Eastern Cape as well as Northern Cape Provinces. Natasha has obtained extensive experience in conducting terrestrial as well as wetland related surveys in the mining, residential and infrastructure development industries as well as development of several wind energy facilities. Natasha also gained experience in Biodiversity Offset Initiatives as well as RDL/protected plant permit applications.

Over the course of her career, Natasha has completed a number of floral identification short courses as well as wetland assessment courses and is registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) in the field of botany. Natasha is also a member of the International Affiliation for Impact Assessments (IAIAsa) group, Botanical Society of SA as well as the Western Cape Wetlands Forum.

Louise Zdanow (B.Sc. Hons UCT)

Louise Zdanow completed an undergraduate degree majoring in botany and zoology at the Nelson Mandela Metropolitan University. This degree was awarded with distinction in 2009. On completion of this degree, Louise undertook an honours course in Botany at the University of Cape Town (2011). During her honours year she completed two mini theses, both of which focused on plant ecophysiology. During her time at UCT Louise underwent training in the identification of fynbos species and communities. From her experience in the field, she has gained an understanding of the unique systems and processes found within fynbos vegetation.

Louise graduated from UCT at the end of 2011 and joined Scientific Aquatic Services at the beginning of 2012. Since joining the company Louise has gained experience in the Western Cape, the Northern Cape as well as the Eastern Cape Provinces and has completed work in Mozambique. She has been involved in both floral and wetland based ecological assessments, including the assessment of wind energy facilities in the Western Cape, the development of rescue and relocation plans for mining developments in the Western Cape, the Northern Cape, the Limpopo and Mpumalanga Provinces and the ecological assessment of residential, mining, agricultural and infrastructural developments. Louise is also a member of the Botanical Society of South Africa as well as the Western Cape Wetlands Forum.

1.3 Indemnity and Terms of Use of this Report

The findings, results, observations, conclusions and recommendations presented in this report are based on the author’s best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and SAS cc and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

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1.4 Legislative Requirements

Minerals and petroleum Resource Development Act (MPRDA) (Act 28 of 2002)

The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the DMR for a NOMR which triggers a process of compliance with the various applicable sections of the MPRDA. The NOMR process requires environmental authorisation in terms of the MPRDA Regulations and specifically requires the preparation of a Scoping Report, an Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP), and a Public Participation Process.

National Environmental Management Act (Act 107 of 1998)

- The National Environmental Management Act (Act 107 of 1998) and the associated Regulations (Listing No R. 544, No R. 545 and R. 546) as amended in June 2010, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment process or the Environmental Impact Assessment (EIA) process depending on the nature of the activity and scale of the impact.

National Water Act (NWA; Act 36 of 1998)

- The NWA; Act 36 of 1998 recognises that the entire ecosystem and not just the water itself in any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water Affairs (DWA).
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWA in terms of Section 21 of the NWA.

General Notice (GN) 1199 as published in the Government Gazette 32805 of 2009 as it relates to the NWA, 1998 (Act 36 of 1998)

- Wetlands are extremely sensitive environments and as such, the Section 21 (c) and (i) water use General Authorisation does not apply to any wetland or any water resource within a distance of 500 meters upstream or downstream from the boundary of any wetland.

GN 704 – Regulations on use of water for mining and related activities aimed at the protection of water resources, 1999

- These Regulations, forming part of the NWA, were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.
- It is recommended that the proposed project complies with Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that:

No person in control of a mine or activity may-

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;

According to the above, the activity footprint must fall outside of the 1:100 year floodline of the drainage feature or 100m from the edge of the feature, whichever distance is the greatest.

1.5 Assumptions and Limitations

- Access to the following farms were not granted and therefore were not ground truthed: Mons, Bierman, Stubbs, Schalk, Ancaster, Scheveninge and Ursa Minor. However, the precautionary principle was applied and all features identified on a desktop level, included in the assessment as well as sensitivity mapping as part of this report
- The wetland assessment is confined to the study area as well as the immediate adjacent areas of relevance and does not include the neighbouring and adjacent properties;
- Due to the extent of the areas that form part of the study area, use was made of aerial photographs, digital satellite imagery as well as provincial and national wetland databases to identify areas of interest prior to the field survey. Any additional wetland areas and drainage lines noted during the field survey were also assessed. Although all possible measures were undertaken to ensure all wetland features, riparian zones and drainage lines were assessed and delineated, however some smaller ephemeral drainage lines may have been overlooked. However, if the sensitivity map is consulted during the planning phases of the mine the majority of wetland habitat considered to be of increased EIS will be safeguarded;
- Due to the majority of drainage features being ephemeral within the region, very few areas were encountered that displayed more than one wetland characteristic as defined by the DWA 2005 method. As a result, identification of the outer boundary of temporary wetland zones and riparian zones proved difficult in some areas and in particular in the areas where wetland conditions and riparian zones are marginal. Therefore, the wetland

delineation as presented in this report is regarded as a best estimate of the wetland boundary based on the site conditions present at the time of assessment; and

- Wetlands and terrestrial areas form transitional areas where an ecotone is formed as vegetation species change from terrestrial species to facultative wetland species. Within this transition zone some variation of opinion on the wetland or riparian zone boundary and the occurrence of a true riparian zone may occur however if the DWA 2005 method is followed, all assessors should get largely similar results; and
- Aquatic, wetland and riparian ecosystems are dynamic and complex. Some aspects of the ecology of these systems, some of which may be important may have been overlooked. The findings of this study were largely based on a single site visit undertaken late in the low flow season at a time when extremely low flows were being experienced. A more reliable assessment would have required that seasonal assessments take place with at least one assessment in the high flow season also undertaken. Some historical data for the Sand River a relatively short distance upstream of the study area from which additional inferences could be made about the system.

2 METHOD OF ASSESSMENT

2.1 Literature Review

A desktop study was compiled with all relevant information as presented by the South African National Biodiversity Institutes (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org). Wetland specific information resources taken into consideration during the desktop assessment of the study area included:

- National Freshwater Ecosystem Priority Areas (NFEPAs, 2011)
  - NFEPA water management area (WMA)
  - NFEPA wetlands/National wetlands map
  - Wetland and estuary FEPA
  - FEPA (sub)WMA % area
  - Sub water catchment area FEPAs
  - Water management area FEPAs
  - Fish sanctuaries
  - Wetland ecosystem types
- Threatened Terrestrial Ecosystems for South Africa, 2009
- National Wetlands Inventory, 2006

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the EIS, Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined, and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems.

Water resources are generally classified according to the degree of modification or level of impairment. The classes used by the South African River Health Program (RHP) are presented in the table below and will be used as the basis of classification of the systems in the study area.

Table 2: Classification of river health assessment classes in line with the RHP

Class	Description
A	Unmodified, natural.
B	Largely natural, with few modifications.
C	Moderately modified.
D	Largely modified.
E	Extensively modified.
F	Critically modified.

In addition the ecological category (EC) classification will be employed using the eco-status A to F continuum approach (Kleynhans and Louw 2007). This approach allows for boundary categories denoted as B/C, C/D etc., as illustrated in Figure 3.

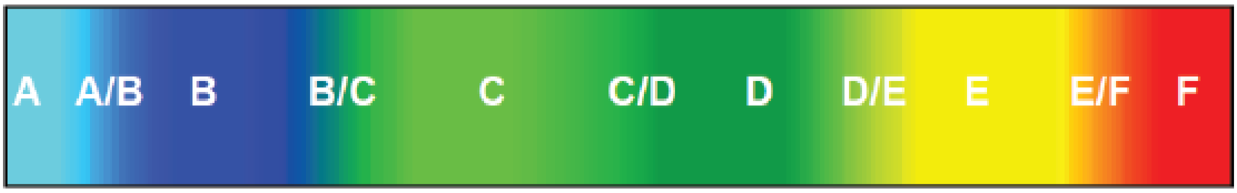


Figure 3: Ecological categories (EC) eco-status A to F continuum approach employed (Kleynhans and Louw 2007)

2.2 Wetland Site Selection and Field Verification

Due to the extent of the areas that form part of the study area, use was made of aerial photographs, digital satellite imagery as well as provincial and national wetland databases to identify points of interest prior to the field survey. Points of interest were defined taking the following into consideration:

- Ensuring a geographic spread of points to ensure that conditions in all areas were addressed; and
- Ensuring that features displaying a diversity of digital signatures were identified in order to allow for field verification. In this regard specific mention is made of the following:
  - Riparian vegetation: a distinct increase in density as well as tree size near drainage lines;
  - Hue: with drainage lines and outcrops displaying soils of varying chroma created by varying vegetation cover and soil conditions identified; and
  - Texture: with areas displaying various textures, created by varying vegetation cover and soil conditions being identified.

A site visit was undertaken during July 2013 to assess as many of the points of interest as possible which were identified during the desktop assessment phase The presence of any wetland characteristics as defined by the DWA 2005 or riparian habitat as defined by the NWA (Act 36 of 1998) was noted at each river, drainage line, pan and artificial impoundment to determine if features can be considered to contain areas displaying wetland or riparian characteristics. Factors influencing the habitat integrity of each feature group identified during the field survey was noted, the functioning and the environmental and socio-cultural services provided by the various features was determined.

2.3 Aquatic Ecological Assessment sites and site selection

Aquatic biomonitoring was undertaken at four sites in the current assessment along the Sand River. In addition two additional sites were considered where historical information was available to the south of the Mopane project area. In addition one assessment point was assessed in the middle of the Sand River which was dry, however consideration was given to the riparian vegetation at this point. Three sites (GSP8 to GSP10) represented surrounding farm dams which were assessed in order to obtain an indication of the ecology of these lacustrine systems.

Table 3 below present geographic information with regards to the monitoring points on the sand River system as well as the farm dams sampled. Figure 4 visually presents the locations of the various points along the Sand River assessed either in the current assessment or by accessing information available from the literature review and historical data collected.

Table 3: Location of the biomonitoring points with co-ordinates

Site	Detailed Site Description	GPS coordinates	
		South	East
	Riverine assessment points		
GSP1	Sand River: Most downstream point of the Mopane Project area.	-22.5280	29.8925
GSP2	Sand River: Midpoint of the Mopane Project area. The site was dry at the time of the current assessment.	-22.5437	29.7937
GSP3	Sand River: Most upstream point of the Mopane Project area.	-22.5923	29.7471
GSP4	Sand River: Downstream of the Chapudi Project area and upstream of the Mopane Project area.	-22.8068	29.6122
GSP5	Sand River: Most downstream point of the of the Chapudi Project area. This site could not be sampled at the time of the current assessment.	-22.8586	29.6270
GSP 6	Sand River: Most uptream point of the of the Chapudi Project area.	-22.9100	29.6107
GSP7	Sand River: Point upstream of Chapudi Project area. This site could not be sampled at the time of the current assessment.	-22.9270	29.6154
	Impoundment assessment points		
MOP1	Relatively large impoundment with good aquatic vegetation cover and variation in depth	-22.655487	29.786642
MOP2	An inlet to a dam. Water was shallow at this point but good cover was available	-22.665797	29.770622
MOP3	A medium sized dam with limited cover and a sandy substrate	-22.675518	29.769816

The sites assessed were all visually assessed. The Invertebrate Habitat Assessment System (IHAS), Intermediate Habitat Assessment Integrity Assessment (IHIA), fish Habitat Cover Ratings (HCR), the South African Scoring System version 5 (SASS5) and Macro-Invertebrate Risk Assessment Index (MIRAI) for the assessment of the macro-invertebrate community and the Fish Risk Assessment Index (FRAI) in order to assess the risks to the fish community were employed at sites GSP1, GSP3, GSP4 and GSP6 on the Sand River in addition to the analyses of biota specific water quality. The aquatic macro-invertebrate community and fish community as well as biota specific water quality in each of the three dams was also assessed. The protocols of applying the indices were strictly adhered to and all work was carried out by a South African River Health Program (SARHP) accredited assessor.

The use of additional sites beyond the site boundary was undertaken since these points were deemed useful to characterize the Present Ecological State (PES) of the system on a broader scale and since historical information on these points was available for previous environmental baseline studies undertaken for the Chapudi Project.

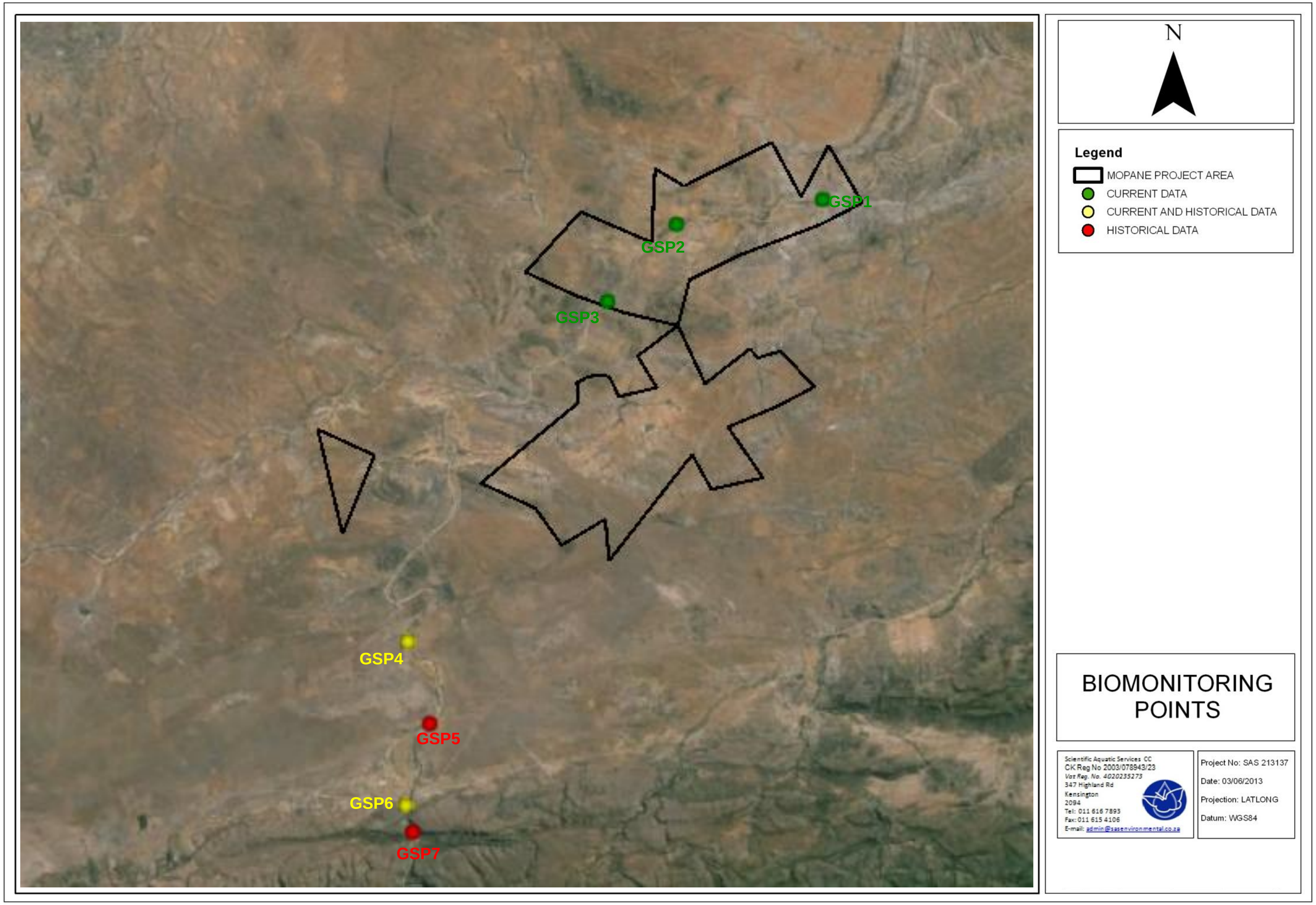


Figure 4: Aquatic ecological assessment points presented on a digital satellite image.

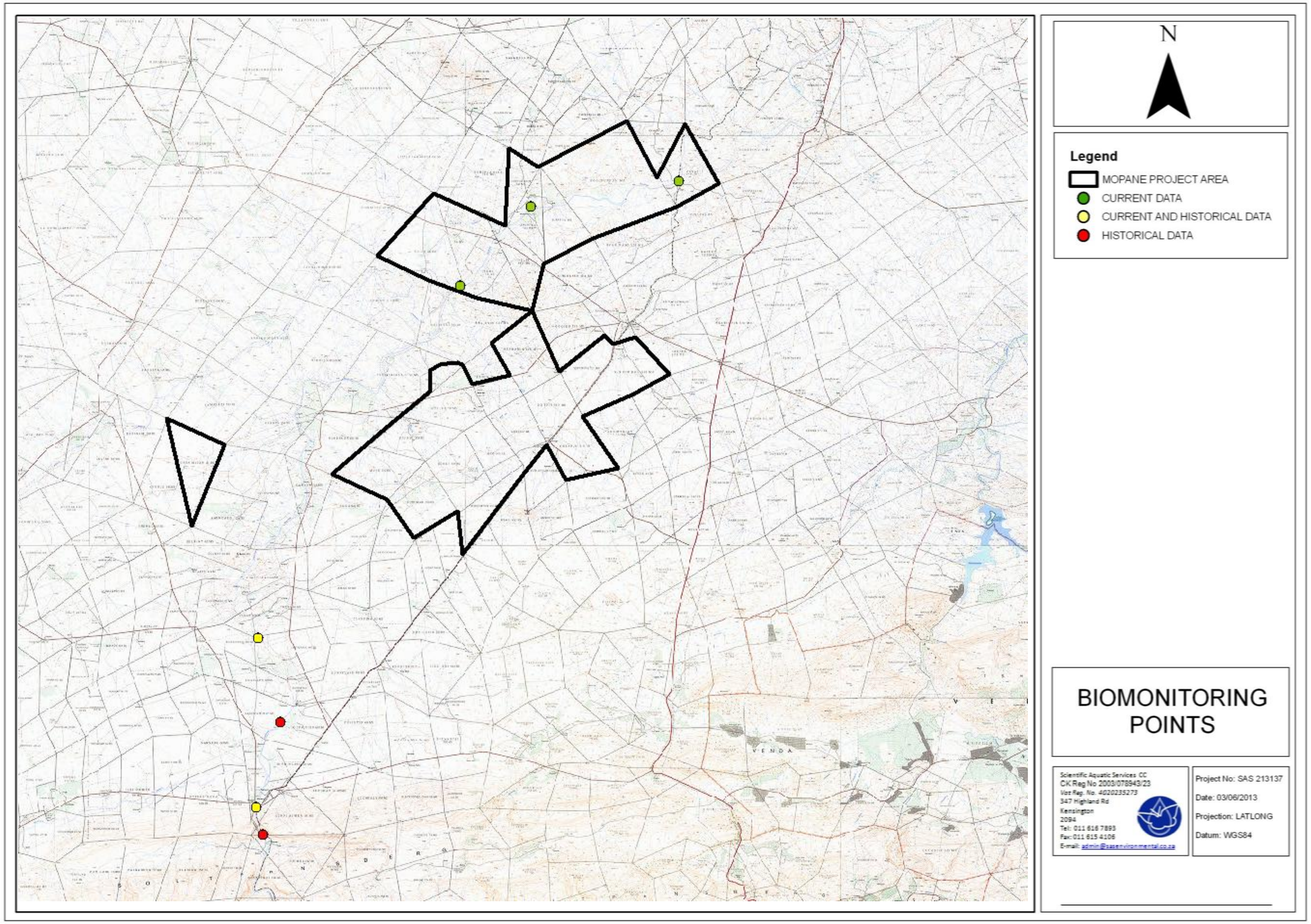


Figure 5: Riverine aquatic ecological assessment points presented on a 1:50 000 topographical map.

2.4 Classification System for Wetlands and other Aquatic Ecosystems in South Africa

All wetland features encountered within the study area were assessed using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems (Ollis *et al*., 2013).

A summary of Levels 1 to 4 of the proposed Classification System for Inland Systems are presented in Table 4 and 5, below.

Table 4: Proposed classification structure for Inland Systems, up to Level 3.

WETLAND / AQUATIC ECOSYSTEM CONTEXT		
LEVEL 1: SYSTEM	LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT
Inland Systems	DWA Level 1 Ecoregions OR NFEPA WetVeg Groups OR Other special framework	Valley Floor
		Slope
		Plain
		Bench (Hilltop / Saddle / Shelf)

Table 5: Hydrogeomorphic (HGM) Units for the Inland System, showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
River	Mountain headwater stream	Active channel
		Riparian zone
	Mountain stream	Active channel
		Riparian zone
	Transitional	Active channel
		Riparian zone
	Upper foothills	Active channel
		Riparian zone
	Lower foothills	Active channel
		Riparian zone
	Lowland river	Active channel
		Riparian zone

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
	Rejuvenated bedrock fall	Active channel
		Riparian zone
	Rejuvenated foothills	Active channel
		Riparian zone
	Upland floodplain	Active channel
		Riparian zone
Channelled valley-bottom wetland	(not applicable)	(not applicable)
Unchannelled valley-bottom wetland	(not applicable)	(not applicable)
Floodplain wetland	Floodplain depression	(not applicable)
	Floodplain flat	(not applicable)
Depression	Exorheic	With channelled inflow
		Without channelled inflow
	Endorheic	With channelled inflow
		Without channelled inflow
	Dammed	With channelled inflow
		Without channelled inflow
Seep	With channelled outflow	(not applicable)
	Without channelled outflow	(not applicable)
Wetland flat	(not applicable)	(not applicable)

2.4.1 Level 1: Inland Systems

For the proposed Classification System, Inland Systems are defined as ***an aquatic ecosystem that have no existing connection to the ocean***[1] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but ***which are inundated or saturated with water, either permanently or periodically.*** It is important to bear in mind, however, that certain Inland Systems may have had an historical connection to the ocean, which in some cases may have been relatively recent.

2.4.2 Level 2: Ecoregions

For Inland Systems, the regional spatial framework that has been included at Level 2 of the proposed Classification System is that of DWA's Level 1 Ecoregions for aquatic ecosystems (Kleynhans et al., 2005). There are a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland (figure below). DWA Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

[1] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

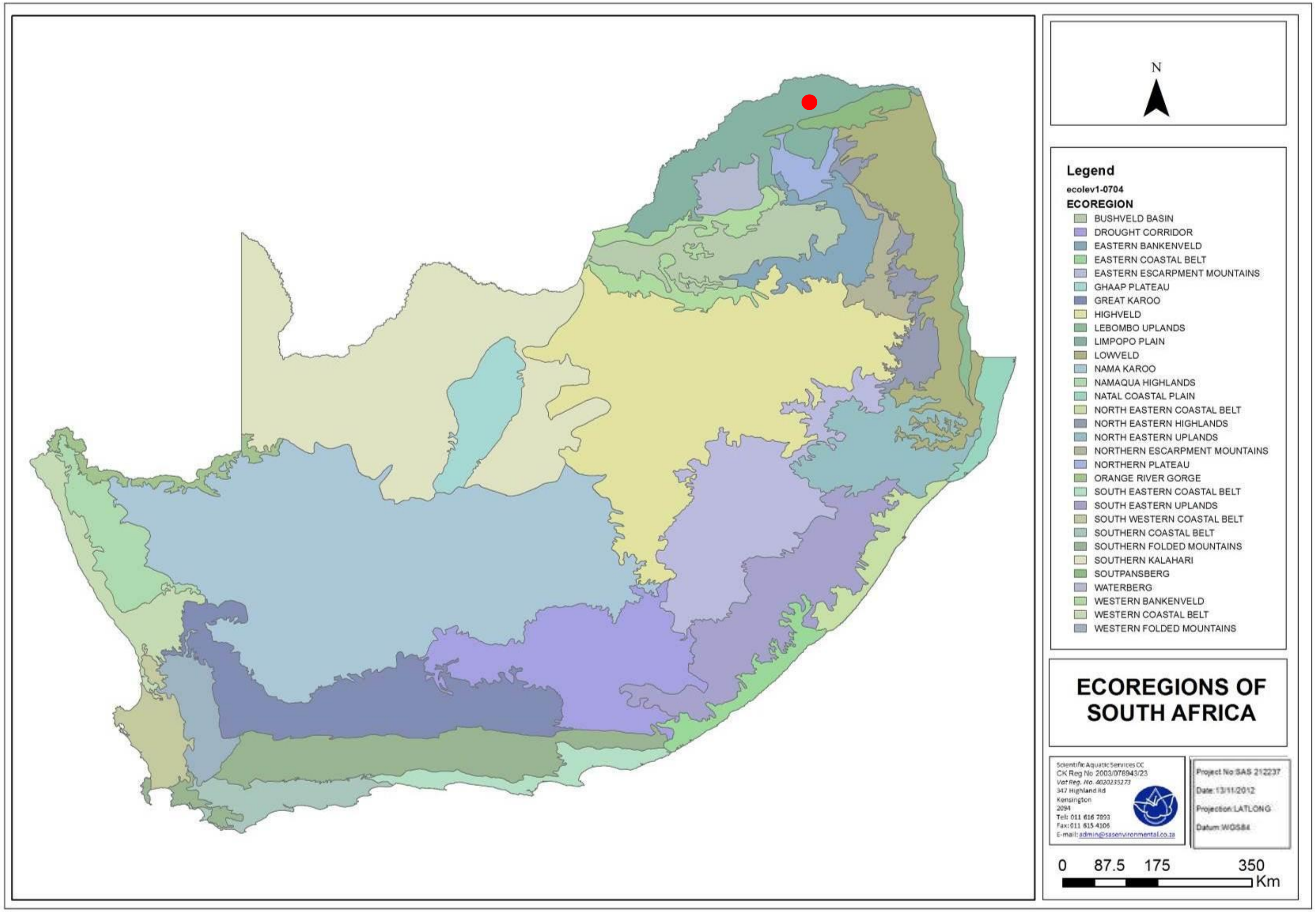


Figure 6: **Map of Level 1 Ecoregions of South Africa, with the approximate position of the study area indicated in red.**

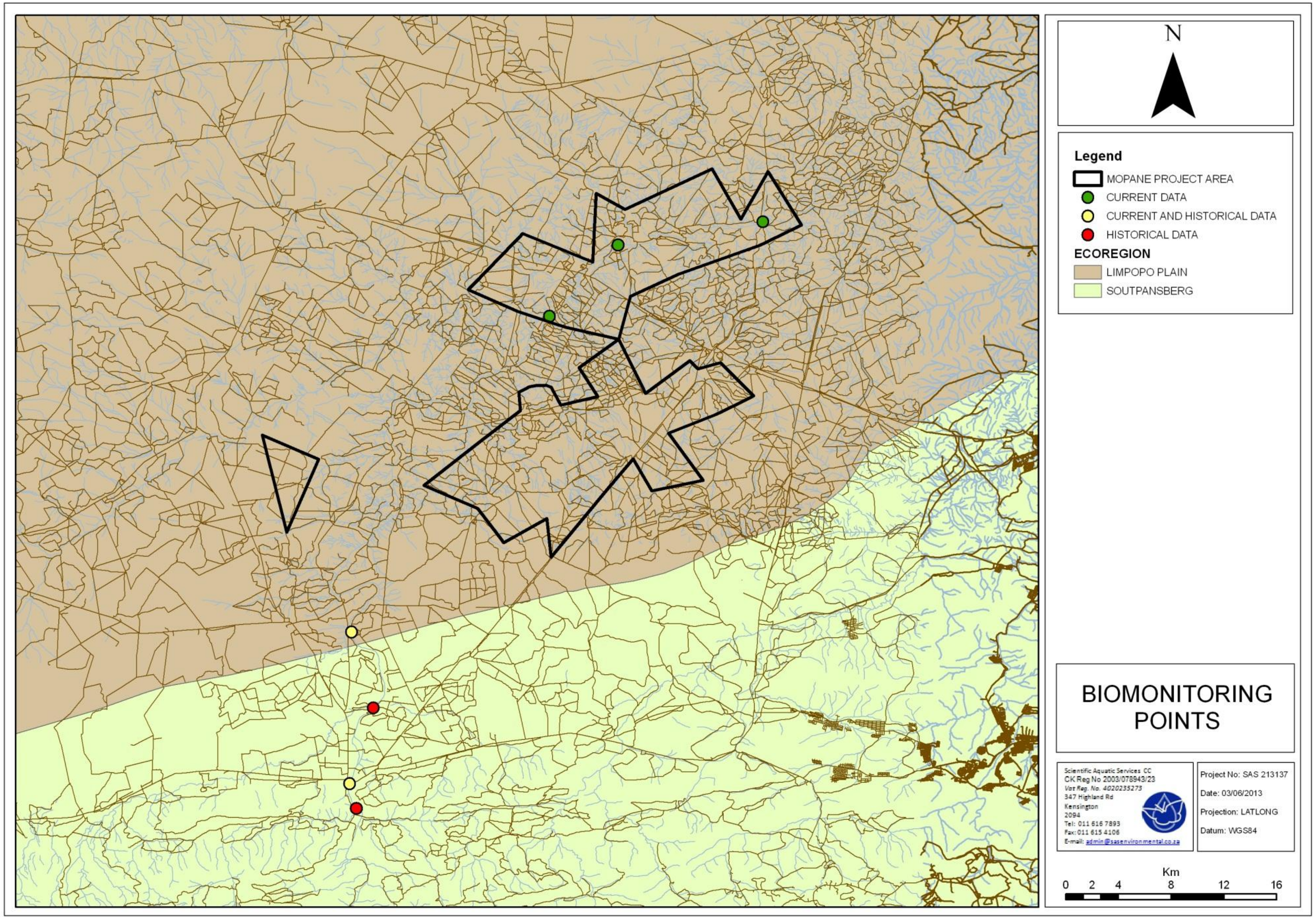


Figure 7: Map of Level 1 Ecoregions of South Africa, with the study area and aquatic ecological assessment points.

2.4.3 Level 2: NFEPA Wet Veg Groups

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) groups vegetation types across the country according to Biomes, which are then divided into Bioregions. To categorise the regional setting for the wetland component of the NFEPA project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting Bioregions into smaller groups through expert input (Nel et al., 2011). There are currently 133 NFEPA WetVeg Groups. It is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

2.4.4 Level 3: Landscape Setting

At Level 3 of the proposed classification System, for Inland Systems, a distinction is made between four Landscape Units (Table 4) on the basis of the landscape setting (i.e. topographical position) within which an HGM Unit is situated, as follows (Ollis et al., 2013):

- **Slope**: an included stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley.
- **Valley floor**: The base of a valley, situated between two distinct valley side-slopes.
- **Plain**: an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.
- **Bench** (hilltop/saddle/shelf): an area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately permendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

2.4.5 Level 4: Hydrogeomorphic Units

Eight primary HGM Types are recognised for Inland Systems at Level 4A of the proposed Classification System (Table 5), on the basis of hydrology and geomorphology (Ollis *et al*., 2013), namely:

- ***River:*** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
- ***Channelled valley-bottom wetland:*** a valley-bottom wetland with a river channel running through it.

- ***Unchannelled valley-bottom wetland:*** a valley-bottom wetland without a river channel running through it.
- ***Floodplain wetland:*** the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank.
- ***Depression:*** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.
- ***Wetland Flat:*** a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat
- ***Seep:*** a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the Classification System to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for “channel”, “flat” and “valleyhead seep”) is used, for example, in the recently developed tools produced as part of the Wetland Management Series including WET-Health (Macfarlane et al., 2008) and WET-EcoServices (Kotze et al., 2005).

2.5 WET-Health

Healthy wetlands are known to provide important habitats for wildlife and to deliver a range of important goods and services to society. Management of these systems is therefore essential if these attributes are to be retained within an ever changing landscape. The primary purpose of this assessment[2] is to evaluate the ecophysical health of wetlands, and in so doing promote their conservation and wise management.

2.5.1 Level of Evaluation

Two levels of assessment are provided by WET-Health:

- Level 1: Desktop evaluation, with limited field verification. This is generally applicable to situations where a large number of wetlands need to be assessed at a very low resolution;

[2] Kleynhans et al., 2007

- Level 2: On-site evaluation. This involves structured sampling and data collection in a single wetland and its surrounding catchment; and
- Due to the extensive areas that were needed to be covered for this project this study was undertaken as a level 1 assessment.

2.5.2 Framework for the Assessment

A set of three modules has been synthesised from the set of processes, interactions and interventions that take place in wetland systems and their catchments: hydrology (water inputs, distribution and retention, and outputs), geomorphology (sediment inputs, retention and outputs) and vegetation (transformation and presence of introduced alien species).

2.5.3 Units of Assessment

Central to WET-Health is the characterisation of hydrogeomorphic (HGM) units, which have been defined based on geomorphic setting (e.g. hillslope or valley-bottom; whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated) and pattern of water flow through the wetland unit (diffusely or channelled) as described under the *Classification System for Wetlands and other Aquatic Ecosystems* in Section 2.2.

2.5.4 Quantification of Present State of a Wetland

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. This takes the form of assessing the spatial *extent* of impact of individual activities and then separately assessing the *intensity* of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall *magnitude* of impact. The impact scores and Present State categories are provided in Table 6.

Table 6: Impact scores and categories of present State used by WET-Health for describing the integrity of wetlands.

Impact category	Description	Impact score range	Present State category
None	Unmodified, natural	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

2.5.5 Assessing the Anticipated Trajectory of Change

As is the case with the Present State, future threats to the state of the wetland may arise from activities in the catchment upstream of the unit or from within the wetland itself or from processes downstream of the wetland. In each of the individual sections for hydrology, geomorphology and vegetation, five potential situations exist depending upon the direction and likely extent of change (Table 7).

Table 7: Trajectory of Change classes and scores used to evaluate likely future changes to the present state of the wetland.

Change Class	Description	HGM change score	Symbol
Substantial improvement	State is likely to improve substantially over the next 5 years	2	↑↑
Slight improvement	State is likely to improve slightly over the next 5 years	1	↑
Remain stable	State is likely to remain stable over the next 5 years	0	→
Slight deterioration	State is likely to deteriorate slightly over the next 5 years	-1	↓
Substantial deterioration	State is expected to deteriorate substantially over the next 5 years	-2	↓↓

2.5.6 Overall Health of the Wetland

Once all HGM units have been assessed, a summary of health for the wetland as a whole needs to be calculated. This is achieved by calculating a combined score for each component by area-weighting the scores calculated for each HGM unit. Recording the health assessments for the hydrology, geomorphology and vegetation components provides a summary of impacts, Present State, Trajectory of Change and Health for individual HGM units and for the entire wetland.

2.6 Riparian Vegetation Response Assessment Index (VEGRAI)

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

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[3]. Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

Table 8: Descriptions of the A-F ecological categories.

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

[3] Kleynhans et al, 2007

2.7 Wetland Function Assessment

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[4] The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et al* (2005). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- · Flood attenuation
- · Stream flow regulation
- · Sediment trapping
- · Phosphate trapping
- · Nitrate removal
- · Toxicant removal
- · Erosion control
- · Carbon storage
- · Maintenance of biodiversity
- · Water supply for human use
- · Natural resources
- · Cultivated foods
- · Cultural significance
- · Tourism and recreation
- · Education and research

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the wetlands. Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the wetland.

Table 9: Classes for determining the likely extent to which a benefit is being supplied.

Score	Rating of the likely extent to which the benefit is being supplied
<0.5	Low
0.5-1.2	Moderately low
1.3-2	Intermediate
2.1-3	Moderately high
>3	High

[4] DWA and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999*

2.8 Index of Habitat Integrity (IHI)

The WETLAND-IHI[5] is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the RHP. The WETLAND-IHI has been developed to allow the NAEHMP to include floodplain and channelled valley bottom wetland types to be assessed. The output scores from the WETLAND-IHI model are presented in A-F ecological categories (Table below), and provide a score of the PES of the habitat integrity of the wetland system being examined.

Table 10: Descriptions of the A-F ecological categories (after Kleynhans, 1996, 1999).

Ecological Category	PES % Score	Description
A	90-100%	Unmodified, natural.
B	80-90%	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	60-80%	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	40-60%	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. E 20-40% Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
E	20-40%	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0-20%	Critically / Extremely modified. Modifications have reached a critical level and the 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.

2.9 Recommended Ecological Category (REC)

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability, but carries a higher risk of ecosystem failure." [6]

The REC was determined based on the results obtained from the PES, reference conditions and EIS of the resource (sections above). Followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

[5] DWA and Forestry Resource Quality Services, 2007

[6] DWA and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources 1999*

A wetland may receive the same class for the PES, as the REC if the wetland is deemed to be in good condition, and therefore must stay in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as to enhance the PES of the wetland feature.

Table 11: Description of REC classes.

Class	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified
E/F	Unacceptable/intolerable

2.10 Wetland Delineation

For the purposes of this investigation, a wetland habitat is defined in the NWA (Act 36 of 1998) as including the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.

The wetland zone delineation of the rivers features took place according to the method presented in the final draft of "A practical field procedure for identification and delineation of wetlands and riparian areas" published by the DWA in February 2005. Based on these delineation principles the foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils and
- The presence of alluvial soils in stream systems.

By observing the evidence of these features, in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWA 2005).

Riparian and wetland zones can be divided into three zones (DWA 2005). The permanent zone of wetness is nearly always saturated. The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year, but is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland area.

2.11 Visual Assessment of Aquatic Assessment Points

Each site was selected in order to identify current conditions, with specific reference to impacts from surrounding activities where applicable. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the systems identified, was identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual records of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- Upstream and downstream significance of each point, where applicable;
- Significance of the point in relation to the study area;
- stream morphology;
- instream and riparian habitat diversity;
- stream continuity;
- erosion potential;
- depth flow and substrate characteristics;
- signs of physical disturbance of the area; and
- other life forms reliant on aquatic ecosystems.

2.12 Physico-chemical Water Quality Data

On site testing of biota specific water quality variables took place on all sites where surface water was present. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF, 1996 vol. 7).

2.13 Intermediate Habitat Integrity Assessment (IHIA)

It is important to assess the habitat of riverine systems in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration. The general habitat integrity of the sites was assessed based on the application of the Intermediate Habitat Integrity Assessment for (Kemper; 1999). The Intermediate Habitat Integrity Assessment (IHIA) protocol, as described by Kemper (1999), was used using the site specific application protocols. This is a simplified procedure, which is based on the Habitat Integrity approach developed by Kleynhans (1996). The IHIA is conducted as a first level exercise, where a comprehensive exercise is not practical. The Habitat Integrity of each site was scored according to 12 different criteria which represent the most important (and easily quantifiable) anthropogenically induced possible impacts on the system. The instream and riparian zones were analysed separately, and the final assessment was then made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone is, primarily interpreted in terms of the potential impact on the instream component. The assessment of the severity of impact of modifications is based on six descriptive categories with ratings. Analysis of the data was carried out by weighting each of the criteria according to Kemper (1999). By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score can be obtained for each site. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitats of the sites. The method classifies Habitat Integrity into one of six classes, ranging from unmodified/natural (Class A), to critically modified (Class F).

2.14 Invertebrate Habitat Suitability (Invertebrate Habitat Assessment: IHAS)

The Invertebrate Habitat Assessment System (IHAS) was applied to sites GSP1, GSP3, GSP4 and GSP6 according to the protocol of McMillan (1998). This index was used to determine specific habitat suitability for aquatic macro-invertebrates, as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65%: habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community.

- 65%-75%: habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community.
- >75%: habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community.

2.15 Aquatic Macro-Invertebrates: South African Scoring System (SASS5)

Aquatic macro-invertebrate communities of the accessible sites (GSP1, GSP3, GSP4 and GSP6) were investigated according to the method, which is specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998). The assessment was undertaken according to the South African Scoring System (SASS) protocol as defined by Dickens and Graham (2001). All work was undertaken by an accredited South African Scoring System, version 5 (SASS5) practitioner.

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score in conjunction with a low habitat score can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score together with a high habitat score would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

The perceived reference state for the local streams was determined in consideration of the ecoregion conditions as well as local habitat conditions. Local conditions are extremely poorly suited for supporting aquatic macro-invertebrates and very low diversities and abundances of aquatic macro-invertebrates can be expected. Only more tolerant taxa and those with specific adaptations to the unstable sandy habitat are deemed likely to occur in the area. Reference scores were defined as a SASS5 score of 128 and an Average Score Per Taxon (ASPT) of 5.5. Interpretation of the results in relation to the reference scores was made according to the classification of SASS5 scores presented in the SASS5 methodology published by Dickens and Graham (2001) as well as according to Dallas (2007).

Table 12: Definition of Present State Classes in terms of SASS and ASPT scores as presented in Dickens and Graham (2001)

Class	Description	SASS Score%	ASPT%
A	Unimpaired. High diversity of taxa with numerous sensitive taxa.	90-100 80-89	Variable >90
B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.	80-89 70-79 70-89	<75 >90 76-90
C	Moderately impaired. Moderate diversity of taxa.	60-79 50-59 50-79	<60 >75 60-75
D	Largely impaired. Mostly tolerant taxa present.	50-59 40-49	<60 Variable
E	Severely impaired. Only tolerant taxa present.	20-39	Variable
F	Critically impaired. Very few tolerant taxa present.	0-19	Variable

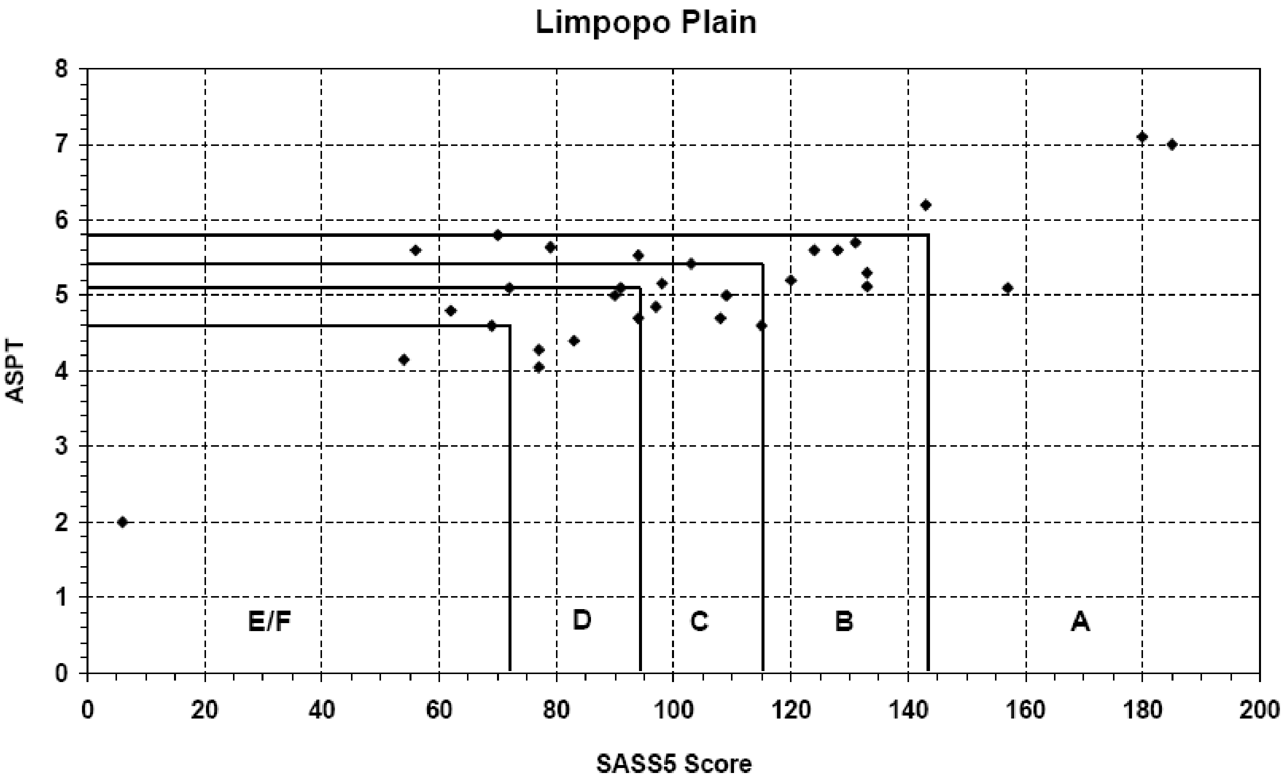


Figure 8: SASS5 Classification using biological bands calculated form percentiles for the Limpopo plain ecoregion, Dallas, 2007

2.16 Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with particular reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs. An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions).

To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly habitat preferences and requirements for each taxa present should be obtained. As such reference conditions can be established against which any response to drivers can be measured. Secondly habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result expected and actual patterns can be evaluated to achieve an ECostatus Category (EC) rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to sites GSP1, GSP3, GSP4 and GSP6 following methodology described by Thirion (2007). Aquatic macro-invertebrates expected at each point were derived both from previous studies of rivers near the area as well as habitat, flow and water parameters (Thirion 2007).

2.17 Fish biota: Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)

This approach was developed to assess habitats according to different attributes that are surmised to satisfy the habitat requirements of various fish species. At each site, the following depth-flow (df) classes are identified, namely:

- Slow (<0.3m/s), shallow (<0.5m) - Shallow pools and backwaters.
- Slow, deep (>0.5m) - Deep pools and backwaters.
- Fast (>0.3m/s), shallow - Riffles, rapids and runs.
- Fast, deep - Usually rapids and runs.

The relative contribution of each of the above mentioned classes at a site was estimated and indicated as:

0 = Absent

1 = Rare (<5%)

2 = Sparse (5-25%)

3 = Moderate (25-75%)

4 = Extensive (>75%)

For each depth-flow class, the following cover features (cf) -considered to provide fish with the necessary cover to utilise a particular flow and depth class- were investigated:

- Overhanging vegetation
- Undercut banks and root wads
- Stream substrate
- Aquatic macrophytes

The amount of cover present at each of these cover features (cf) was noted as:

0 = absent

1 = Rare/very poor (<5%)

2 = Sparse/poor (5-25%)

3 = Moderate/good (25-75%)

4 = Extensive/excellent (>75%)

The fish habitat cover rating (HCR) was calculated as follows:

- The contribution of each depth-flow class at the site was calculated (df/Σdf).
- For each depth-flow class, the fish cover features (cf) were summed (Σcf).

  HCR = df/Σdf x Σcf.

The amount and diversity of cover available for the fish community at the selected sites was graphically expressed as habitat cover ratings (HCR) for different flow-depth classes as a stacked bar chart.

2.18 Fish biota: Fish Response Assessment Index (FRAI)

The FRAI (Kleynhans 2008) is based on the premise that “drivers” (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species.

This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category (EC) shown previously in Figure 3. Fish expected to occur in the system is summarised in Table 13.

Table 13: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the Sand River (Limpopo River system) of the study area (Skelton, 2001; Kleynhans, 2003; Kleynhans, Louw and Moolman, 2007).

SPECIES NAME	COMMON NAME	INTOLERANCE RATING [2]	COMMENTS
Barbus paludinosis [1]	Straightfin barb	1.8	Widespread
Barbus trimaculatus [1]	Threespot barb	2.2	Common in many river systems of southern Africa
Barbus unitaeniatus [1]	Longbeard barb	1.7	Widely distributed in southern Africa
Barbus bifrenatus	Hyphen barb	2.8	Widespread in the northern parts of southern Africa, including the Limpopo River systems
Barbus viviparus	Bowstripe barb	2.4	East coastal rivers from the Ruvuma south to Vungu in KwaZulu-Natal.
Barbus mattozi [1]	Papermouth	3.0	Limpopo system, headwater of Zambezi and Cunene.
Barbus toppini [1]	East coast barb	2.3	East coastal rivers from Malawi south to Mkuze system in KwaZulu-Natal.
Chiloglanis pretoriae	Shortspine Suckermouth or Rock catlet	4.6	Widespread (Incomati, Limpopo & Zambezi)
Chiloglanis paratus [1]	Sawfin Suckermouth or Sawfin rock catlet	3.5	Incomati, Limpopo & Phongolo River systems
Clarias gariepinus [1]	*Sharptooth Catfish*	1.2	Most widely distributed fish in Africa.
Cyprinus carpio	Carp	1.4	Widespread alien species
Gambusia affinis	Mosquito fish	2.0	Widespread
Labeo cylindricus	Redeye labeo	3.1	Widespread East-African rivers down to Phongolo system in KwaZulu-Natal
Labeo molybdinus	Leaden labeo	3.2	Middle and lower Zambezi down to Tugela system in KwaZulu-Natal
Labeo ruddi	Silver labeo	2.8	Warmer Lowveld regions of Limpopo and Incomati systems, also Cunene river
Labeo rosae	Rednose labeo	2.4	Lowveld region of the Limpopo, Incomati and Phongolo systems
Labeobarbus marequensis [1]	Largescale yellowfish	2.6	Widespread but unlikely to occur at the site
Mesobola brevianelis	River sardine	2.3	East coastal rivers from Limpopo to Umfolozi in KwaZulu-Natal
Micralestes acutidens	Silver robbers	2.3	Cunene, Okavango, Zambezi and east coast rivers south to Phongolo.
Micropterus salmoides	Largemouth bass	2.2	Widespread
Oreochromis mossambicus [1]	Blue Kurper	1.3	Widespread
Pseudocrenilabrus philander [1]	Southern mouthbrooder	1.3	Widespread
Tilapia sparrmanii	Banded Tilapia	1.3	Widespread
Tilapia rendalli	Redbreast tilapia	1.8	Cunene, Okavango, Zambezi and east coast rivers south to Phongolo.
Schilbe intermedius [1]	Silver catfish	1.7	Cunene, Okavango, Zambezi and east coast rivers south to Phongolo.

Tolerant: 1-2; Moderately tolerant :> 2-3; Moderately Intolerant: >3-4; Intolerant: >4

[1] **Fish species previously encountered in the Sand River (catchment A71J) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007). Based on known distribution (Limpopo River system) and habitat preference (e.g. Skelton 2001) the other species listed may, however, also occur in the area. For details of actual collection data and FROC values employed refer to Results section.**
[2] **Average overall intolerance rating as per Kleynhans (1999).**

2.19 Impact Assessment Report

In order for the Environmental Assessment Practitioner (EAP) to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The first stage of the risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that is possessed by an organisation.
- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[7]. The interaction of an aspect with the environment may result in an impact.
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or wellbeing, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.

[7] The definition has been aligned with that used in the ISO 14001 Standard.

- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the table below. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary[8].

The assessment of significance is undertaken twice. Initial, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

[8] Some risks/impacts that have low significance will however still require mitigation

Table 14: Criteria for assessing significance of impacts

LIKELIHOOD DESCRIPTORS

Probability of impact	RATING
Highly unlikely	1
Possible	2
Likely	3
Highly likely	4
Definite	5
Sensitivity of receiving environment	**RATING**
Ecology not sensitive/important	1
Ecology with limited sensitivity/importance	2
Ecology moderately sensitive/ /important	3
Ecology highly sensitive /important	4
Ecology critically sensitive /important	5

CONSEQUENCE DESCRIPTORS

Severity of impact	RATING
Insignificant / ecosystem structure and function unchanged	1
Small / ecosystem structure and function largely unchanged	2
Significant / ecosystem structure and function moderately altered	3
Great / harmful/ ecosystem structure and function Largely altered	4
Disastrous / ecosystem structure and function seriously to critically altered	5
Spatial scope of impact	**RATING**
Activity specific/ < 5 ha impacted / Linear features affected < 100m	1
Development specific/ within the site boundary / < 100ha impacted / Linear features affected < 100m	2
Local area/ within 1 km of the site boundary / < 5000ha impacted / Linear features affected < 1000m	3
Regional within 5 km of the site boundary / < 2000ha impacted / Linear features affected < 3000m	4
Entire habitat unit / Entire system/ > 2000ha impacted / Linear features affected > 3000m	5
Duration of impact	**RATING**
One day to one month	1
One month to one year	2
One year to five years	3
Life of operation or less than 20 years	4
Permanent	5

Table 15: Significance rating matrix

LIKELIHOOD (Frequency of activity + Frequency of impact)	CONSEQUENCE (Severity + Spatial Scope + Duration)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 16: Positive/Negative Mitigation Ratings

Significance Rating	Value	Negative Impact management recommendation	Positive Impact management recommendation
Very High	126 - 150	Consider the viability of the project. Very strict measures to be implemented to mitigate impacts according to the impact mitigation hierarchy	Actively promote the project
High	101 - 125	Consider alternatives in terms of project execution and location. Ensure designs take environmental sensitivities into account and Ensure management and housekeeping is maintained and attention to impact minimisation is paid according to the impact mitigation hierarchy	Promote the project and monitor ecological performance
Medium High	76 – 100	Consider alternatives in terms of project execution and Ensure management and housekeeping is maintained and attention to impact minimisation is paid according to the impact mitigation hierarchy	Implement measures to enhance the ecologically positive aspects of the project while managing any negative impacts
Medium Low	51 - 75	Ensure management and housekeeping is maintained and attention to impact minimisation is paid	Implement measures to enhance the ecologically positive aspects of the project while actively managing any negative impacts
Low	26 - 50	Promote the project and ensure management and housekeeping is maintained	Monitor ecological performance and pay extensive attention to minimising potential negative environmental impacts
Low Very	1 - 25	Promote the project	Actively seek measures to implement impact minimisation according to the impact mitigation hierarchy and identify positive ecological aspects to be promoted

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the *project's area of influence* encompassing:
  - Primary project site and related facilities that the client and its contractors develops or controls;
  - Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and
  - Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- Risks/Impacts were assessed for all stages of the project cycle including:
  - Pre-construction
  - Construction and;
  - Operation.
  - Decommissioning and closure
- If applicable, transboundary or global effects were assessed;
- Individuals or groups who may be differentially or disproportionately affected by the project because of their *disadvantaged* or *vulnerable* status were assessed.
- Particular attention was paid to describing any residual impacts that will occur after rehabilitation.

2.19.1 Mitigation Measure Development

The following points present the key concepts considered in the development of mitigation measures for the proposed construction.

- *Mitigation* and *performance improvement measures* and actions that address the risks and impacts[9] are identified and described in as much detail as possible. Mitigating measures are investigated according to the impact minimisation hierarchy as follows:
  - Avoidance or prevention of impact
  - Minimisation of impact
  - Rehabilitation
  - Offsetting
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation.

[9] Mitigation measures should address both positive and negative impacts

- Desired outcomes are defined, and have been developed in such a way as to be *measurable events with performance indicators, targets and acceptable criteria* that can be tracked over *defined periods*, wherever possible.

2.19.2 Recommendations possible

Recommendations were developed to address and mitigate potential impacts on the wetland ecology associated with the Greater Soutpansberg Mopane project. These recommendations also include specific management measures applicable to individual Wetland Management Units as well as general management measures which apply to the mine area as a whole.

3 RESULTS OF LITERATURE REVIEW

3.1 Conservation Importance of the Study Area with Regards to Wetlands

3.1.1 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 Greater Soutpansberg Mopane Project falls within the Limpopo Plain Aquatic Ecoregion and is located within the A71J, A71K and A72B quaternary catchments. Figure 9 below indicates the aquatic ecoregions and quaternary catchments.

Table 17: Summary of the ecological status of the Limpopo Plains Region.

MAIN ATTRIBUTES	LIMPOPO PLAIN
Terrain Morphology: Broad division (dominant types in bold) (Primary)	**Plains; Low Relief;** Plains Moderate Relief; Lowlands; Hills and Mountains; Moderate and High Relief; Closed Hills; Mountains; Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	**Mopane Bushveld; Sweet Bushveld; Mixed Bushveld** Waterberg Moist Mountain Bushveld; Clay hills; Mountains; Kalahari Plains Thorn Bushveld
Altitude (m a.m.s.l) (modifying)	300-1100 (1100-1300 limited)
MAP (mm) (Secondary)	200 to 600
Coefficient of Variation (% of annual precipitation)	25 to 40
Rainfall concentration index	60 to >65
Rainfall seasonality	Early to mid-summer
Mean annual temp. (°C)	18 to >22
Mean daily max. temp. (°C): February	26 to 32
Mean daily max. temp. (°C): July	20 to >24
Mean daily min. temp. (°C): February	16 to >20
Mean daily min temp. (°C): July	2 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 to 60 (60-100 limited)

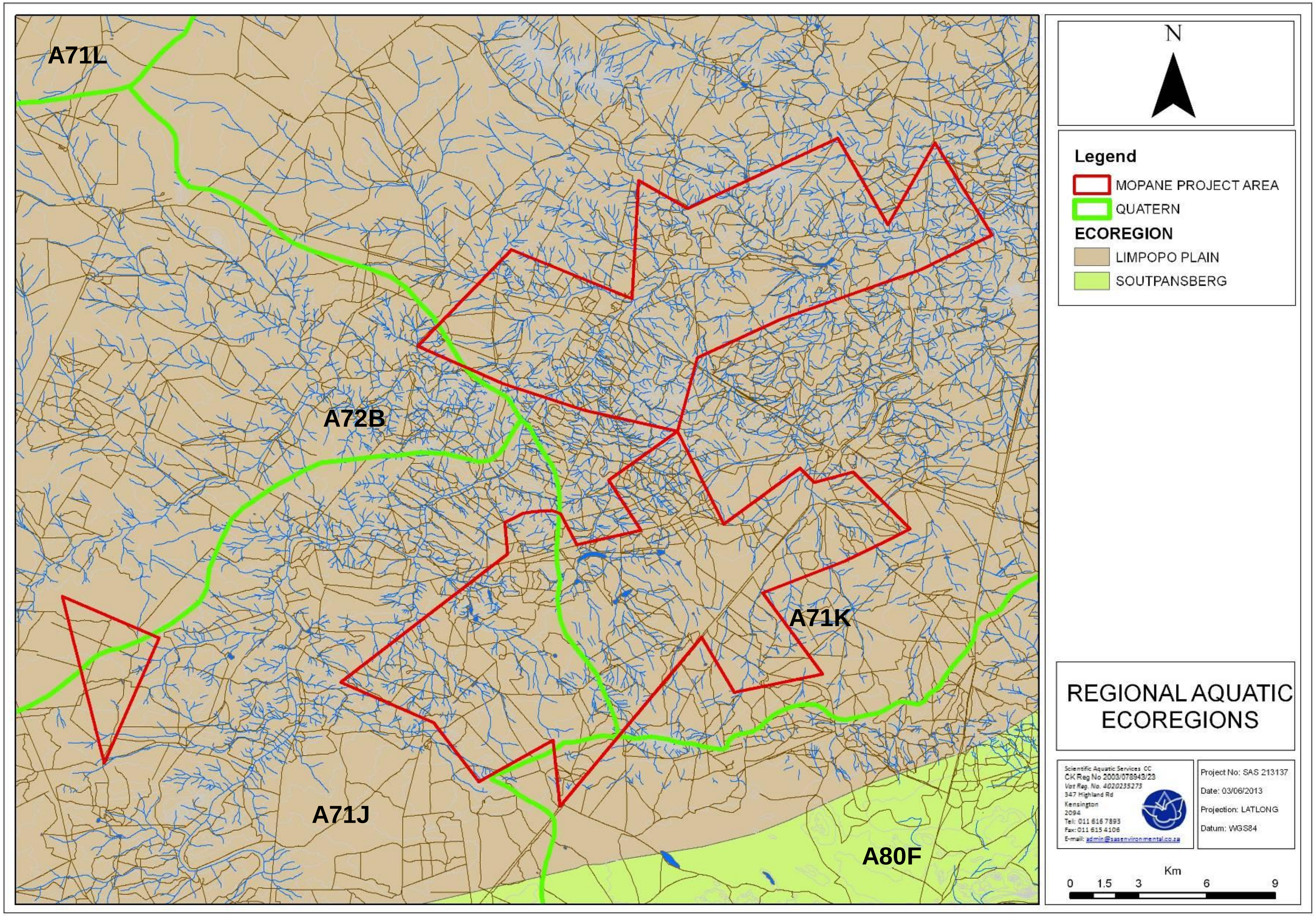


Figure 9: Quaternary catchment and aquatic ecoregions applicable to the study area.

3.1.2 Ecostatus Classification

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the EIS, PEMC and DEMC were defined and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems, prior to assessment or as part of a desktop assessment.

This database was searched for the catchment of concern in order to define the EIS, PEMC and DEMC. The results of the assessment are summarised in the table below.

Table 18:Summary of the ecological status of quaternary catchments A71J, A71K and A72B based on Kleynhans (1999)

Catchment	Resource	EIS	PESC	DEMC
A71J	Sand River	Low/Marginal	Class B	D: Resilient system
A71K	Sand River	Moderate	Class B	C: Moderately sensitive system
A72B	Brak River	Low/ Marginal	Class B	D: Resilient system

A71J

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

The points below summarise the impacts on the aquatic resources in the A71J quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been moderately affected by bed modification as a result of erosion, grazing and sedimentation within the catchment.
- Flow modification within the catchment is considered very low.
- Marginal impacts from inundation of the system occur as a result of weirs within the catchment.
- Riparian zones and stream bank conditions are considered to be moderately impacted by erosion, grazing and sedimentation.
- A very low impact occurs as a result of the introduction of instream biota.
- Impacts on water quality in the system are considered very low.

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

- The riverine systems in this catchment have a marginal diversity of habitat types.
- The site has a very low importance in terms of conservation.
- The riverine resources in this system have no intolerance to flow and flow related water quality changes.
- The aquatic resources in the area have a marginal importance in terms of migration of species.
- The system is considered to be of no importance in terms of rare and endemic species conservation.
- The aquatic resources in this catchment are marginally important in terms of the provision of refuge areas.
- The riverine resources in this system have a low sensitivity to changes in water quality and flow.
- The aquatic resources in this area are of moderate importance in terms of Species/Taxon richness with up to 10 different species present.
- The system is of no importance with regards to unique or endemic species.

A71K

According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Moderately Sensitive s*ystem which, in its present state, can be considered a Class B (largely natural) stream.

The points below summarise the impacts on the aquatic resources in the A71K quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been marginally affected by bed modification as a result of sedimentation within the system.
- Flow modification due to the presence of weirs within the system is considered marginal.
- Marginal impacts from inundation of the system occur as a result of weirs on the Voorburg Dam.
- Riparian zones and stream bank conditions are considered to be marginally impacted by farming activities.
- A marginal impact occurs as a result of the introduction of instream biota with special mention of *Cyprinus carpio* (Common Carp).
- Impacts on water quality in the system are considered low.

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

- The riverine systems in this catchment have a moderate diversity of habitat types including sandy beds, rapids and riparian vegetation.
- The site has a moderate importance in terms of conservation with special mention of the Messina Nature Reserve.
- The riverine resources in this system have a high intolerance to flow and flow related water quality changes with special mention of *Labeo* species, *Chiloglanis paratus* (Sawfin Suckermouth) and *Labeobarbus marequensis* (Largescale Yellowfish).
- The aquatic resources in the area have a moderate importance in terms of migration of species with special mention of bird species.
- The system is considered to be of moderate importance in terms of rare and endemic species conservation with special mention of crocodile species.
- The aquatic resources in this catchment are moderately important in terms of the provision of refuge areas for birds and fish.
- The riverine resources in this system have a low sensitivity to changes in water quality and flow.
- The aquatic resources in this area are of moderate importance in terms of Species/Taxon richness with up to 8 different species present.
- The system is of no importance with regards to unique or endemic species.

A72B

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

The points below summarise the impacts on the aquatic resources in the A72B quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been marginally affected by bed modification.
- Flow modification within the catchment is considered very low.
- Marginal impacts from inundation of the system occur.
- Riparian zones and stream bank conditions are considered to be marginally impacted.
- A low impact occurs as a result of the introduction of instream biota.
- Impacts on water quality in the system are considered low.

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

- The riverine systems in this catchment have a moderate diversity of habitat types.
- The site has a moderate importance in terms of conservation with special mention of the Langjan Nature Reserve.
- The riverine resources in this system have a moderate intolerance to flow and flow related water quality changes with special mention of CGAR.
- The aquatic resources in the area have a moderate importance in terms of migration of species.
- The system is considered to be of no importance in terms of rare and endemic species conservation.
- The aquatic resources in this catchment are moderately important in terms of the provision of refuge areas.
- The riverine resources in this system have a low sensitivity to changes in water quality and flow.
- The aquatic resources in this area are of marginal importance in terms of Species/Taxon richness with up to 5 different species present.
- The system is of no importance with regards to unique or endemic species.

3.1.3 Importance according to SANBI Wetlands Database (2006) and the National Freshwater Ecosystem Priority Areas (2011) Database

The SANBI Wetland Inventory (2006) and NFEPA (2011) databases were consulted to define the ecology of the wetland or river systems within the Mopane Project Area that may be of ecological importance. Aspects applicable to the Mopane Project Area and surroundings are discussed below:

- The Mopane Project Area falls within the Limpopo WMA. Each WMA is divided into several subWMA, where catchment or watershed is defined as a topographically defined area which is drained by a stream or river network. The subWMA indicated for the Mopane Project is the Sand subWMA;
- The subWMA is not regarded important in terms of fish sanctuaries, rehabilitation or corridors;
- The subWMA is not considered important in terms of translocation and relocation zones for fish;
- The subWMA is not listed as a fish FEPA;

- The Sand River and tributaries of the Sand River extend through the Mopane Project Area;
- The Sand River is a perennial system classified as a Class B (largely natural) river and is not indicated as a free flowing or flagship river. However, the northern portion of the Sand River is indicated as a FEPA river and the southern portion of the Sand River is indicated as an Upstream Management Area (Figure 10);
- River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. Although FEPA status applies to the actual river reach within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and smaller stream network need to be managed in a way that maintains the good condition (A or B ecological category) of the river reach;
- Upstream Management Areas are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas; and
- Although not indicated by NFEPA maps, the Tokwespruit is also located within the Mopane Project Area. The Tokwespruit traverses the western portion of the Voorburg Section of the Mopane Project Area (Figure 10).

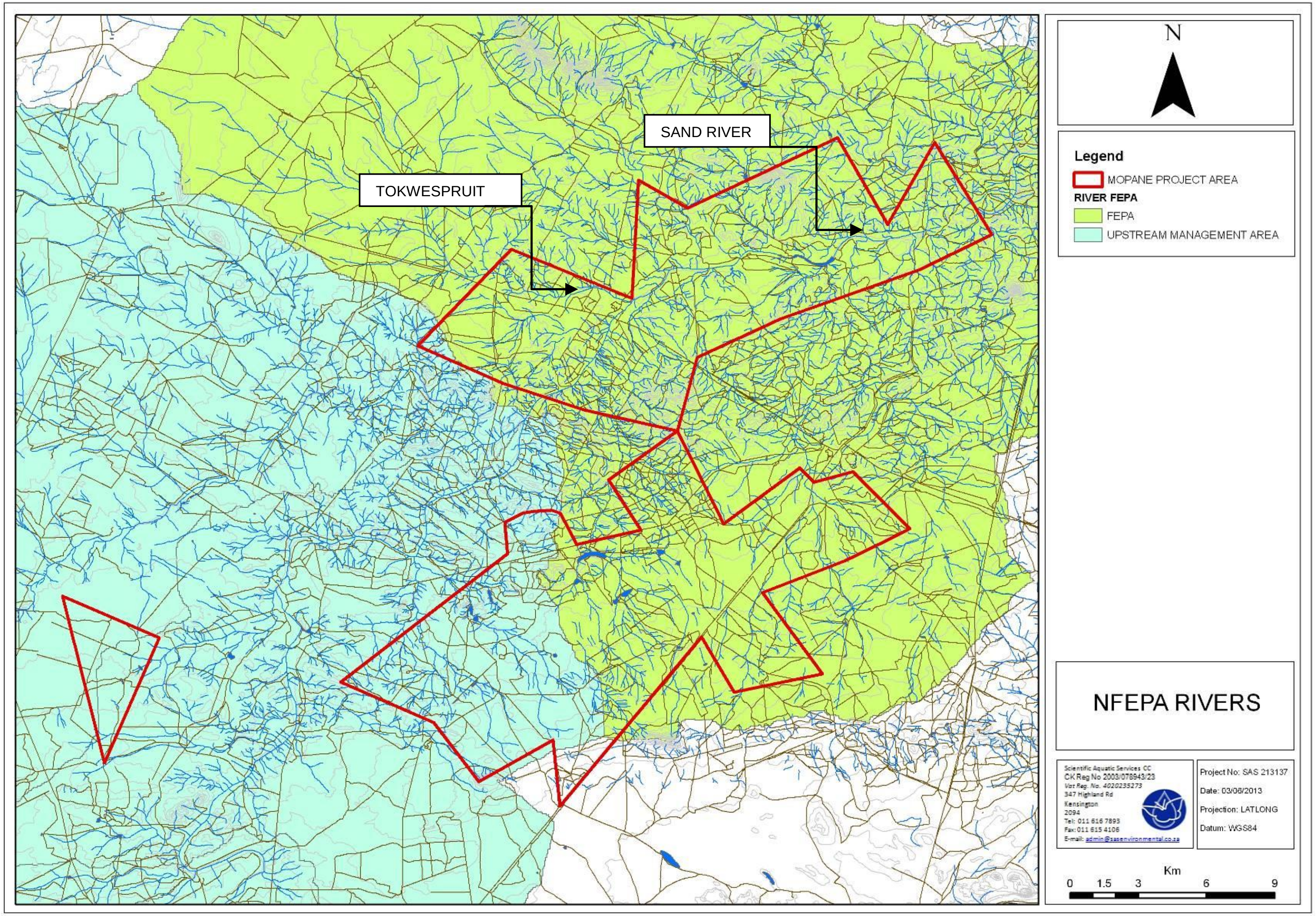


Figure 10: Map depicting the NFEPA rivers located within the Mopane Project Area.

- For mapping purposes the Mopane Project Area was divided into three sections, a northern portion referred to as the Voorburg Section, a southern portion referred to as the Jutland Section and a triangular portion referred to as the Ursa Minor Section (farm name) (Figure 11). Separate NFEPA wetland maps at different scales are presented for each of these portions;
- Numerous wetland features are located within the Mopane Project Area. Two different wetland types, valley floor and slope wetlands, occur within the Mopane Project Area. The Voorburg and Ursa Minor Sections contain valley floor wetland features (Figure 12 and 14) while the Jutland Section contains valley floor wetland features as well as slope wetland features (Figure 13);
- Both natural and artificial wetland features occur within the Mopane Project Area. The Voorburg Section contains two artificial wetland features, however, one natural feature is indicated to overlap with an artificial feature (Figure 15). The majority of the wetland features in the Jutland Section are indicated to be artificial, however, two natural wetland features are also indicated to overlap with artificial features (Figure 16). The Ursa Minor Section contains two artificial wetland features only (Figure 17);
- The condition of the wetland features within the Mopane Project Area is depicted in the figures to follow. The Voorburg Section contains Category Z2 and Category Z3 wetlands (Figure 18), the Jutland Section contains Category Z1, Category Z2 and Category Z3 wetlands (Figure 19) and the Ursa Minor Section contains Category Z3 wetlands (Figure 20):
  - Category Z1 – Wetland overlaps with a 1: 50 000 "artificial" inland water body from the Department of Land Affairs: Chief Directorate of Surveys and Mapping (2005 – 2007);
  - Category Z2 – Majority of the wetland unit is classified as "artificial" in the wetland delineation GIS layer; and
  - Category Z3 - Percentage natural land cover smaller than 25%.
- Wetlands within the Mopane Project Area were ranked according to general importance. All wetland features within the Voorburg, Jutland and Ursa Minor Sections were ranked as Rank 6 wetlands depicted in Figures 21-23 below:
  - Rank 6 – No importance indicated.
- No wetland features within the Mopane Project Area are considered important with regards the conservation of biodiversity;
- No wetland features within the Mopane Project Area are indicated as FEPA wetlands;
- Wetlands located within the Mopane Project Area are not shown to have sighting or breeding areas for cranes;
- No RAMSAR wetlands are located within or close to the Mopane Project Area;

- No wetlands are indicated to fall within 500m of an IUCN threatened frog point locality; and
- According to the NFEPA database (2011), none of the wetland features within the Mopane Project Area are considered of significant biodiversity importance. All wetland features are indicated to be in a heavily to critically modified condition and are not considered important with regards to the conservation of biodiversity in the area.

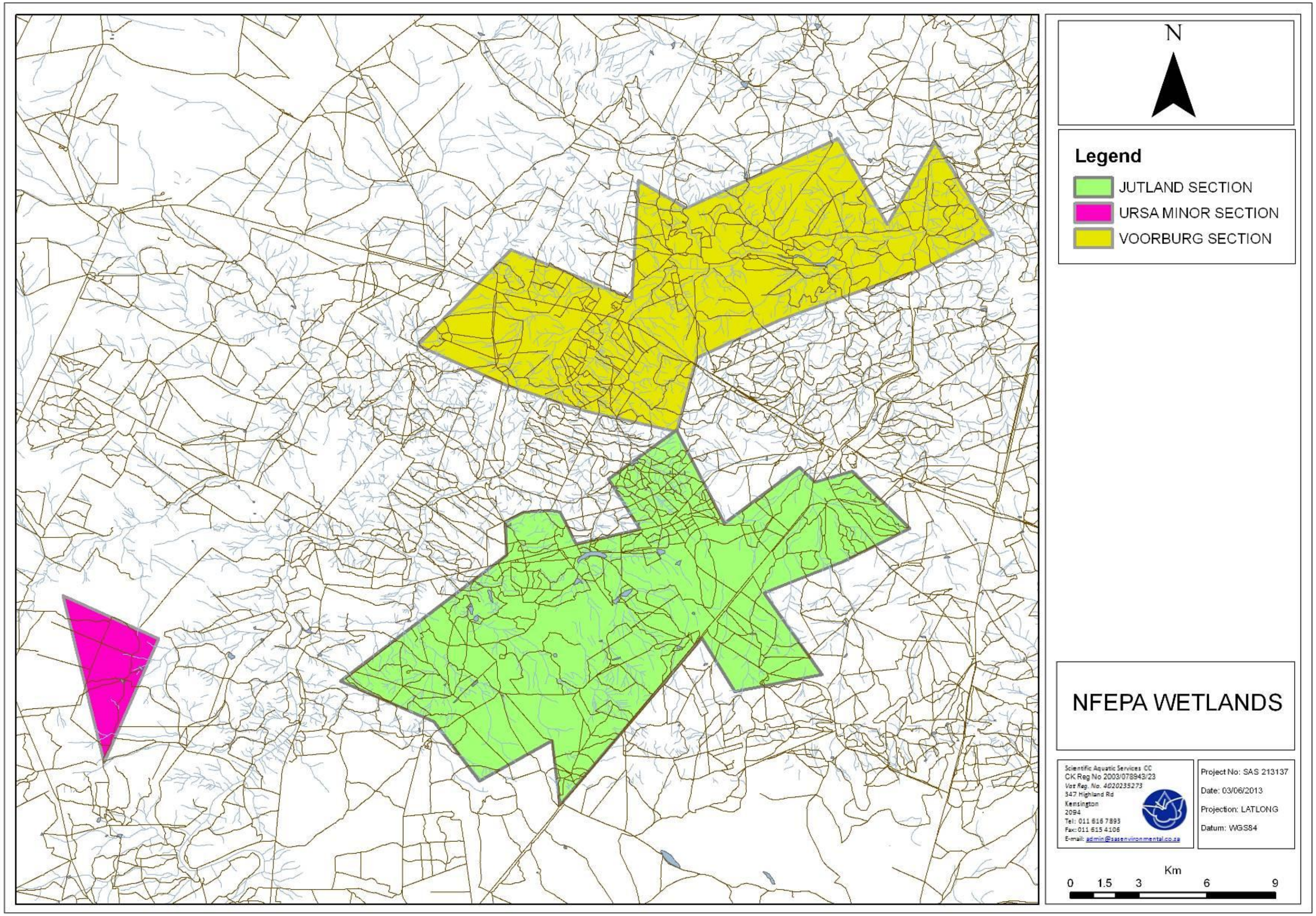


Figure 11: **Map indicating the position of the Voorburg, Jutland and Ursa Minor Sections in relation to the entire Mopane Project Area.**

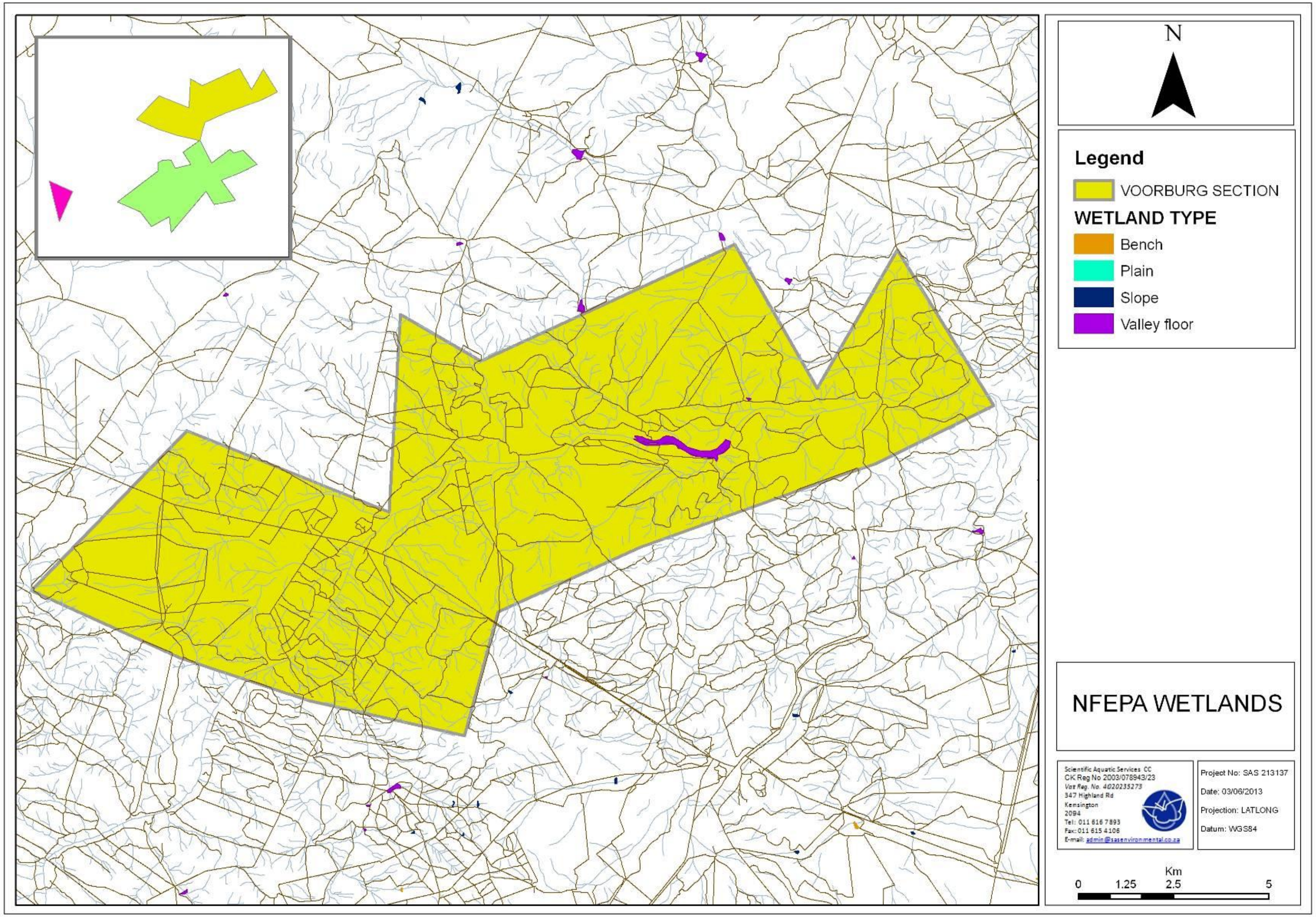


Figure 12: **NFEPA wetland types within the Voorburg Section of the Mopane Project Area.**

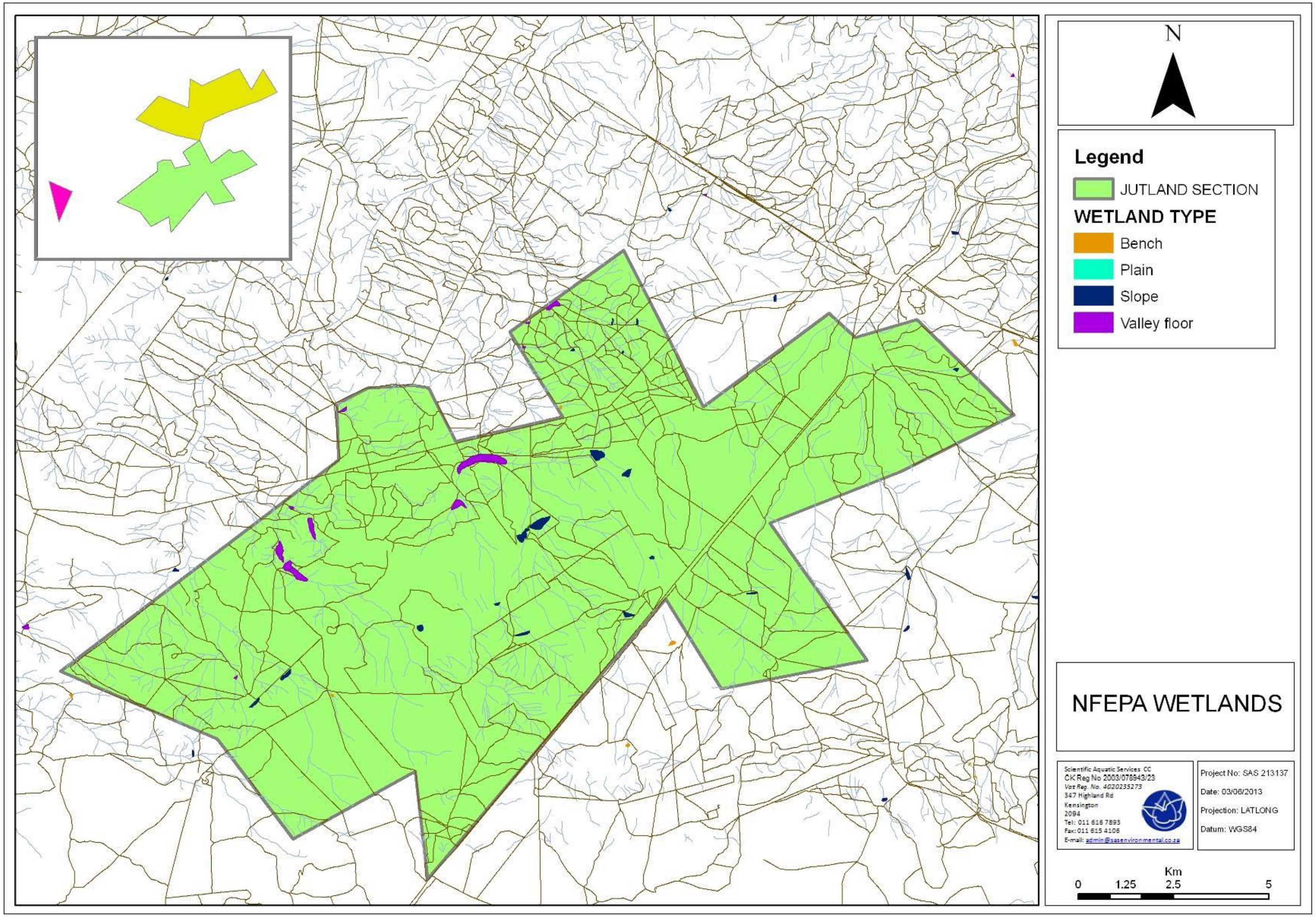


Figure 13: NFEPA wetland types within the Jutland Section of the Mopane Project Area.

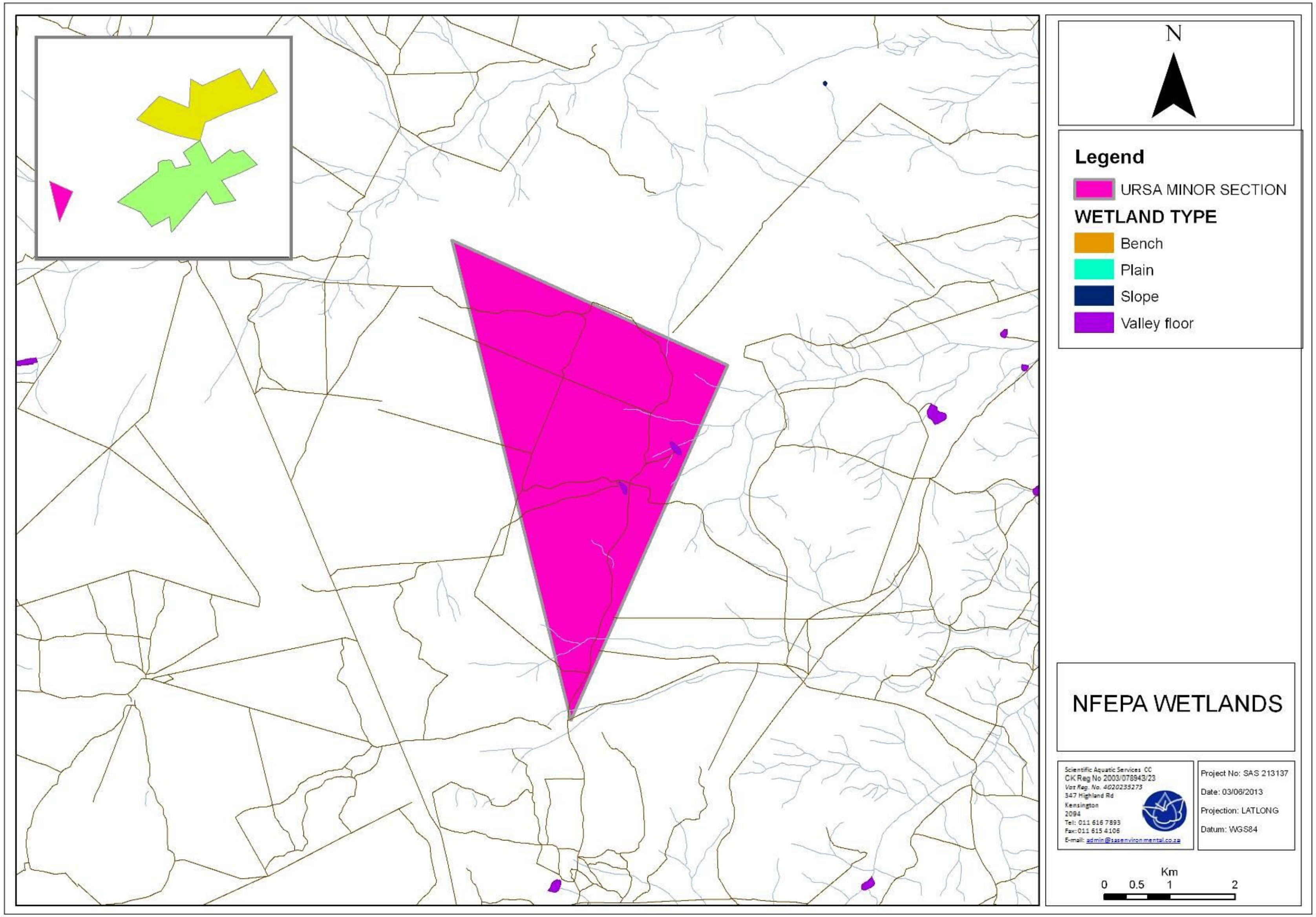


Figure 14: NFEPA wetland types within the Ursa Minor Section of the Mopane Project Area.

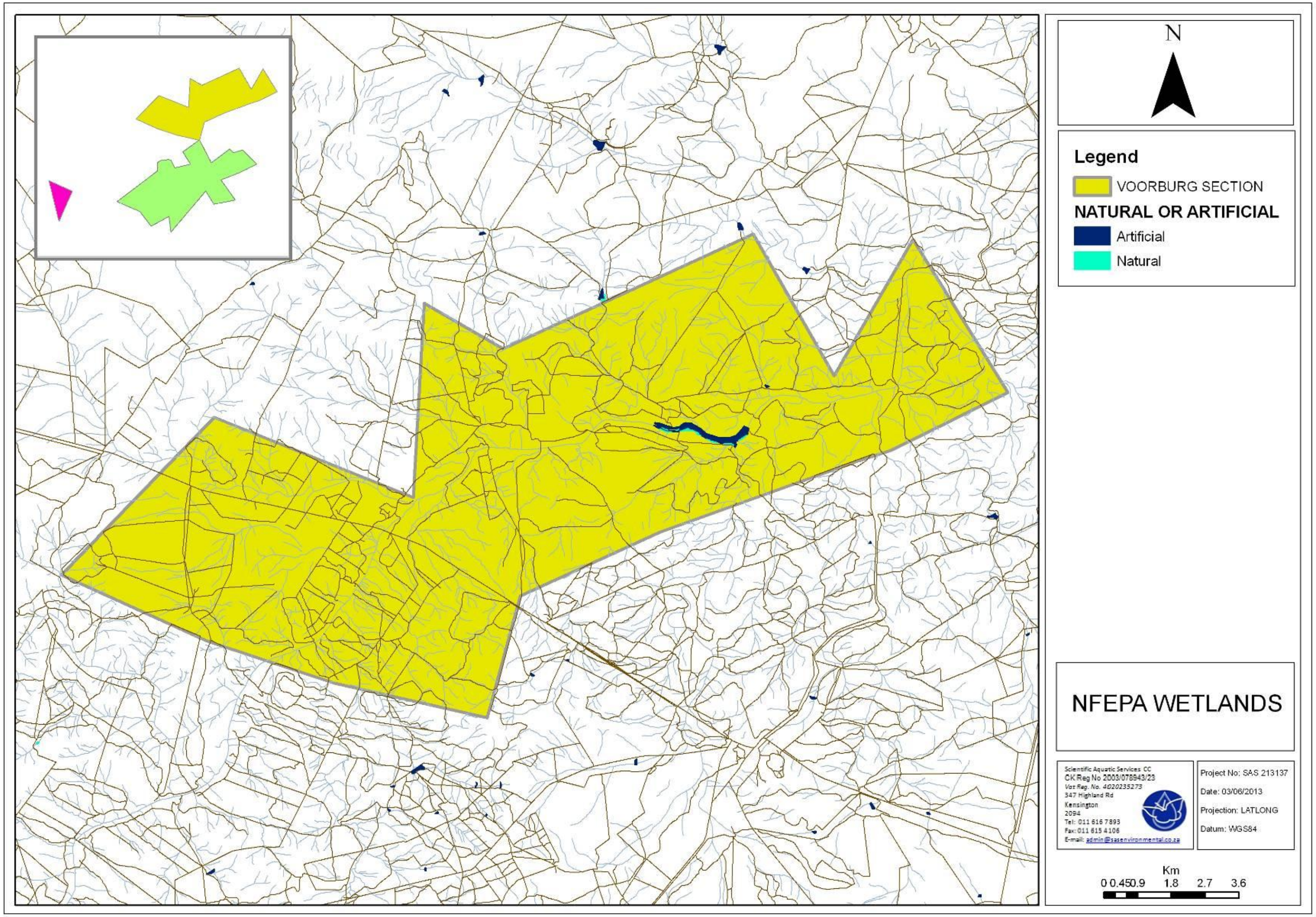


Figure 15: Natural and Artificial wetlands within the Voorburg Section of the Mopane Project Area.

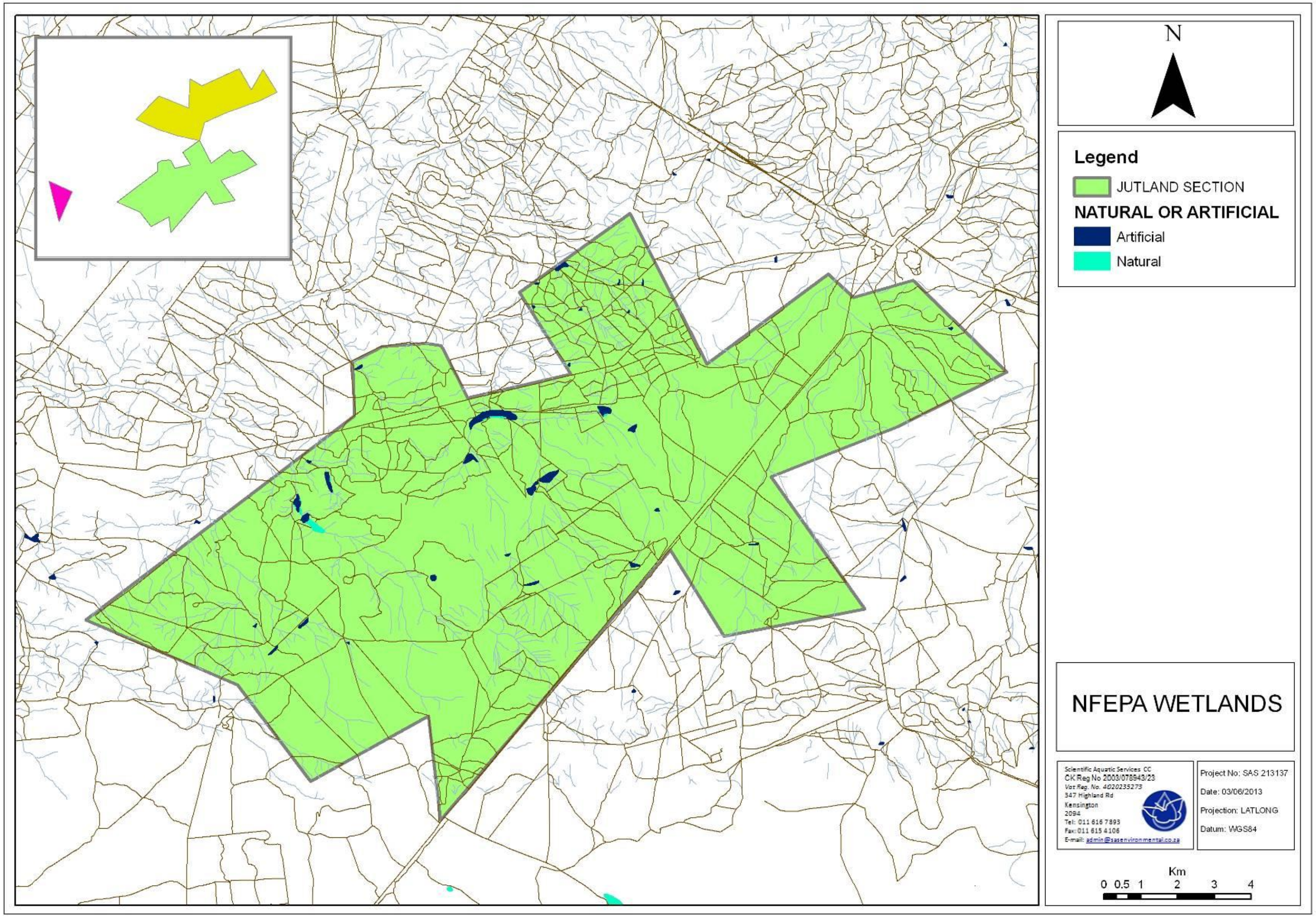


Figure 16: Natural and Artificial wetlands within the Jutland Section of the Mopane Project Area.

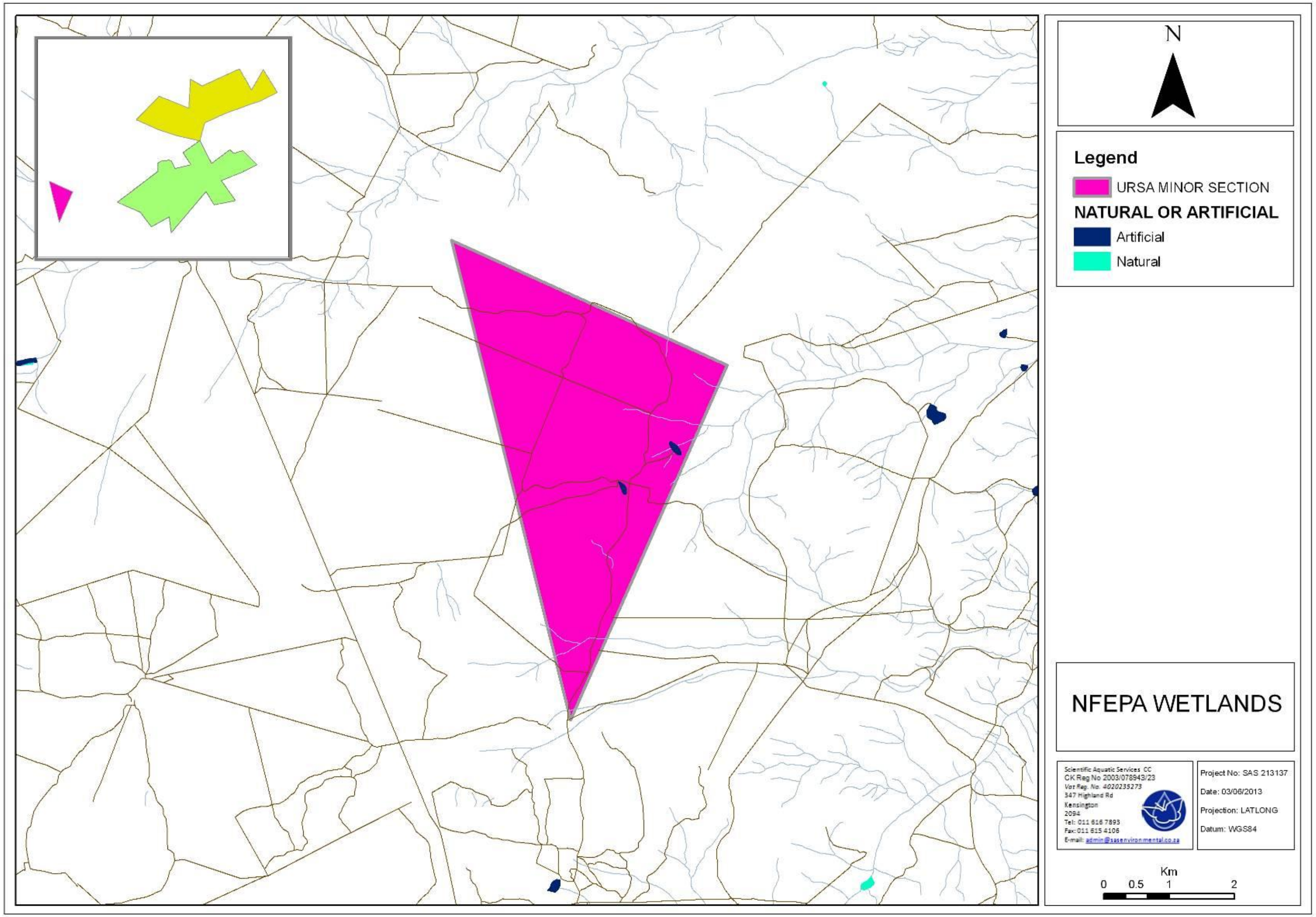


Figure 17: Artificial wetlands within the Ursa Minor Section of the Mopane Project Area.

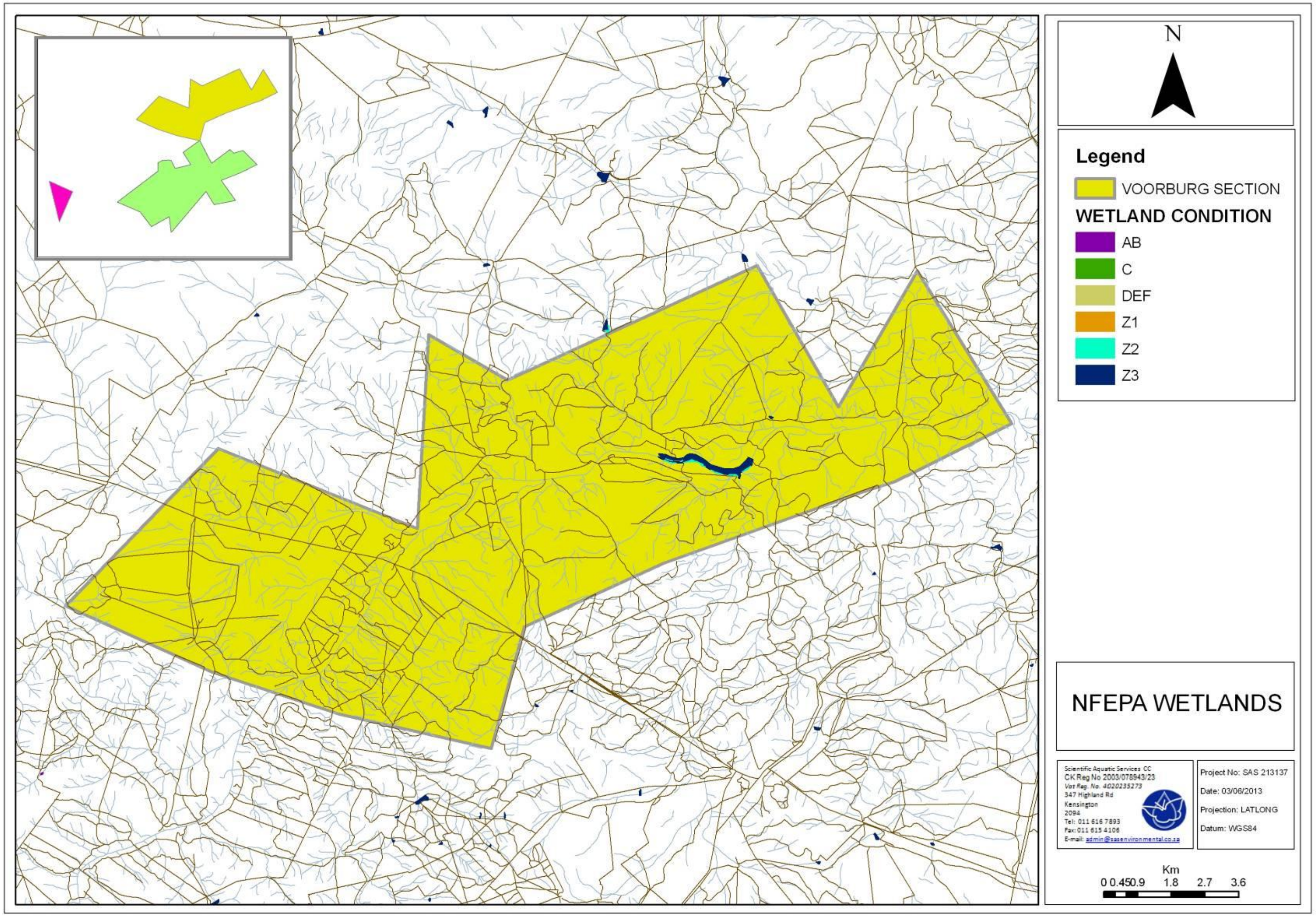


Figure 18: NFEPA wetland conditions within the Voorburg Section of the Mopane Project Area

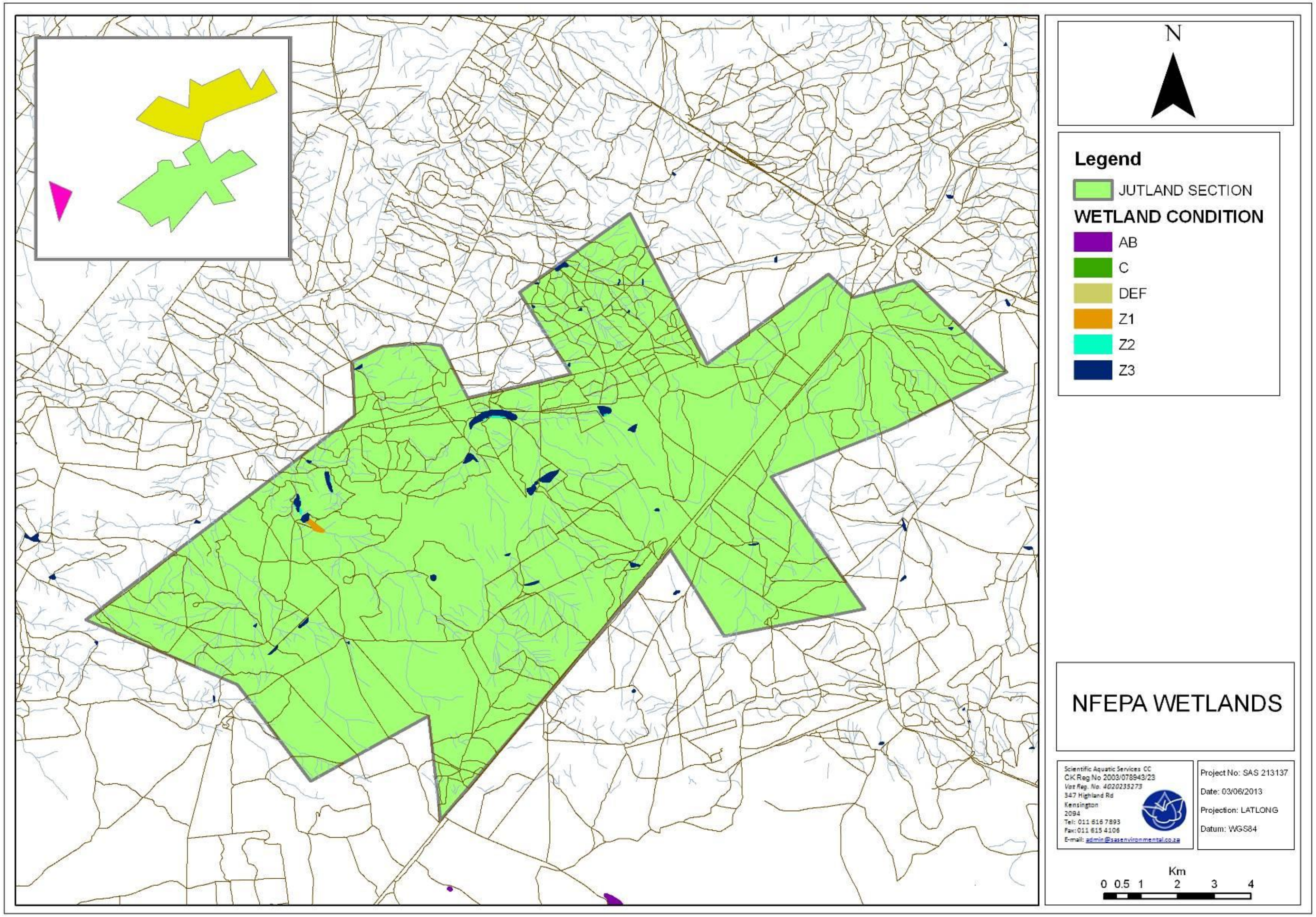


Figure 19: NFEPA wetland conditions within the Jutland Section of the Mopane Project Area.

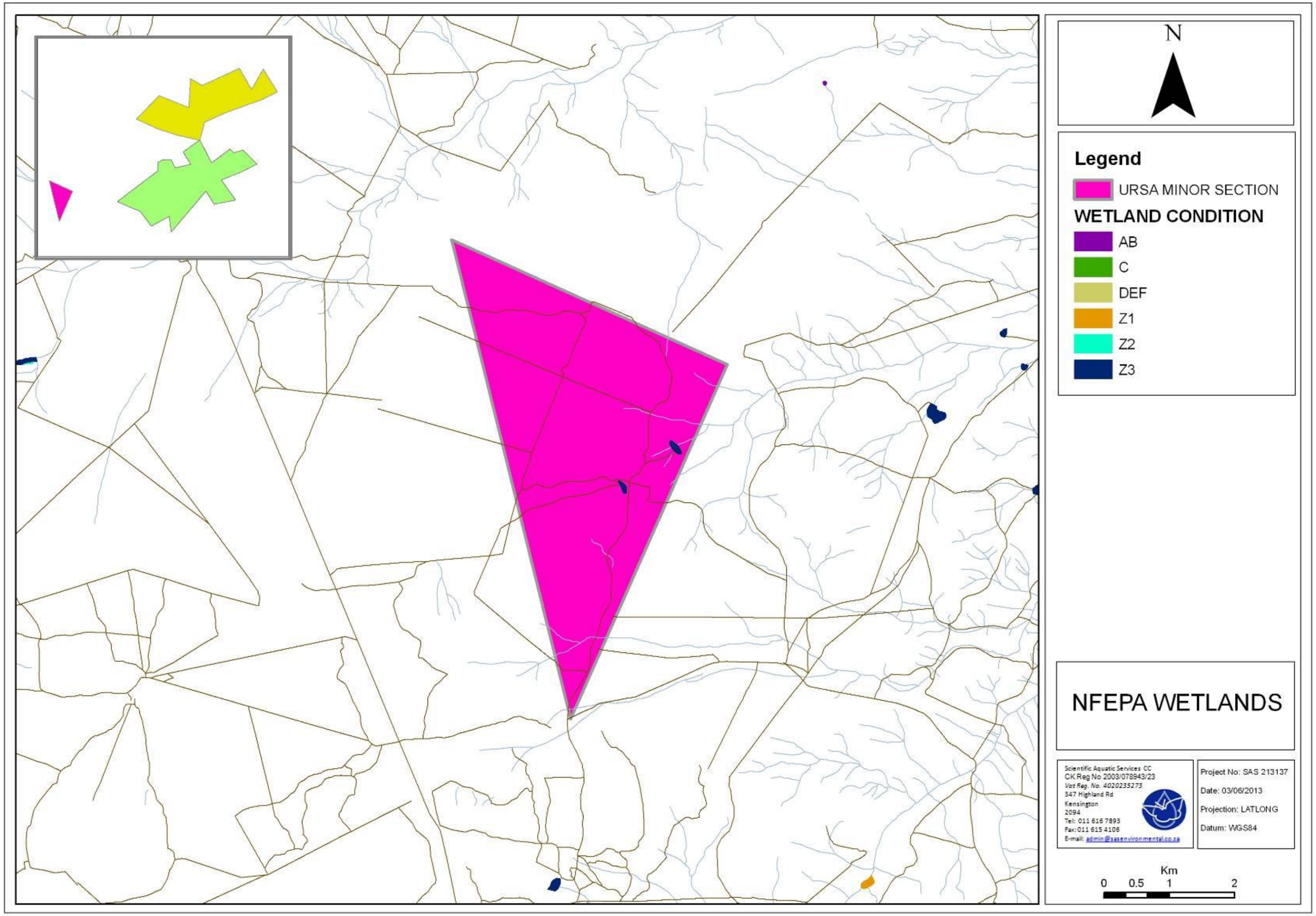


Figure 20: **NFEPA wetland conditions within the Ursa Minor Section of the Mopane Project Area.**

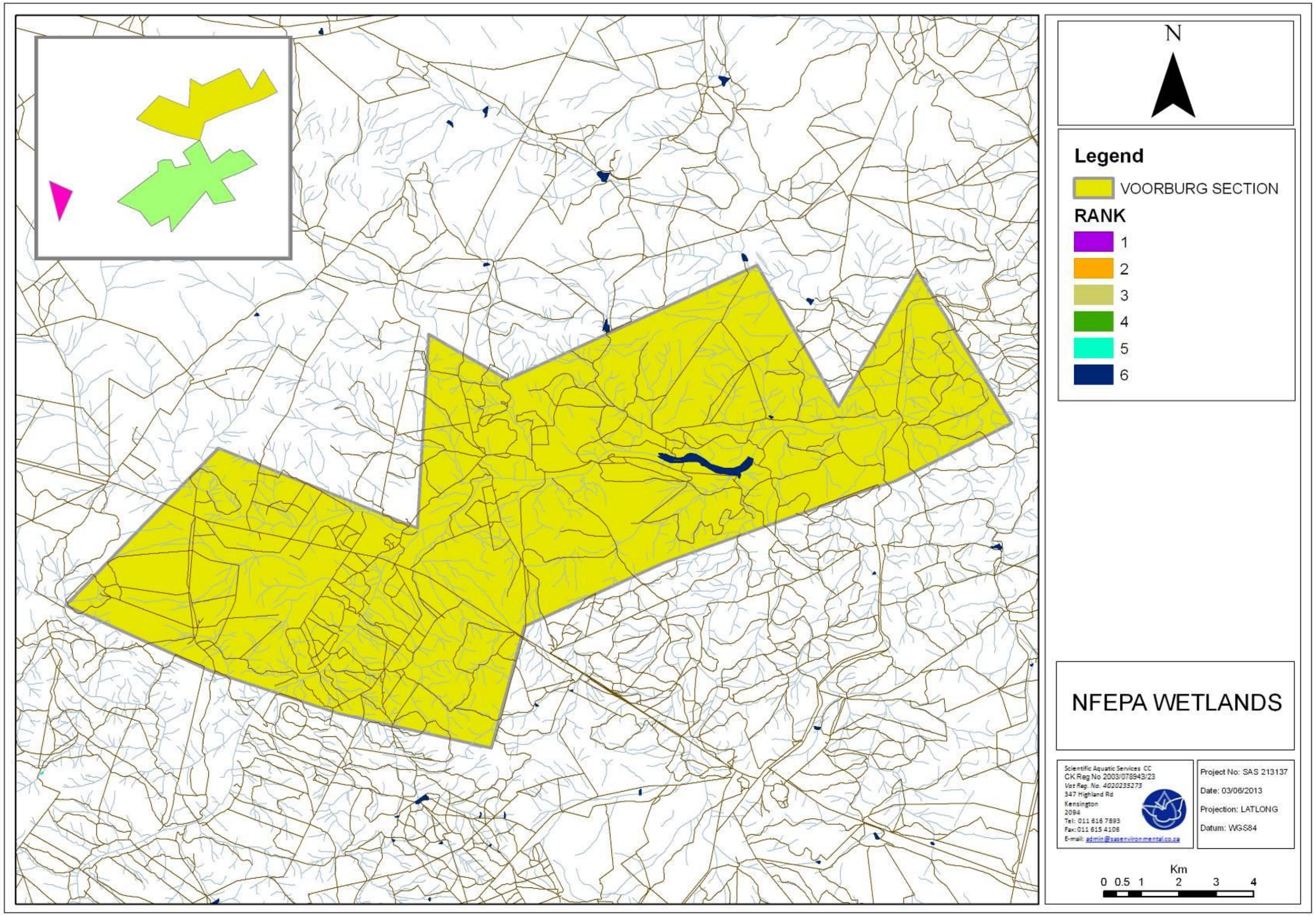


Figure 21: NFEPA wetland ranks within the Voorburg Section of the Mopane Project Area.

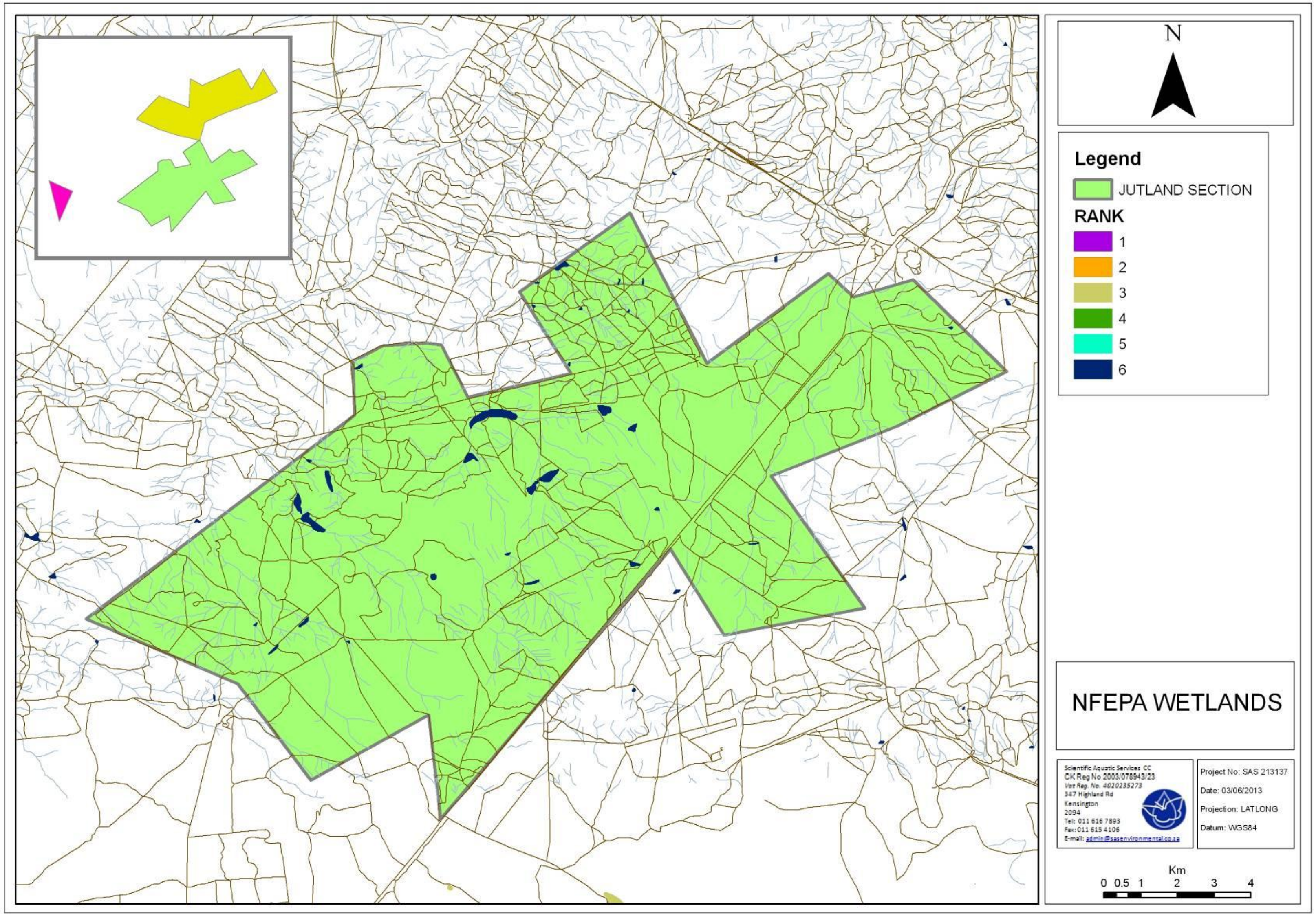


Figure 22: NFEPA wetland ranks within the Jutland Section of the Mopane Project Area.

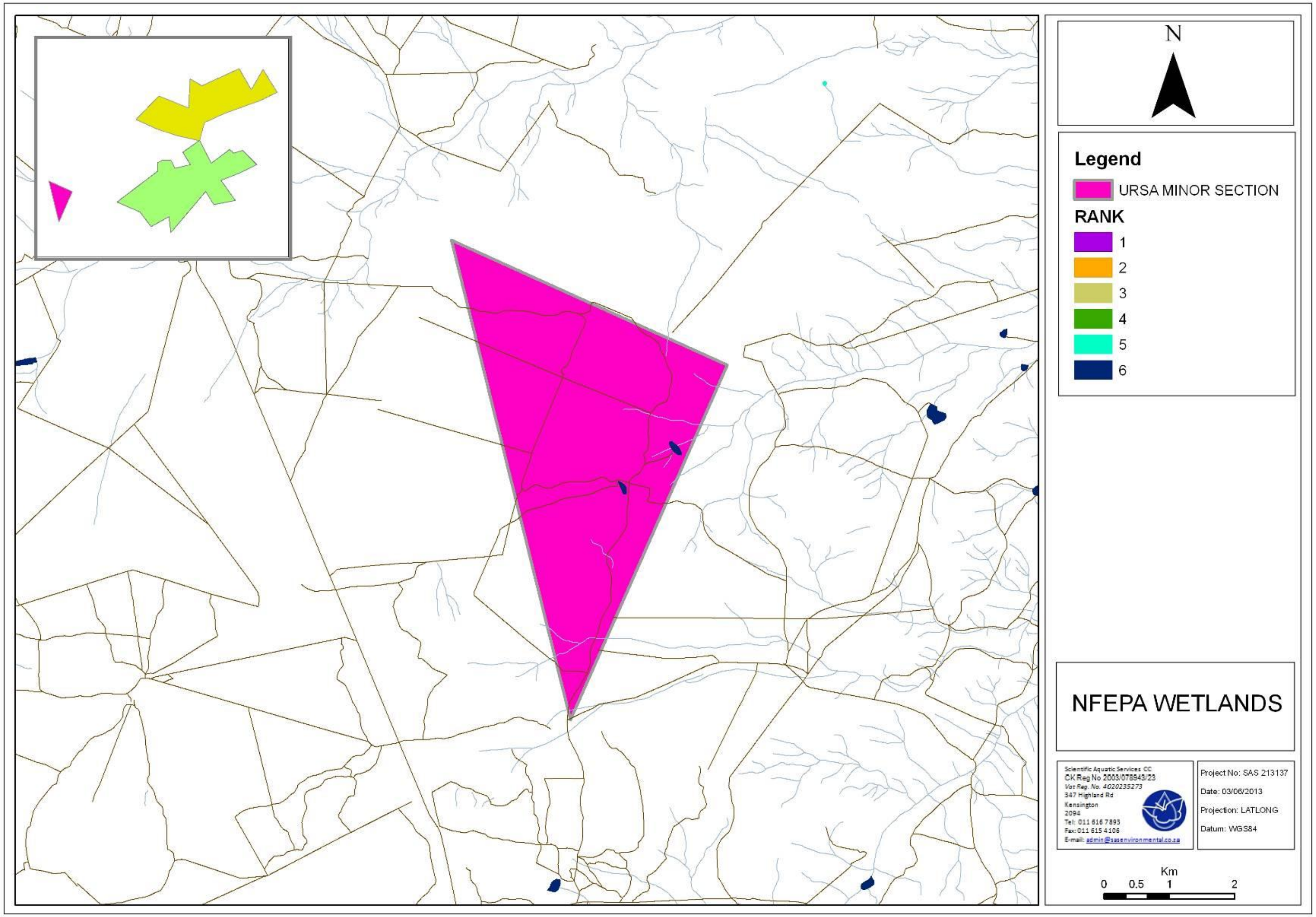


Figure 23: NFEPA wetland ranks within the Ursa Minor Section of the Mopane Project Area.

4 WETLAND ASSESSMENT SITE SELECTION RESULTS

Due to the extent of the study area as well as restricted access to several farms sites were selected, considered to be representative of the characteristics of the features within the study area. Selection of areas representative of the different feature groups, took place with the use of desktop methods (contours, flood lines, digital satellite imagery and topographical maps indicating depressions or drainage lines) after which selected points of interest were identified which are representative of the various systems. Each point of interest was assessed during the field survey to distinguish between true wetland and non-wetland as well as true riparian and non-riparian habitat. For the purposes of this investigation, use was made of distinguishing factors as either defined by DWA (2005) for 'wetland habitat' or defined in the NWA (Act No 36 of 1998) for 'riparian habitat', as discussed below.

Riparian vegetation is described in the NWA (Act No 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

Wetland habitat was defined as a feature with the following distinguishing factors as advocated by DWA (2005):

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils; and
- The presence of alluvial soils in stream systems.

Areas of interest were defined taking the following into consideration:

- Ensuring a geographic spread of points to ensure that conditions in all areas were addressed; and
- Ensuring that features displaying a diversity of digital signatures were identified in order to allow for field verification. In this regard specific mention is made of the following:
    - Riparian vegetation: a distinct increase in density as well as tree size near drainage lines;

- Hue: with drainage lines and outcrops displaying soils of varying chroma created by varying vegetation cover and soil conditions identified;
- Surface water: to aid with the identification of artificial impoundments that may sustain wetland habitat the presence of surface water were considered informative; and
- Texture: with areas displaying various textures, created by varying vegetation cover and soil conditions being identified.

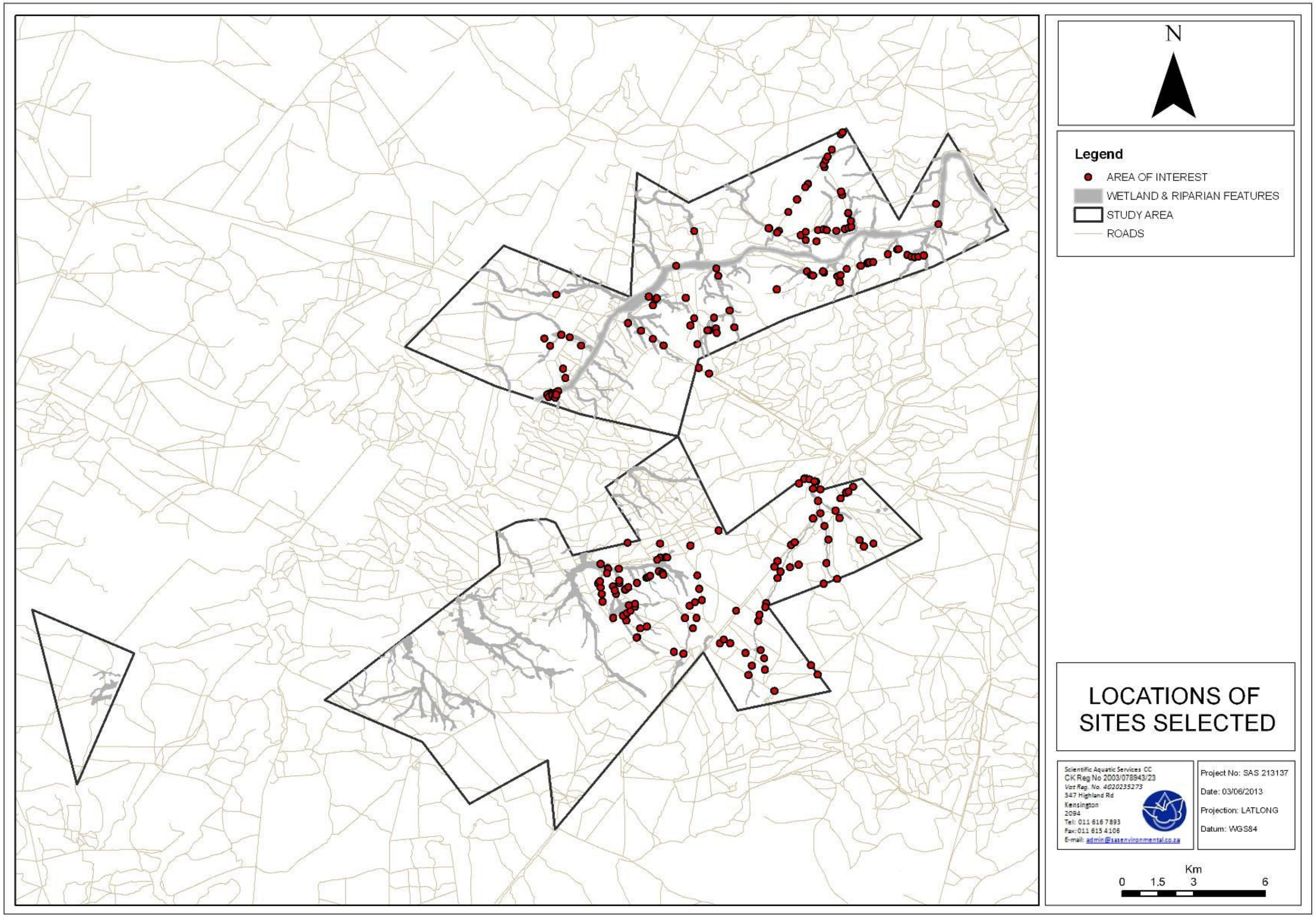


Figure 24: Areas of interest selected for assessment during the field survey.

5 Classification System for Wetlands and other Aquatic Ecosystems in South Africa

Features within the study area were categorised with the use of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, 2013). After the field assessment it can be concluded that three main feature groups are present within the study area, namely depressions, rivers (Sand River, Tokwespruit, Banff Stream and Voorburg Stream) and smaller drainage lines. The results are illustrated in the tables below. For the ease of reference larger river systems which are unnamed on 1:50 000 topographical maps were named based on farm located within.

Several features which as best described as depressional features are scattered through the Jutland section of the project. Although the terrain units of the pan features are similar to that of wetland depressions, these features are hydrologically isolated and therefore would not be of the same importance in terms of function and eco-services.

Artificial depressions within the study area were also classified as depressions, based on the fact that the landform characteristics of the impoundments, even though artificially created, fit the definition of a depression similar to that of pans.

Table 19: Classification for Artificial Depressions (SANBI 2013).

Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit	
			HGM Type	Longitudinal zonation / landform / Inflow drainage
An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	The study area falls within the Limpopo Plain Ecoregion and Mopane Group 1 and 2 wetland vegetation groups (NFEPA WetVeg).	Plain: An extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.	Depression: A landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.	Artificial- with channelled inflow.

Table 20: Classification for the Sand, Tokwe, Banff and Voorburg Rivers as well as Larger Tributaries (SANBI 2013).

Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit	
			HGM Type	Longitudinal zonation / landform / Inflow drainage
An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	The study area falls within the Limpopo Plain Ecoregion and Mopane Group 1 and 2 wetland vegetation groups (NFEPA WetVeg).	Valley floor: The base of a valley, situated between two distinct valley side slopes, where alluvial or fluvial processes typically dominate.	Channelled valley bottom wetland: a valley bottom wetland with a river channel running through it.	N/A

Table 21: Classification for the Drainage Lines (SANBI 2013).

Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit	
			HGM Type	Longitudinal zonation / landform / Inflow drainage
An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	The study area falls within the Limpopo Plain Ecoregion and Mopane Group 1 and 2 wetland vegetation groups (NFEPA WetVeg).	Plain: An extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.	Channelled valley bottom wetland: a valley bottom wetland with a river channel running through it.	N/A

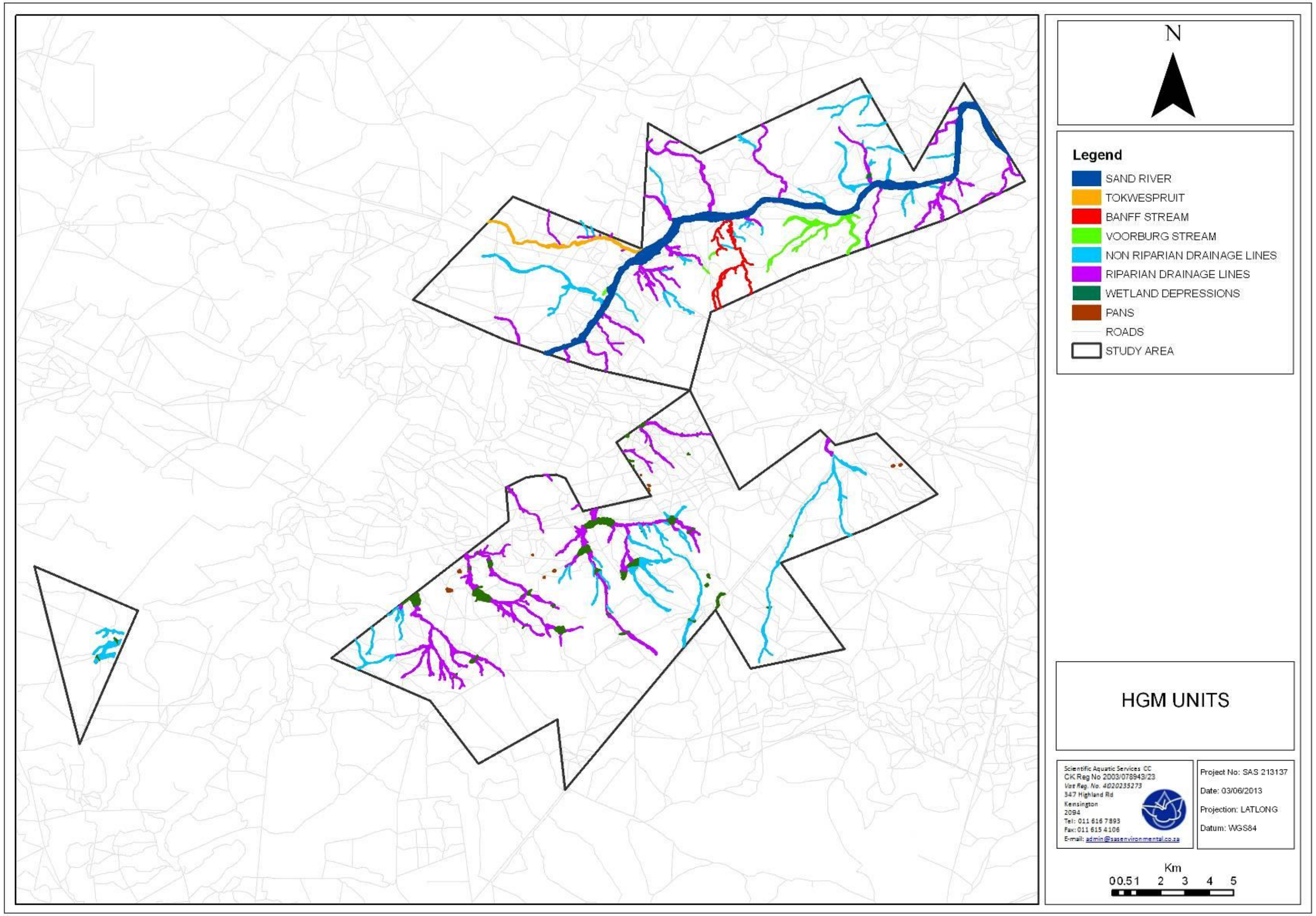


Figure 25: **Locations of the three groups in relation to the study area.**

With the use of *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, 2013) all features within the study area could be divided into three main groups namely rivers, smaller drainage lines and depressions. The features identified during the assessment where further divided into either wetland or riparian habitat based on the characteristics as defined by the NWA No 36 of 1998, provided below.

Wetland habitat – land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (NWA; Act No. 36 of 1998).

Riparian habitat - includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure ***distinct*** from those of adjacent land areas.

The rivers assessed (Sand River, Banff Stream, Voorburg Stream and Tokwespruit) are considered riparian habitat due to the presence of alluvial soil as well as the presence of vegetation, with a composition and physical structure, distinct from adjacent areas. Many smaller drainage lines within the study area also display these characteristics and were therefore also considered riparian habitat. The wetland catchment of some of the drainage lines are however smaller and did not allow for the establishment of the defined riparian habitat characteristics and were therefore considered non-riparian habitat.

Artificial impoundments were encountered within smaller drainage lines, most likely created as an effort to retain water for as long as possible. Several of these artificial impoundments hold water throughout the year and the presence of water for prolonged periods of the year has resulted in the formation of wetland characteristics as defined by the NWA (1998). Impoundments created only recently or located within weak watercourses or areas of sheet runoff did not display any of these characteristics and were therefore considered non-wetland depressions.

In summary, the rivers and smaller drainage lines were subdivided into riparian or non-riparian habitat and the artificial depressions subdivided into wetland or non-wetland habitat. All pan features encountered could be defined as wetland habitat based on the presence of gleyed soil as well as degree of soil saturation noted within soil samples. In the sections that follow riparian habitat was assessed with use of the VEGRAI, Wetland Function Assessment, Wet-Health, and Wetland IHI. Wetland habitat was assessed with the use of Wet-Health and the Wetland Function Assessment. Refer to section 2 for the method of assessment.

5.1 Rivers

Four main river systems namely the Tokwespruit, Banff Stream, Voorburg Stream and Sand River flow through the study area with numerous tributaries and drainage lines also identified throughout the study area. The Tokwespruit, Banff and Voorburg Streams all flow into the Sand River where after the Sand River flows into the Limpopo River.

The terrain units and soil were considered largely similar when the different rivers were compared and therefore dominant characteristics were discussed together in the sections that follow. The extent of surface water as well as vegetation communities were considered to be different to some degree and were therefore discussed separately.

Figure 26: Sand River.

Figure 27: Tokwespruit.

Figure 28: Banff Stream.

Figure 29: Voorburg Stream.

5.1.1 Terrain Units

The sandy nature of the soil within the region, make water courses prone to erosion and has resulted in incised river features within the study area. The degree of incision of the various riverine features formed a clear continuum. Smaller drainage features showed very limited levels of incision while larger drainage features were more incised. The largest rivers within the study area such as the Banff, Voorburg and Tokwespruit streams as well as the Sand River showed significant incision and clear stream banks.

5.1.2 Soil

Figure 30: Alluvial soil within the active channel of rivers.

The active channel of all rivers mainly constituted of alluvial soil and larger boulders and cobbles in certain areas as well as isolated areas of bedrock. The coarse alluvial sands showed clear indications of surface water movement from time to time with the degree of development characterised by the size of the system. Water movement for prolonged periods has resulted in leaching of soil components such as iron and manganese from the soil resulting in soil with a low chroma. A distinct increase in chroma is evident on the banks where significantly less leaching has taken place.

5.1.3 Vegetation

The larger drainage features are considered characteristic of the Subtropical Alluvial vegetation type (Mucina and Rutherford, 2006). A vegetation type characterised by flat alluvial riverine terraces supporting an intricate complex of macorphytic vegetation, marginal reed belts (in sheltered oxbows and along very slow flowing water courses) as well as riverine thickets.

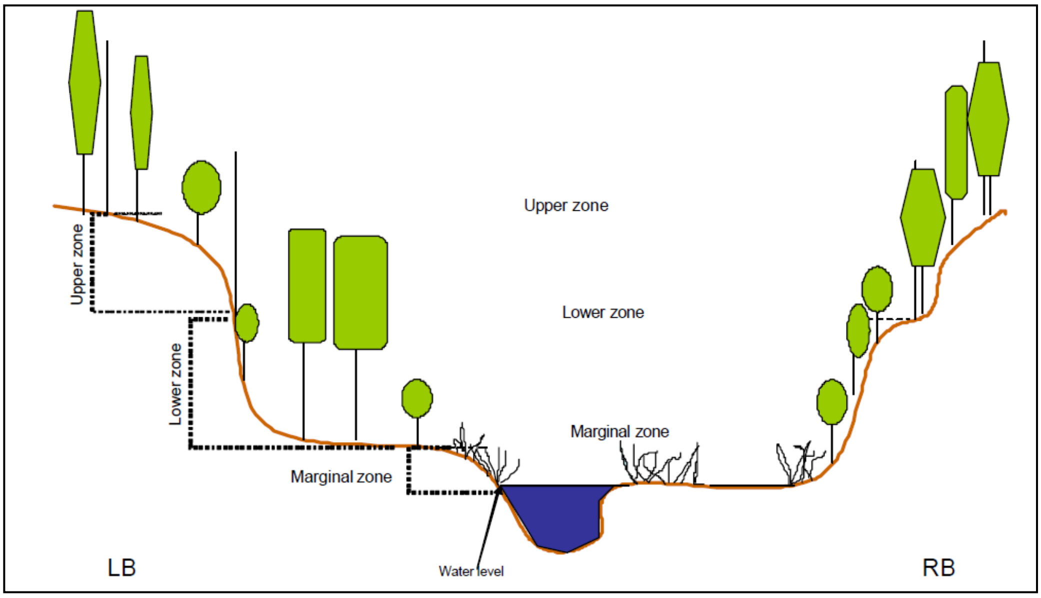


Figure 31: Cross sectional sketch[10] of a river system.

According to the three different zones defined for river systems by the WET-Health assessment (Kleynhans et al., 2007), abundance and diversity of vegetation were assessed at each site selected for a river system. A distinctive change in vegetation abundance as well as diversity was noted in the lower and upper zones compared to the surrounding terrestrial zones. Although the width of the active channel of the different rivers varied, the dominant riparian vegetation communities within the lower and upper zones were considered uniform. The most distinct difference between the different rivers assessed was in terms of the marginal zone. The Sand River and Voorburg Stream hosted *Cyperus spp*. and *Phragmites australis* (common reed) not identified within any of the marginal zones of the other smaller river systems. Both these species are obligate floral species and are therefore adapted to the anaerobic soil conditions found within the active channel of larger river systems. Therefore their presence are directly related to the volume of water within a system for the largest part of the year. The additional permanent and seasonal habitat provided by the Sand River and Voorburg Stream do increase both systems importance in terms of wetland biodiversity and it is deemed likely that with the continuation and possible increase in the volume of water abstracted from these systems that a decline in obligate/facultative floral species habitat is possible. It should further be noted that larger tree species located within the lower and upper zones would most likely also be impacted upon by a decrease in the water table resulting from abstraction.

[10] Kleynhans et al., 2007

The table below lists the dominant floral species identified during the assessment of all the rivers, the dominant species listed for the marginal zone are only applicable to the Sand River and Voorburg Stream.

Table 22: Dominant floral species identified during the assessment of the rivers.

Upper zone	Lower zone	Marginal zone
Colophospermum mopane (Mopane)	*Faidherbia albida* (Ana tree)	*Phragmites australis* (Common reed)
Combretum apiculatum (Red bushwillow)	*Grewia flava* (Velvet raisin)	*Cyperus compressus*
Dichrostachys cinerea (Sickle bush)	*Cyperus fastigiatus*	*Cyperus fastigiatus*
Acacia karroo (Sweet thorn)	*Cynodon dactylon* (Couch grass)	*Cyperus distans*
Acacia nigrescens (Knob thorn)	*Panicum maximum* (Guinea grass)	*Ammannia baccifera* (Waterbessiekruid)
Terminalia prunioides (Lowveld cluster-leaf)	*Heliotropium sp.*	
Ziziphus mucronata (Buffalo-thorn)		
Combretum mossambicense (Kobbly creeper)		
Euclea undulata (Common guarri)		
Grewia bicolor (White raisin)		
Gymnosporia senegalensis (Red spike thorn)		
Combretum imberbe (Leadwood)		
Xanthocercis zambesiaca (Nyala tree)		

Riparian Vegetation Response Assessment Index (VEGRAI)

Where access was allowed onto farms, up and downstream areas of each river system were assessed during the field survey. In order to get an overall VEGRAI rating, VEGRAI was applied to all points assessed and a mean score calculated for each system.

5.1.3.1.1 Sand River

Figure 32: Upstream (Aquatic assessment point GSP3); Middle (GSP2); Downstream (GSP1) within the study area.

Figure 33: Two sites assessed along the Sand River upstream of the study area (GSP4 left and GSP6 right).

Table 23: VEGRAI Ecological Category Description Scores for the Sand River.

Name	VEGRAI %	EC	Definition
GSP3	60%	C/D	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
GSP2	71%	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
GSP1	54%	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
GSP4	86%	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.
GSP6	86%	B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged.
Mean	71%	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

Five areas along the Sand River were assessed during the field survey. The overall score calculated falls within an EC class C (moderately modified). The Sand River, presently, constitutes a great volume of the water used for agriculture and in some instances domestic water. As a result water quantity in the river would be reduced due to abstraction. Furthermore, agricultural land was evident within several areas along the river banks. The likelihood of impact on water quality therefore is also considered a possibility, although water samples will have to be analysed to determine the degree of impact. Overall, the riparian vegetation community at all points assessed was considered relatively representative of the reference condition with a slight decrease in woody species and increase in non woody species noted.

5.1.3.1.2 Tokwespruit

Figure 34: Representative point on the Tokwespruit.

Table 24: VEGRAI Ecological Category Description Scores for the Tokwespruit.

Name	VEGRAI %	EC	Definition
Tokwespruit	72%	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

Only one point was assessed for the Tokwespruit falling within an EC class C (moderately modified). Species composition, cover and abundance of riparian vegetation assessed at drainage lines located within farms adjacent to the Tokwespruit were considered similar to the point assessed within the Tokwespruit. Therefore, it is considered unlikely that areas upstream and downstream of the point would significantly deviate from the calculated percentage. The EC class is therefore considered representative of the portion of the Tokwespruit located within the study area.

The Tokwespruit is a relatively large tributary of the Sand River, located within an area with increased crop cultivation. Therefore, the abstraction of water from the system is considered highly likely. The degree of riparian vegetation transformation was also considered higher when compared to more isolated systems such as the Banff Stream.

5.1.3.1.3 Banff Stream

Figure 35: Lower reaches (left); Middle reaches(middle); upper reaches (right) of the Banff stream

Table 25: VEGRAI Ecological Category Description Scores for the Banff Stream.

Point	VEGRAI %	EC	Definition
Upper reaches	84%	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.
Middle reaches	84%	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.
Lower reaches	75%	C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
Mean	81%	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.

The mean percentage calculated indicates the Banff Stream as a class B (largely natural with few modifications) system. It is evident from the results above that the riparian ecosystem has remained largely intact, with limited change of cover, abundance and species composition when compared to the reference condition in both the marginal as well as non-marginal zones. The Banff Stream is also located further away from anthropogenic activity and no evidence was encountered that the system is presently used for water abstraction.

5.1.3.1.4 Voorburg Stream

Figure 36: Representative point on the Voorburg Stream.

Table 26: VEGRAI Ecological Category Description Scores for the Voorburg Stream.

Point	VEGRAI %	EC	Definition
Upstream	81%	B/C	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

The Voorburg Steam with immediate surrounding areas have remained largely free from anthropogenic activities. As a result, vegetation transformation can be considered marginal. The VEGRAI percentage calculated therefore is considered representative of the system in its PES.

5.1.4 Surface Water

The field assessment was undertaken during winter, as a result surface water was only encountered within depressions of the Sand River and Voorburg Stream. Evidence of faunal species burrowing for water was also encountered and indicates substantial sub-surface flow within these features during the drier months. Increasing the importance of rivers in terms of water provision for faunal species during the winter season when surface water is scarce.

Although no surface water was observed within the Tokwespruit or the Banff Stream, these systems are still considered very important in terms of water provision for fauna as well as abstraction for crop cultivation for surrounding areas.

5.1.5 Biodiversity

The study area is located within a water stressed region and as a result available wetland and riparian habitat are considered to be of increased ecological conservation importance in terms of wetland dependent floral and faunal species. Even though surface water was only encountered within the Sand River and Voorburg Stream the Banff Stream and Tokwespruit will still be used for shelter and migratory connectivity by both wetland dependent as well as terrestrial faunal species. The riparian habitat associated with these features is therefore considered worth a conservation effort.

Charismatic as well as species of concern were also documented during prior studies done in the area. A tree species namely *Combretum imberbe* (Leadwood) is protected in accordance to the National Forests Act (Act No 84 of 1998 as amended September 2008) and was identified within riparian zones. Aquatic species such as crocodiles and fish are known to utilise the Sand River, Voorburg Stream and Tokwespruit as migrational corridors during summer. Endangered avifaunal species also expected to utilise the river resources within the study area include *Ephippiorhynchus senegalensis* (Saddle billed stork: endangered) and *Mycteria ibis* (Yellow billed stork: Near threatened)[11]. Furthermore, *Pyxicephalus adspersus* (Giant Bullfrog), listed as near threatened[12], was identified within seasonally rain filled depressions within wetlands of nabouring properties and it is therefore considered likely to also be found within the study area.

The northern portion of the Sand River is indicated to be a FEPA river and the southern portion of the Sand River is indicated as an Upstream Management Area (refer to section 3.1.3). River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. Although FEPA status applies to the actual river reach within such a sub-quaternary catchment, the surrounding land and smaller stream networks need to be managed in a way that maintains the good condition (A or B ecological category) of the river reach.

5.1.6 Wetland Function Assessment

The function and service provision was calculated for the Sand River, Towkespruit, Voorburg Steam and the Banff Stream according to characteristics discussed in the previous sections.

[11] SRK Consulting, 2009
[12] Du Preez and Carruthers, 2009

The average score is presented in the following table as well as the radar plot in the figure that follow the table.

Table 27: Wetland service and function assessment.

Ecosystem service	Sandrivier	Tokwespruit	Voorburg Stream	Banff Stream
Flood attenuation	1.8	1.5	1.4	1.4
Streamflow regulation	2.5	2	2.3	2
Sediment trapping	3	3	3.6	3
Phosphate assimilation	2.1	1.5	1.7	1.3
Nitrate assimilation	2.2	1.8	2.2	1.8
Toxicant assimilation	2.1	1.7	1.9	1.6
Erosion control	2	1.9	2.3	2
Biodiversity maintenance	3.2	2.6	3.3	3.3
Carbon Storage	1	1	2.3	2.3
Water Supply	3.6	2.5	1.8	0.5
Harvestable resources	0	0	0	0
Cultural value	0	0	0	0
Cultivated foods	0	0	0	0
Tourism and recreation	3.1	2.9	2.9	2.9
Education and research	2.5	2.5	1.8	1.8
SUM	**29.1**	**24.9**	**27.5**	**23.9**
Average score	**1.9**	**1.7**	**1.8**	**1.6**

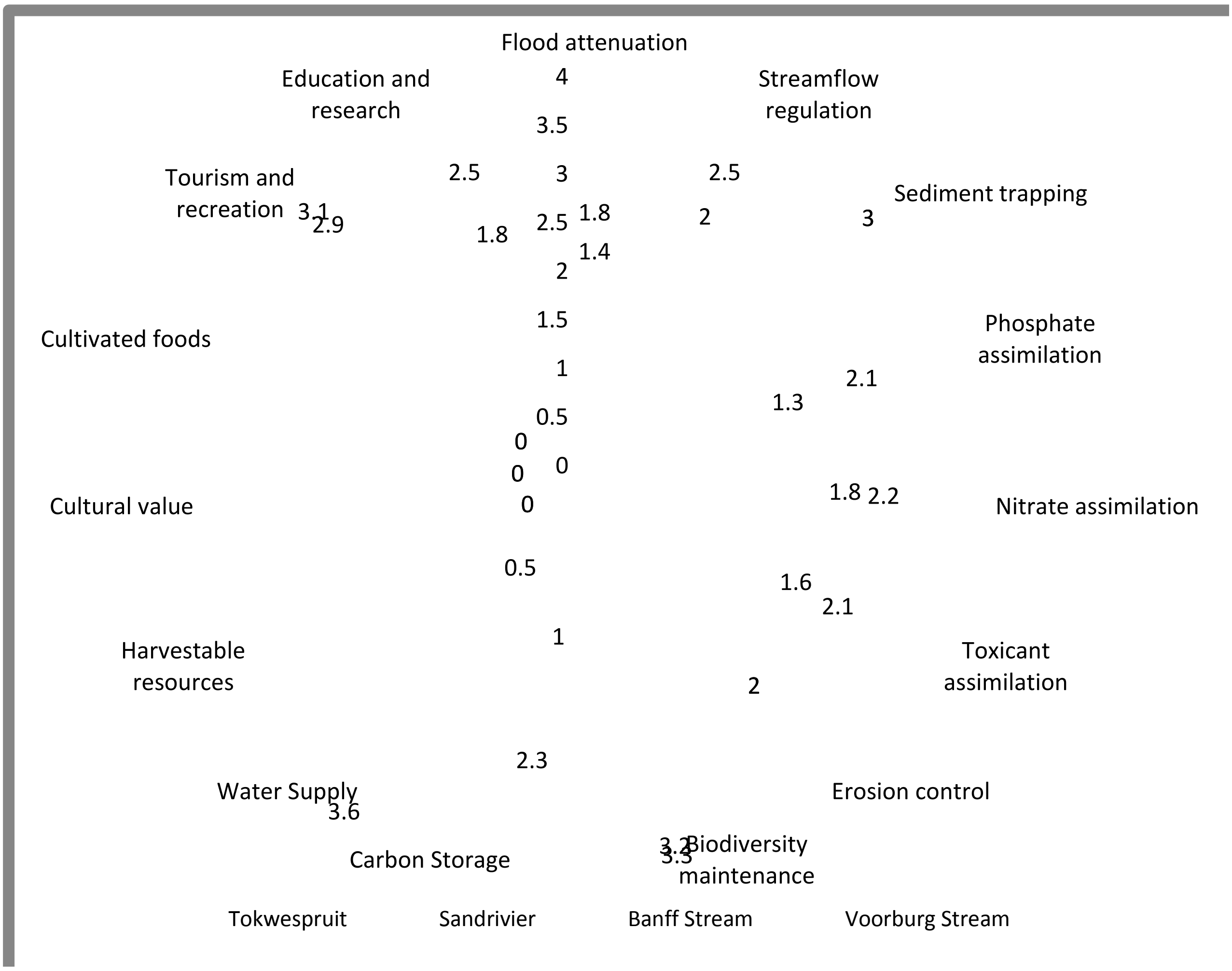


Figure 37: Radar plot of wetland services.

All the features are considered to be of intermediate importance in terms of wetland function and service provision. The Banff and Voorburg Streams are both located within farm portions not presently used for agriculture and therefore impact related to vegetation clearing, gravel roads and invasive species are lower when compared to the Sand River and Tokwespruit. All these factors contributed to a high biodiversity maintenance score for these two features. It is however notable that the Sand River, being the largest system in the area is of significant importance in terms of biodiversity maintenance in the area, supporting fish, macro-invertebrates as well as reptiles and avifauna with an affinity for surface water.

It should be noted that water is not readily available within the vicinity of the study area and as a result farmers depend on water from the rivers for general water provision for agriculture as well as livestock and game farming with specific reference to the Sand River and Tokwespruit. Furthermore, it would be difficult if not impossible to substitute the water supply from rivers with alternative water sources. The highest score calculated was therefore for water supply. If the proposed mining activity results in a decrease in available water volumes many farmers within the study area as well as downstream areas would be significantly affected. Due to sandy soil in combination with terrain units, characteristic of the region, it is also doubtful that the rivers can be diverted to prevent impact. These features are also considered of increased significance with regards to biodiversity maintenance due to the presence of fish as well as crocodiles that would be restricted to river corridors and ponds formed during the winter months. Therefore, reduced water volumes will directly impact on the survival as well as migratory corridors of aquatic species. Due to the constraints of the IHI method carbon storage is indicated as being high in the system however in reality the carbon storage value in the system is considered to be very low.

5.1.7 Index of Habitat Integrity (IHI)

The Wetland IHI index was applied to the various riverine resources in order to assist in defining the EC of these systems. The sections below present the summaries of the calculations undertaken as well as discussions of the results.

5.1.7.1 Sand River

Table 28: Sand River IHI

OVERALL PES (PES) SCORE					
	Ranking	Weighting	Score	Confidence Rating	PES Category
DRIVING PROCESSES:		**100**	**1.4**		
Hydrology	1	100	2.0	*2.5*	**C/D**
Geomorphology	2	80	0.9	*3.1*	**B**
Water Quality	3	30	0.6	*3.9*	**A/B**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.7**	***3.8***	
Vegetation Alteration Score	1	100	0.7	*3.8*	**B**
OVERALL SCORE:			**1.1**	***Confidence Rating***	
	PES %		**78.5**		
	PES Category:		**B/C**	***1.7***	

The average score calculated for the Sand River with the use of the IHI, indicates that the feature can be considered to fall within PES Category B/C. Moderately modified, loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. The largest impact and consequently the lowest PES Category are considered to be in terms of hydrology due to abstraction for agriculture along extensive portions of the Sand River. Some small changes to the system as a result of altered geomorphology and reduced water quality were also noted. Some impact on the riparian vegetation of the area was also note leading to further deviations from the expected reference condition.

5.1.7.2 Tokwespruit

Table 29: Tokwespruit IHI

OVERALL PES (PES) SCORE					
	Ranking	**Weighting**	**Score**	***Confidence Rating***	**PES Category**
DRIVING PROCESSES:		**100**	**0.7**		
Hydrology	1	100	1.2	*2.9*	**C**
Geomorphology	2	80	0.4	*3.4*	**A/B**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.1**	***3.2***	
Vegetation Alteration Score	1	100	0.1	*3.2*	**A**
OVERALL SCORE:			**0.5**	***Confidence Rating***	
	PES %		**90.6**		
	PES Category:		**A/B**	***1.4***	

The average score calculated for the Tokwespruit with the use of the IHI, indicates that the feature can be considered to fall within PES Category A/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. Water is also abstracted from the Tokwespruit that resulted in a lowered PES Category for hydrology, however water quality and geomorphology as well as riparian vegetation condition has remained largely unchanged.

5.1.7.3 Banff Stream

Table 30: Banff Stream IHI

OVERALL PES (PES) SCORE					
	Ranking	Weighting	Score	Confidence Rating	PES Category
DRIVING PROCESSES:		**100**	**0.7**		
Hydrology	1	100	1.0	2.9	**B/C**
Geomorphology	2	80	0.4	2.9	**A/B**
Water Quality	3	30	0.1	3.9	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.1**	**3.2**	
Vegetation Alteration Score	1	100	0.1	3.2	**A**

OVERALL SCORE:		**0.4**	***Confidence Rating***
	PES %	**91.9**	
	PES Category:	A/B	***1.4***

The average score calculated for the Banff Stream with the use of the IHI, indicates that the features can be considered to fall within PES Category A/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. However, some hydrological and geomorphological changes have occurred within the system that resulted in a decrease of the overall PES Category. Vegetation conditions along this system can be considered natural

5.1.7.4 Voorburg Stream

Table 31: Voorburg Stream IHI

OVERALL PES (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.7**		
Hydrology	1	100	1.0	*2.9*	**B/C**
Geomorphology	2	80	0.4	*3.4*	**A/B**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.1**	***3.2***	
Vegetation Alteration Score	1	100	0.1	*3.2*	**A**

OVERALL SCORE:		**0.4**	***Confidence Rating***
	PES %	**91.9**	
	PES Category:	**A/B**	***1.4***

The average score calculated for the Voorburg Stream with the use of the IHI, indicates that the feature can be considered to fall within PES Category A/B. Largely natural with few modifications. The Voorburg Stream is presently used for abstraction of water, therefore impact on hydrology would be present. Otherwise, the system has remained largely undisturbed and therefore vegetation as well as geomorphology has remained in a very high PES and minimal changes to water quality are deemed likely.

5.1.8 Conclusion

All the rivers investigated in the sections above are located within the Voorburg section of the study area. As a result, the Voorburg section is considered to be of higher importance in terms of conservation of riparian habitat in comparison to the Jutland and Ursa Minor sections of the Mopane Project area.

After the assessment it can be concluded that the river resources are of importance in terms of function and service provision with special mention of biodiversity as well as water provision for farmers within a water stressed region. Game farming is also the present land use of the majority of the farms investigated within the Voorburg section, with limited areas utilised for crop cultivation, consequently the river systems within the Voorburg section has remained largely undisturbed increasing importance in terms of biodiversity value. The Sand River also has significant downstream importance for socio-cultural purposes with special mention of water supply as well as biodiversity maintenance and other basic ecosystem services. Measures to ensure the ongoing functioning of the Sand River in the area are therefore considered of high significance.

Mining related activities and infrastructure as proposed by the present layout provided by the proponent would most likely impact on the Sand River and Voorburg River and would definitely result in loss of riparian habitat associated with the Banff River. Placement of infrastructure near the Sand River would 'fix' the natural movement of the corridor and would most likely result in erosion of the banks due to the sandy nature of the soil. Should mining activity encroach onto the allocated 100m buffer zones, effective mitigation of impacts would be unlikely.

It should be noted that the region in the vicinity of the study area is significantly water stressed and as a result farmers depend on water from the rivers for general water provision for agriculture as well as livestock and game farming with specific reference to the Sand River and Tokwespruit. Furthermore, it would be difficult if not impossible to substitute the water supply from rivers with alternative water sources except for possible groundwater use. If the proposed mining activity results in a decrease in available water volumes or result in the formation of a cone dewatering, many farmers within the study area as well as downstream areas would be significantly affected in addition to the ecology of the area. Due to sandy soil in combination with terrain units, characteristic of the region, it is also doubtful that the rivers can be effectively diverted to prevent impact and minimise the loss of flow reduction in the Sand River. These features are also considered to be of increased significance with regards to biodiversity maintenance due to the presence of fish as well as crocodiles that would be restricted to river corridors and refuge formed during the winter months. Therefore, reduced water volumes will directly impact on the survival as well as migratory corridors of aquatic species. Any reduction of streamflow that leads to the loss of refugia for aquatic species or the significant loss of downstream water supply should be considered an extremely high risk to the project and alternatives should be strongly considered.

It is recommended that all requirements in terms of GN 704, Section 21 of the NWA as well as General Notice no. 1199 of 2009 as it relates to the NWA, be adhered to for any proposed activities associated with mining in these areas. In this regard specific mention is made of obtaining authorisation in terms of Section 21 c and i of the NWA for all activities in these areas.

5.2 Smaller Drainage Lines

Numerous ephemeral drainage lines with poorly defined riparian zones were identified throughout the study area. As a result, many of these features could not be considered as either wetland or riparian habitat due to the lack of characteristics as defined by the NWA (Act 36 of 1998) and DWA (2005). Consequently, the digital signatures identified on a desktop level and verified during the field survey were used to distinguish between drainage lines with riparian zones and drainage lines without riparian zones within the remainder of the study area on a desktop level. It should also be noted that numerous artificial impoundments were also encountered within the drainage lines most likely due to farmers trying to retain water for as long as possible. Several of these artificial impoundments have remained inundated for long enough to be considered wetland habitat, discussed in section 5.3.

Features resembling drainage lines were also encountered, however are considered to be mainly as a result of roads or other anthropogenic activity that canalised streamflow and consequently resulted in erosion canals being formed.

Figure 38: Example of a drawing line without a riparian zone identified within the study area.

Figure 39: Distinct riparian vegetation associated with some of the drainage lines.

5.2.1 Terrain Units

Terrain units associated with drainage lines were considered uniform throughout the study area. All features assessed had a distinct active channel consisting of leached alluvial soil and incised banks. The incision of banks is as a result of the sandy nature of the soil that is prone to erosion during rainfall events. Various impoundments were also encountered within drainage lines, most likely as a result of farmers trying to retain water as long as possible.

Figure 40: Terrain units associated with drainage lines.

5.2.2 Soil

Soil within the drainage lines without riparian zones had a higher chroma and finer texture when compared to soil from drainage lines with riparian zones considered to be a result of more volumes of water conveyed by the drainage lines with riparian zones that resulted in the leaching of minerals and the transport of smaller soil granules downstream.

5.2.3 Vegetation

Figure 41: Riparian vegetation.

Due to the sandy nature of the soil, surface water within smaller drainage lines is only expected during a couple of days after sufficient rainfall and therefore saturated soil will not be present long enough within the majority of drainage lines to support floral species which are representative of riparian zones of small drainage lines. As a result the smaller drainage lines were divided based on the presence or absence of distinctive riparian vegetation. The dominant floral species of the riparian community is considered similar to the river systems as assessed in section 5.1.3, with a slight decrease in tree species diversity. The drainage lines with riparian zones do however capture enough water to support larger tree species such as *Combretum imberbe* (leadwood) (protected in accordance to the National Forests Act (Act No 84 of 1998 as amended September 2008)

The dominant floral species identified during the field survey are listed in the table below. All the drainage lines are considered ephemeral and therefore no facultative or obligate floral species were encountered that could be considered indicative of a marginal zone.

Table 32: Dominant floral species identified during the assessment of the smaller drainage lines.

Upper zone	Lower zone
Colophospermum mopane (Mopane)	*Setaria verticillata* (Bur Bristle grass)
Combretum apiculatum (Red bushwillow)	*Cynodon dactylon* (Couch grass)
Terminalia prunioides (Lowveld cluster-leaf)	*Panicum maximum* (Guinea grass)
Ziziphus mucronata (Buffalo-thorn)	
Combretum mossambicensis (Kobbly creeper)	
Euclea undulate (Common guarri)	
Grewia bicolor (White raisin)	
Gymnosporia senegalensis (Red spike thorn)	
Combretum imberbe (Leadwood)	

5.2.3.1 VEGRAI

Numerous drainage lines were assessed within the study area to determine the characteristics of the riparian communities. When results were compared it was evident that the riparian abundances as well as diversity at the different drainage lines were very similar. One VEGRAI assessment was therefore undertaken as representative of all smaller drainage lines.

The majority of the drainage lines are located within less disturbed areas of game farms, with the only impact noted being the crossing of tracks resulting in erosion within the immediate vicinity of the features. Within some features less woody species and more non woody species with special mention of graminoids were noted that decreased the overall score to some degree. However, the EC class B (largely natural) is considered representative of the majority of the drainage lines located within the study area.

Table 33: VEGRAI Ecological Category Description Scores for the drainage lines with riparian zones.

Name	VEGRAI %	EC	Definition
Drainage lines with riparian zones	82	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.

5.2.4 Surface Water

The field assessment was undertaken during winter, as a result no surface water was present within any of the drainage lines assessed. It is also considered highly unlikely that surface water would remain present for extended time periods, even after significant rainfall events, due to the permeability of the soil.

5.2.5 Biodiversity

It is regarded unlikely that any of the drainage lines will retain water long enough to provide breeding and foraging habitat for aquatic macro-invertebrates, amphibians as well as avifaunal species. However, the drainage lines with riparian zones may provide migratory connectivity as well as sheltered nesting habitat for terrestrial avifaunal species.

Furthermore, this is an important habitat type due to the longitudinal connectivity of the habitat offered by the riparian zones. The vegetation cover within riparian zones is often denser and therefore offers better habitat cover for many faunal species for longer periods of the season. This aspect consequently leads to a higher predator species component that not only relies on the better habitat cover, but also the more reliable prey source. This complex habitat type therefore often has relatively high species diversity. Localised terrestrial (or aquatic) negative impacts invariably have negative impacts on the system as a whole.

5.2.6 Wetland Function Assessment

The function and service provision was calculated for the drainage lines according to characteristics discussed in the previous sections. The average score is presented in the following table as well as the radar plot in the figure that follow the table.

Table 34: Wetland service and function assessment.

Ecosystem service	Drainage Lines
Flood attenuation	1.6
Streamflow regulation	1.8
Sediment trapping	2.6
Phosphate assimilation	1.8
Nitrate assimilation	1.7
Toxicant assimilation	1.3
Erosion control	2.1
Biodiversity maintenance	2.8
Carbon Storage	0.7
Water Supply	0.3
Harvestable resources	0
Cultural value	0
Cultivated foods	0
Tourism and recreation	2.5
Education and research	1.8
SUM	**21.0**
Average score	**1.4**

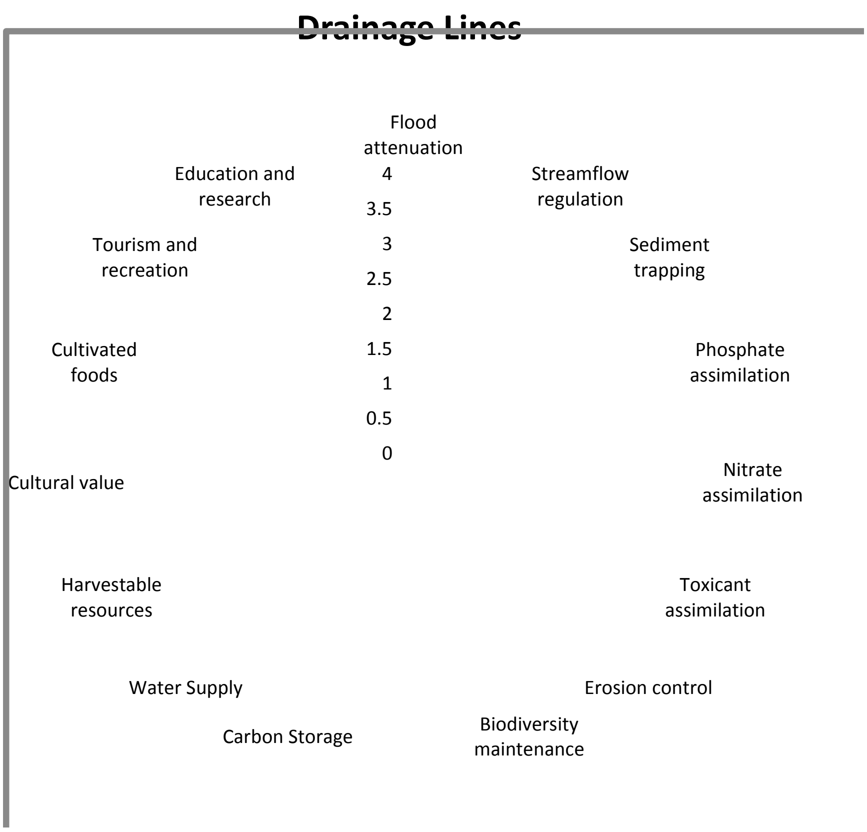


Figure 42: Radar plot of wetland services.

From the results of the assessment, it is evident that the smaller drainage lines encountered within the study area are not regarded to be of exceptional importance in terms of function and service provision. This is mainly as a result of lack of water for extended periods of time limiting the ability to support any aquatic ecological communities or the formation of seasonal and permanent wetland zones that could support a more diverse riparian floral community.

The drainage lines cannot be considered important in terms of harvestable resources or cultivated foods due to lack of sufficient water that would support such activities. However, drainage lines are still considered important in terms of biodiversity maintenance, tourism and recreation as well as sediment trapping.

5.2.7 Wet-Health

Refer to section 5.3.1.7.

5.2.8 Index of Habitat Integrity (IHI)

Table 35: Smaller Drainage Lines IHI.

OVERALL PES (PES) SCORE					
	Ranking	**Weighting**	**Score**	***Confidence Rating***	**PES Category**
DRIVING PROCESSES:		**100**	**0.5**		
Hydrology	1	100	0.7	*2.9*	**B**
Geomorphology	2	80	0.4	*2.9*	**A/B**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.1**	***3.2***	
Vegetation Alteration Score	1	100	0.1	*3.2*	**A**
OVERALL SCORE:			**0.3**	***Confidence Rating***	
	PES %		**93.7**		
	PES Category:		**A**	***1.4***	

The average score calculated for the smaller drainage lines with the use of the IHI, indicates that the features can be considered to fall within PES Category A (Unmodified/Natural). Smaller drainage lines have been left largely undisturbed with marginal change for hydrology and geomorphology calculated.

5.2.9 Conclusion

Smaller drainage lines were not restricted to a specific section within the study area and therefore the Voorburg, Jutland and Ursa Minor sections are all considered to be of importance in terms of riparian habitat associated with these drainage lines. However, mining activities within smaller drainage lines within the Voorburg section will most likely also result in impact on the river systems, due to the close proximity between the features with special mention of sedimentation and reduced water volumes.

Characteristics of smaller drainage lines with riparian zones are considered to be largely uniform throughout the study area. The majority of the features are located within more isolated areas further from farm related activities and the lack of water for extensive periods of the year does not make it feasible for abstraction. All these aspects have resulted in drainage features with marginal present impact, which can be considered important in terms of biodiversity conservation.

Due to the ephemeral nature of the drainage lines, not all drainage lines could be considered riparian habitat as defined by NWA No 36 of 1998. Therefore, distinction was made between drainage lines with riparian zones and drainage lines without riparian zones. Smaller drainage lines with riparian zones are defined as watercourses. If any activities are to take place within 100 meters or the 1:100 year flood lines exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA will also apply and therefore a Water Use Licence will be required.

Smaller drainage lines *without* riparian zones are not considered wetlands but are still defined as watercourses. If any activities are to take place with the 1:100 year flood line exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained, however Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA does not apply and therefore no Water Use Licence will be required.

5.3 Artificial Depressions and Pans

Several artificial depressions were identified, mostly as a result of artificially created impoundments within drainage lines. By considering the distinguishing factors of wetland habitat as defined by DWA (2005), namely presence of surface water, hydromorphic soil and vegetation adapted to saturated soil the depressions encountered can be subdivided into wetland depressions and terrestrial depressions. All depression features would hold water temporarily, during periods of sufficient rainfall. However, depressions can be divided into wetland depressions and terrestrial depressions depending on permeability of the base and the extent of the drainage catchment of the depression and consequent ability to retain water long enough for the formation of hydromorphic soil that would support facultative floral species.

Another important aspect to note is that some of the depressions were only created recently and therefore the soil has not been saturated long enough for the formation of hydromorphic soil or establishment of obligate or facultative vegetation. However, it is considered highly likely that these features would start displaying wetland characteristics in the future as the soil surface becomes more compact retaining surface water for longer.

Figure 43: Terrestrial depression (left) and wetland depressions (right) identified during the field survey.

Several features which as best described as depressional features are scattered through the Jutland section of the project. Although the terrain units of the pan features are similar to that of wetland depressions, these features are hydrologically isolated and therefore would not be of the same importance in terms of function and service provision or Wet-Heath. These two aspects where therefore assessed separately.

5.3.1 Terrain Units

Both pans as well as artificial impoundments (wetland depressions) can be considered depressions. Although the impoundments are located within smaller drainage lines, presently, these features can rather be considered representative of a depression HGM type. The definition of a depression states that it is a wetland or aquatic ecosystem with closed (or near closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates.

5.3.2 Soil

The wetland depressions and pans hold water long enough for hydromorphic soil formation. Therefore, soil within the permanent zone will be permanently waterlogged and only obligate floral species would survive. *Phragmites australis* (common reed) is such an obligate wetland species found within all wetland depressions assessed indicative of permanently waterlogged conditions. Furthermore, soil within the temporary zone had a low chroma compared to surrounding terrestrial zones. A sign of anaerobic conditions under which minerals such as iron becomes soluble and leaches from soil, a characteristic known as gleying.

5.3.3 Vegetation

Obligate and facultative wetland species were only identified within the wetland depressions. The terrestrial depressions were either dominated by pioneer graminiod species not adapted to saturated soil or lacked a vegetation layer completely with no evidence of hydromorphic soil and was therefore not considered wetland habitat.

Although all wetland depressions assessed had similar dominant vegetation communities within the different hydrological zones there was a distinct difference in floral species diversity between wetland depressions and pans. The permanent zones of pans were bare, although soil did display hydromorphic characteristics with special mention of gleying.

Dominant species were characterised as either wetland or terrestrial species. The wetland species were then further categorised as temporary, seasonal and permanent zone species. This characterisation is presented in Table 36 below, and includes the terrestrial species identified near the wetland zones. Obligate as well as facultative wetlands species such as *Cyperus fastigiatus* and *Phragmites australis* (common reed) were the dominant species within permanent zones of wetland depressions and are therefore not related to pans.

Table 36: Dominant floral species identified during the assessment of the wetland depressions and pans.

Terrestrial species	Temporary species	Seasonal species	Permanent species
Colophospermum mopane (Mopane)	*Cynodon dactylon* (Couch grass)	Cyperus fastigiatus	Cyperus fastigiatus
Acacia karroo (Sweet thorn)	*Panicum maximum* (Guinea grass)	*Cynodon dactylon*	*Phragmites australis* (Common reed)
Dichrostachys cinerea (Sickle bush)	*Grewia flava* (Velvet raisin)	*Panicum maximum* (Guinea grass)	*Cyperus sexangularis*
			Cyperus esculentus

Surface Water

The field assessment was undertaken during winter, therefore only features with the ability to retain water for extended periods of time had surface water at the time of the assessment. Terrestrial depressions lacked surface water completely, with some evidence encountered of seasonal inundation in the form of a cracked soil surface. However, water never remains long enough for the formation of hydromorphic soil as was evident within the wetland depressions or pans.

5.3.4 Biodiversity

Wetland depressions and pans are considered to be of increased sensitivity due to their ability to retain water for longer periods of time that would provide habitat for wetland dependant floral and faunal species for longer periods within a region with very limited surface water present year round. Although the terrestrial depressions only retain water seasonally, these features will still provide habitat for amphibian and avifaunal species during the rainy season. However, overall importance in terms of biodiversity is not considered as high as wetland depressions.

At the time of the assessment various avifaunal species were encountered near wetland depressions. *Pelomedusa subrufa* (Marsh Terrapin), although considered common for the region was also noted and would be restricted to areas with sufficient surface water. It is therefore considered important that as far as possible wetland depressions and pans remain undisturbed during the proposed mining activities.

5.3.5 Wetland Function Assessment

The function and service provision was calculated for the wetland depressions according to characteristics discussed in the previous sections. The average score is presented in the following table as well as the radar plot in the figure that follows the table.

Table 37: Wetland service and function assessment.

Ecosystem service	Wetland Depressions	Pans
Flood attenuation	0.7	0.8
Streamflow regulation	2.1	1
Sediment trapping	1.8	0.6
Phosphate assimilation	2	0.7
Nitrate assimilation	2.8	1.7
Toxicant assimilation	2.1	1
Erosion control	1.4	1.6
Biodiversity maintenance	2.9	2.8
Carbon Storage	1.3	2.3
Water Supply	2.5	1
Harvestable resources	0	0
Cultural value	0	0
Cultivated foods	0	0
Tourism and recreation	3.4	2.9
Education and research	1.3	1.8
SUM	**24.3**	**18.2**
Average score	**1.6**	**1.2**

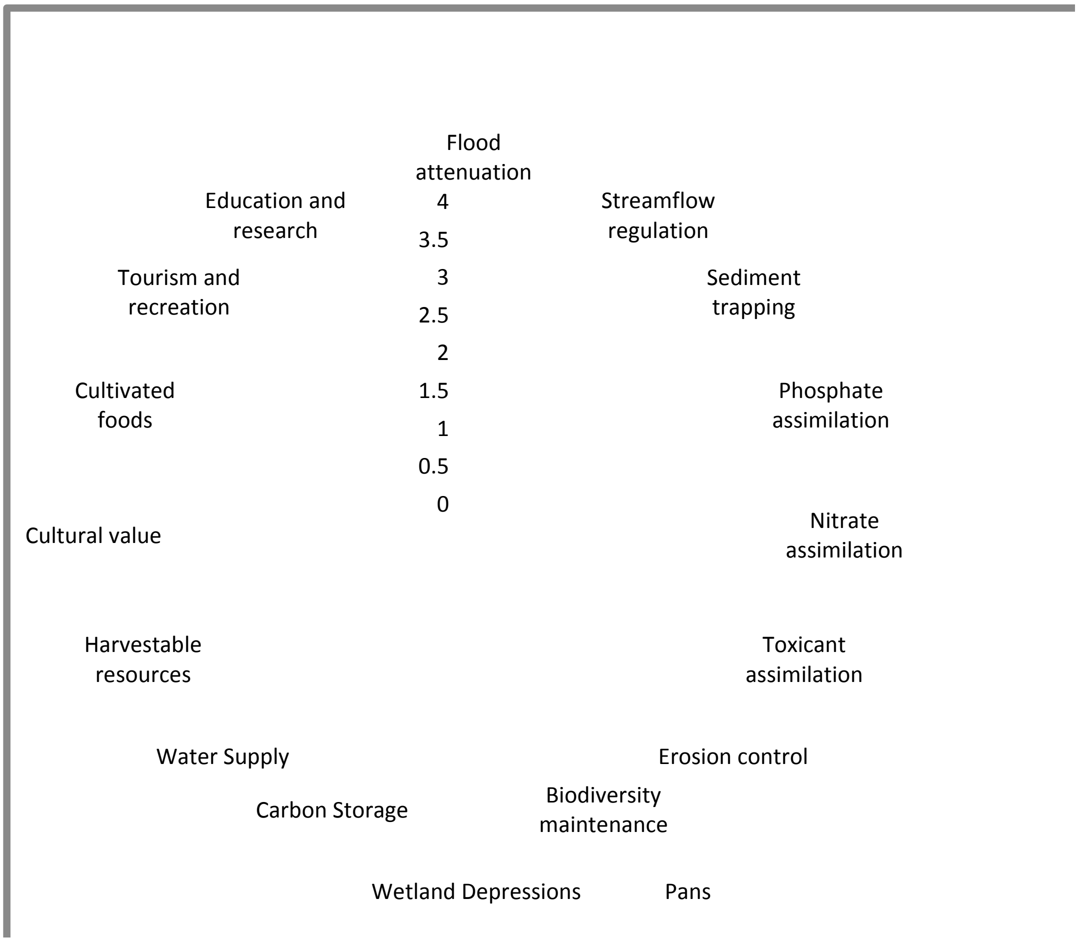


Figure 44: Radar plot of wetland services.

When considering the average scores for both groups it is evident that wetland depressions can be considered of intermediate importance and pans of moderately low importance in terms of service and function provision. Both feature groups can be considered to be the most important in terms of biodiversity maintenance and tourism and research mainly as a result of the presence of open water during extended periods of the year providing water for wildlife during the winter months. Water of larger wetland depressions also constitute a great volume of water for crop cultivation as well as general agricultural activities.

The presence of facultative and obligate wetland species within wetland depressions also increases importance in terms of assimilation of phosphates, nitrates and toxicants that may be washed down within surface water from crop cultivation areas. The pans lack vegetation and therefore the scores obtained for assimilation of chemicals are much lower when compared to wetland depressions.

None of the features are located within a rural communal area and therefore service provision in terms of harvestable resources, cultural value and cultivated food are considered to be insignificant.

5.3.6 Wet-Health

The Wet-Health assessment method allows for a Level 1 assessment where large numbers of wetlands need to be assessed and where time and resources do not allow for a detailed assessment for each individual wetland feature. For the assessment of the study area all pans were considered to fall within the same hydrogeomorphic (HGM) Unit and as a result were assessed collectively. All pans encountered, displayed the same hydrological, geomorphological and vegetation characteristics therefore the combined assessment is considered representative of the group.

It should however be noted that the Wet-Health assessment could not be applied to the wetland depressions as isolated features, they form part of the smaller drainage lines. Therefore, the wetland depressions were assessed as part of the smaller drainage lines.

Table 38: Summary of the overall health of the features based on impact score and change score.

Feature type	Hydrology		Geomorphology		Vegetation	
	Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
Smaller drainage lines	B	→	C	→	A	→
Pans	A	→	A	→	A	→

The drainage lines calculated a score for hydrology that falls within a PES class of B (largely natural with few modifications) and a score for geomorphology that fall within a PES class of C (moderately modified). The impoundments (wetland depressions) are mainly responsible for the reduced PES, however both scores are still considered high. The drainage lines are mostly located within isolated areas within game farms and as a result impact on the vegetation cannot be considered significant.

The limited amount of anthropogenic activity noted during the assessment within the immediate vicinity of the pans resulted in the pans still being in a very high PES (unmodified, natural). Furthermore, endorheic depressions lack surface connectivity to surrounding wetland areas and as a result impact descriptions used within the calculations such as impeding features upstream and downstream as well as stream diversions are not applicable.

In terms of anticipated trajectory[13], should the mining development not take place, it is considered to be highly likely that the PES of both feature groups assessed would remain the same. However, should mining activities occur in close association to any of the features the PES would most likely decrease significantly.

5.3.7 Conclusion

The majority of pans and wetland depressions were identified within the Jutland section, therefore increasing importance in terms of wetland habitat. The majority of the footprint proposed for the Jutland section is infrastructure and the layout could therefore be adjusted to avoid these features with the allocated 100m buffer zones, to reduce or avoid impact related to the proposed mining activities.

[13] Anticipated change over the next 5 years.

Wetland depressions as well as pans showed characteristics of a wetland habitat in which soil is saturated for a sufficient period, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. These depressions are considered to be of increased EIS for aquatic and terrestrial species which rely on these systems for parts of their life cycles as well as drinking water during winter months. It is for this reason that these systems should be conserved wherever possible and that as far as possible connectivity between these areas and surrounding open areas should be maintained in order to support the biodiversity maintenance services that these systems provide.

Artificial impoundments referred to as wetland depressions above are located within smaller drainage lines. As a result, any impact by the proposed mining activities on smaller drainage lines would most likely also impact wetland depressions. Furthermore, the wetland depressions are directly dependent on the smaller drainage lines for recharge. Therefore, reduced surface flow would result in loss of wetland habitat in future.

Pans are depressions without in or outflow, therefore dependent on the surrounding catchment for water. Any activity that would result in a reduction in size of the catchment would impact on the volume of water reaching the pans in turn impacting wetland habitat presently considered to be important in terms of function and service provision.

5.4 Synthesis

Sites selected with the use of desktop methods, were investigated during the field survey undertaken in July 2013. For the purposes of this investigation, use was made of distinguishing factors as either defined by DWA (2005) for 'wetland habitat' or defined in the Water Act (Act No 36 of 1998) for 'riparian habitat'. After the field assessment it can be concluded that four groups representing true wetland or riparian characteristics are present within the study area namely rivers, smaller drainage lines, pans and wetland depressions. These four groups were then assessed to determine importance in terms of function and service provision as well as PES, discussed in the sections above. The bullets below summarise the key findings:

- The results obtained indicate that the Sand River can be considered the most important in terms of function and service provision, with the highest scores calculated for water supply, biodiversity and tourism and recreation. The next highest average scores calculated was for the Voorburg Stream, Banff Stream and wetland depressions;

- Wet-Health was used to determine the PES of smaller drainage lines including wetland depressions and pans. Pans calculated average scores for vegetation, hydrology and geohydrology that fall within a very high PES (unmodified, natural), mainly as a result of their remoteness. Smaller drainage lines calculated the same impact score for vegetation, however hydrology and geohydrology impact scores are lower as a result of impact from earth works due to the construction of the impoundments (wetland depressions) as well as abstraction of water;
- VEGRAI was used to assess the response of riparian vegetation to impacts within rivers as well as smaller drainage lines. The mean average scores calculated for the Sand River and Tokwespruit both fall within Class C (moderately modified) and mean average scores calculated for the smaller drainage lines, Banff and Voorburg Streams fall within Class B (largely natural); and
- The IHI was used to assess the vegetation, hydrology and geomorphology of the different river systems and drainage lines. All three aspects were used to determine the average PES category for each feature assessed. The smaller drainage lines calculated the highest PES score falling within a Class A (unmodified), followed by the Banff Stream, Voorburg Stream and the Tokwespruit all calculating scores falling between Class A and B (largely natural). The Sand River calculated the lowest score falling between Class B and Class C (moderately modified).

5.5 GIS Mapping

Due to time constraints, the vast number of wetland and riparian features within the study area as well as restricted access to some of the farms within the study area, digital signatures were identified during the initial desktop assessment that were ground truthed during the assessment of each site that was selected. These digital signatures were then used to determine if wetland or riparian habitat is present within a feature. The following digital signatures were considered:

- Riparian vegetation: a distinct increase in density as well as tree size near drainage lines;
- Hue: with drainage lines and outcrops displaying soils of varying chroma created by varying vegetation cover and soil conditions identified;
- Surface water: to aid with the identification of artificial impoundments that may sustain wetland habitat the presence of surface water were considered informative; and
- Texture: with areas displaying various textures, created by varying vegetation cover and soil conditions being identified.

5.6 Delineation and Sensitivity Mapping

All features were delineated on a desktop level with the use of aerial photographs, digital satellite imagery and topographical maps. Portions of the features were verified during the field survey according to the guidelines advocated by DWA (2005) and the wetland/riparian delineations as presented in this report are regarded as a best estimate of the temporary and riparian zone boundaries based on the site conditions present at the time of assessment.

The following indicators were used during the verification of riparian and wetland zones:

- Terrain units were used as the primary indicator for both riparian as well as wetland zones;

Figure 45: Terrain unit used as primary indicator.

- Vegetation was also considered informative at all features.
    - A riparian zone is defined as an area that supports vegetation with a composition and physical structure distinct from the adjacent terrestrial zones. Vegetation could therefore be used as secondary indicator for rivers and smaller drainage lines;
    - Facultative and obligate wetland floral species were encountered at all wetland depressions, with a distinct increase of *Colophospermum mopane* (Mopane tree) within terrestrial areas; and
    - Pans lacked vegetation completely within permanent and seasonal zones, with an increase in abundance of terrestrial species within the temporary and terrestrial zones.

Figure 46: Vegetation used as secondary indicator.

- Soil form as indicator was used within areas where vegetation and landscape transformation have taken place.
  - For the soil form indicator at wetland depressions and pans, the presence of gleyed soils (most of the iron has been leached out of the soil leading to a greyish/greenish/bluish colour) and mottling (created by a fluctuating water table) were investigated; and
  - For the soil form indicator at rivers and smaller drainage lines, the presence of leached alluvial soils were investigated.

Figure 47: Gleying evident within the soil profile of the smaller drainage lines with riparian zones (left); gleyed soils within the permanent zone of pans (right).

- The field assessment was undertaken during the middle of winter, as a result no surface water was present within the Banff Stream, Tokwespruit and smaller drainage lines. The Sandspruit, Voorburg Stream, pans and wetland depressions do however retain surface water throughout the year. However, only within deeper depression areas and was therefore not helpful with the delineation.

Figure 48: Surface water.

5.6.1 Legislative requirements

Legislative requirements were used to determine the extent of buffer zone required for each group depending on whether a group is considered wetland/riparian habitat or not.

The Sand River, Tokwespruit, Banff Stream and Voorburg Stream as well as smaller drainage lines with riparian zones are defined as watercourses. If any activities are to take place within 100 meters or the 1:100 year flood lines exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA will also apply and therefore a Water Use Licence will be required.

Smaller drainage lines *without* riparian zones are not considered wetlands but are still defined as watercourses. If any activities are to take place with the 1:100 year flood line exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained, however Section 21 of the NWA (Act 36 of 1998) as well as General Notice no.

1199 of 2009 as it relates to the NWA does not apply and therefore no Water Use Licence will be required.

Wetland depressions form part of smaller drainage lines with riparian zones and as a result are already included within the legislative requirements defined for the smaller drainage lines above.

Pans are considered wetland habitat, therefore a Water Use Licence in terms of section 21 c and i of the NWA will be required, and the 500 m zone of applicability of General Notice no. 1199 of 2009 as it relates to the NWA will also apply.

5.6.2 Buffer Allocations

During the field survey it became evident that the majority of features has remained largely undisturbed and can still be regarded to be in a high PES. Furthermore, features with surface water throughout the year play a vital role in the provision of water for both wildlife as well as agricultural activities. To comply with legislative requirements as defined above as well as to aid with conservation of habitat within the study area, during the proposed mining activities, 100m buffer zones are recommended for all features. The location of the features in relation to the study area is conceptually depicted in the figures**Error! Reference source not found.** below. Subsequently, the activities will fall within the 500m zone of applicability of General Notice no. 1199 of 2009 as it relates to the NWA, therefore a risk assessment might have to be undertaken. It is recommended that the mining proponent liaises with DWA in order to ensure that all legislative requirements are adhered too in terms of General Notice no. 1199.

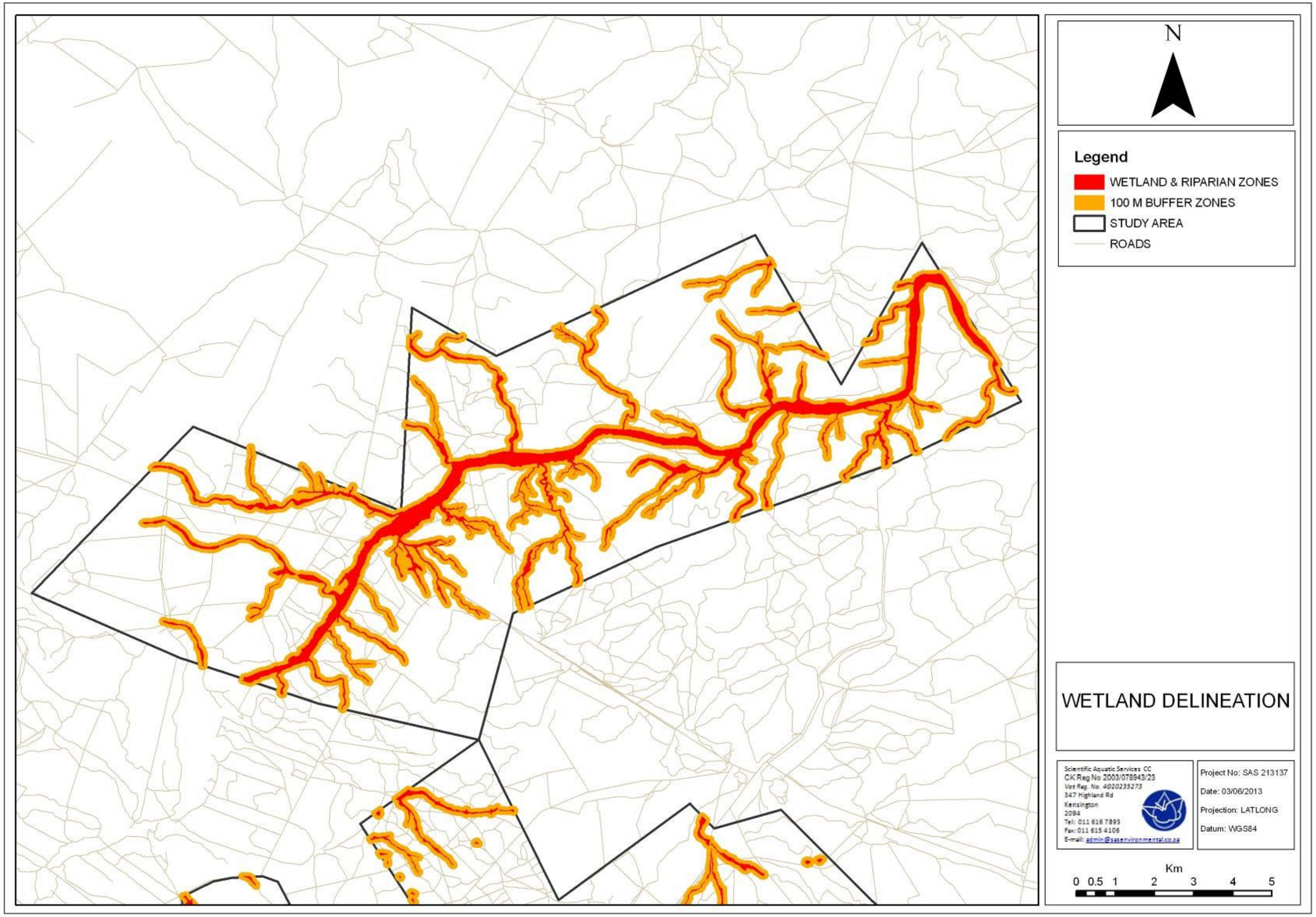


Figure 49: Allocated 100m buffer zones in relation to the Voorburg section.

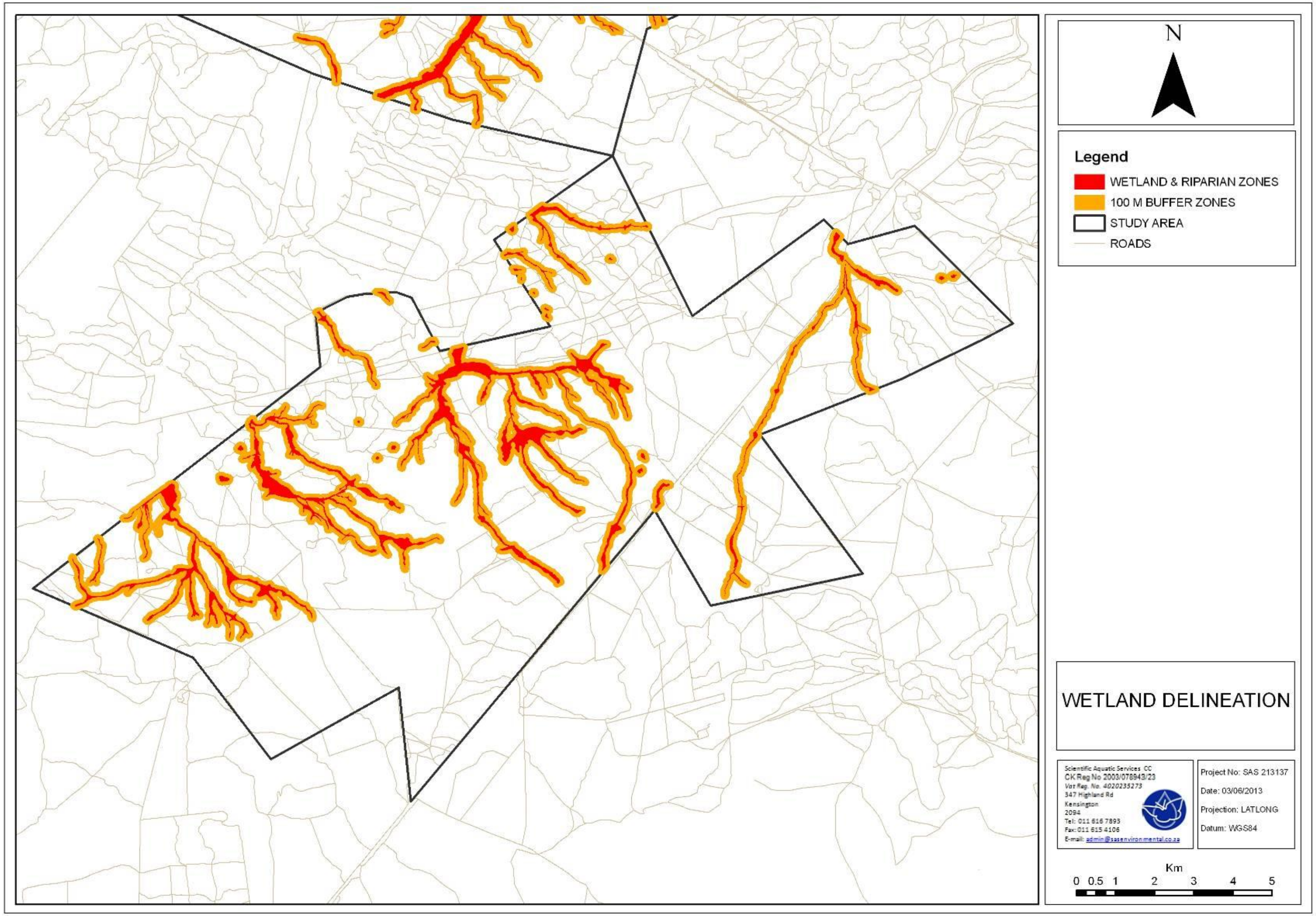


Figure 50: **Allocated 100m buffer zones in relation to the Jutland section.**

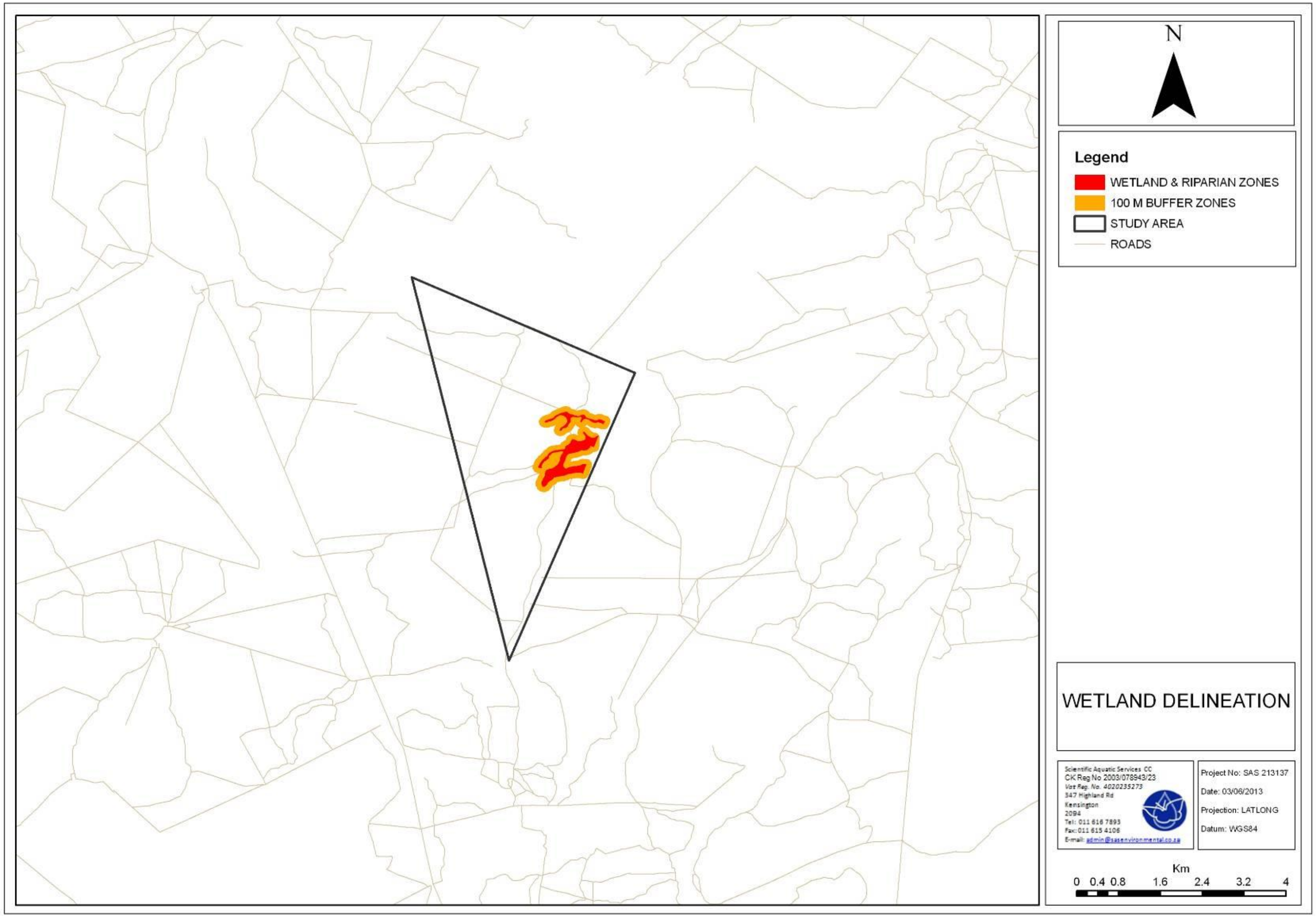


Figure 51: Allocated 100m buffer zones in relation to the Ursa Minor section.

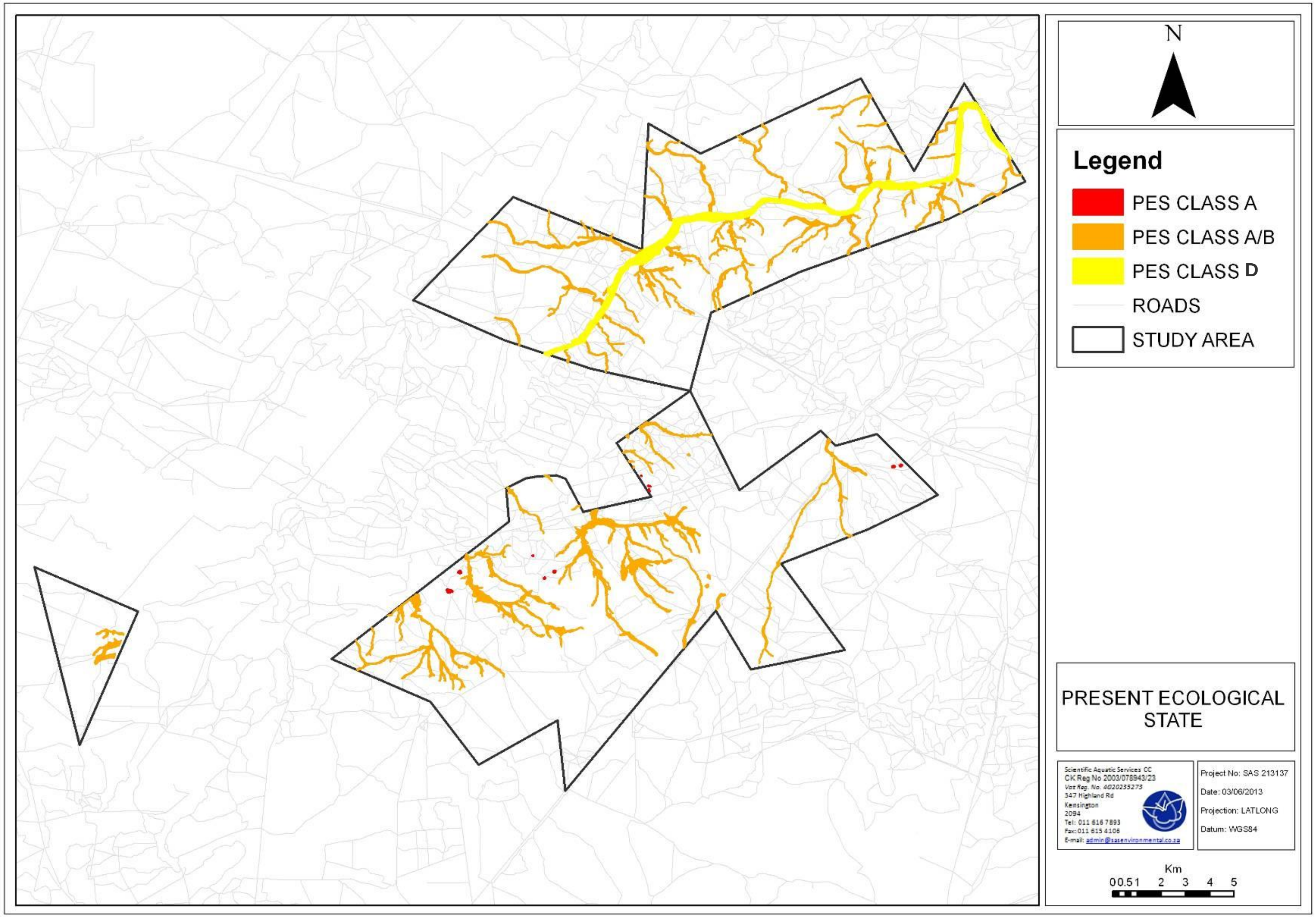


Figure 52: PES category in relation of the study area.

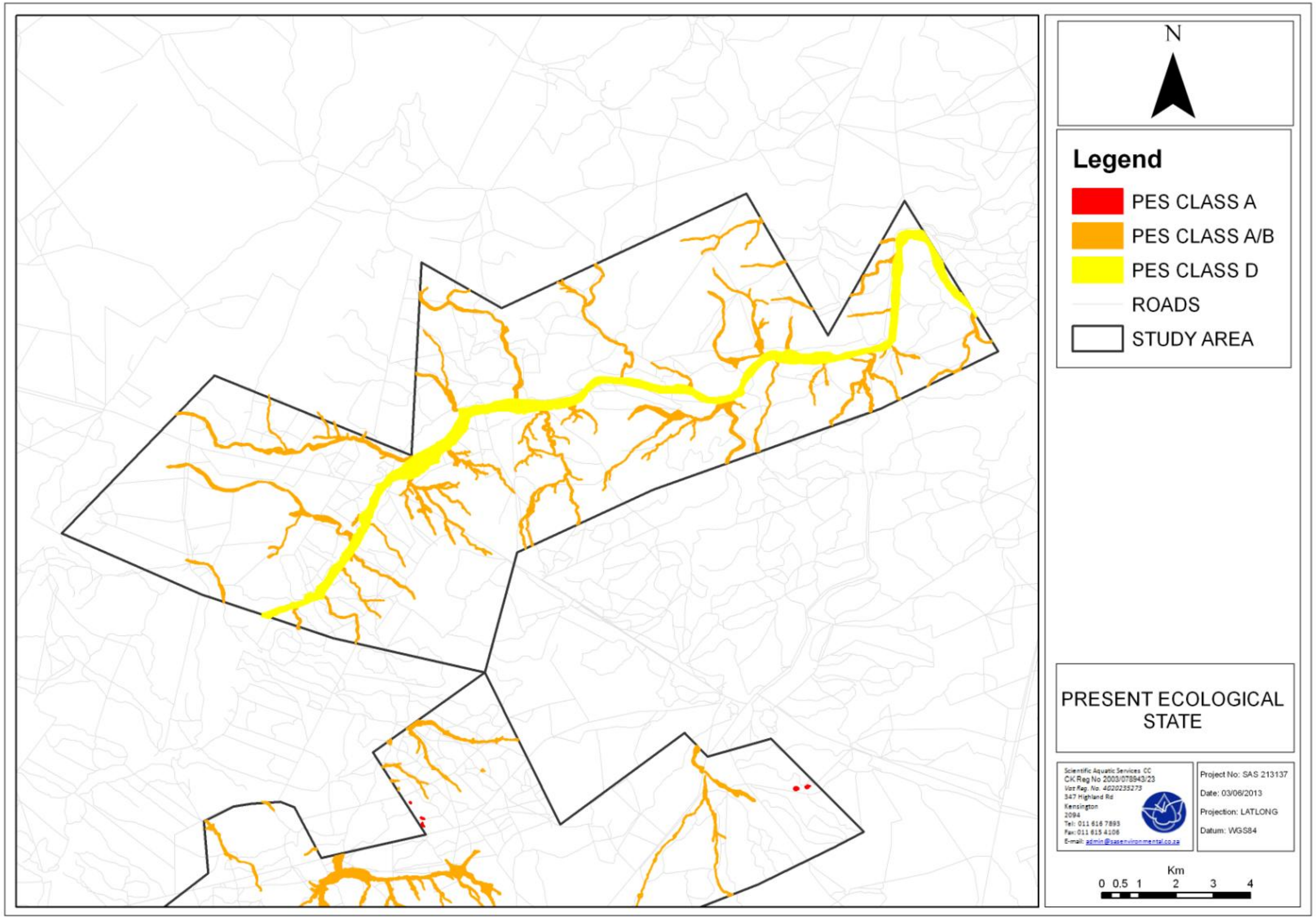


Figure 53: **PES category of features within the Voorburg section.**

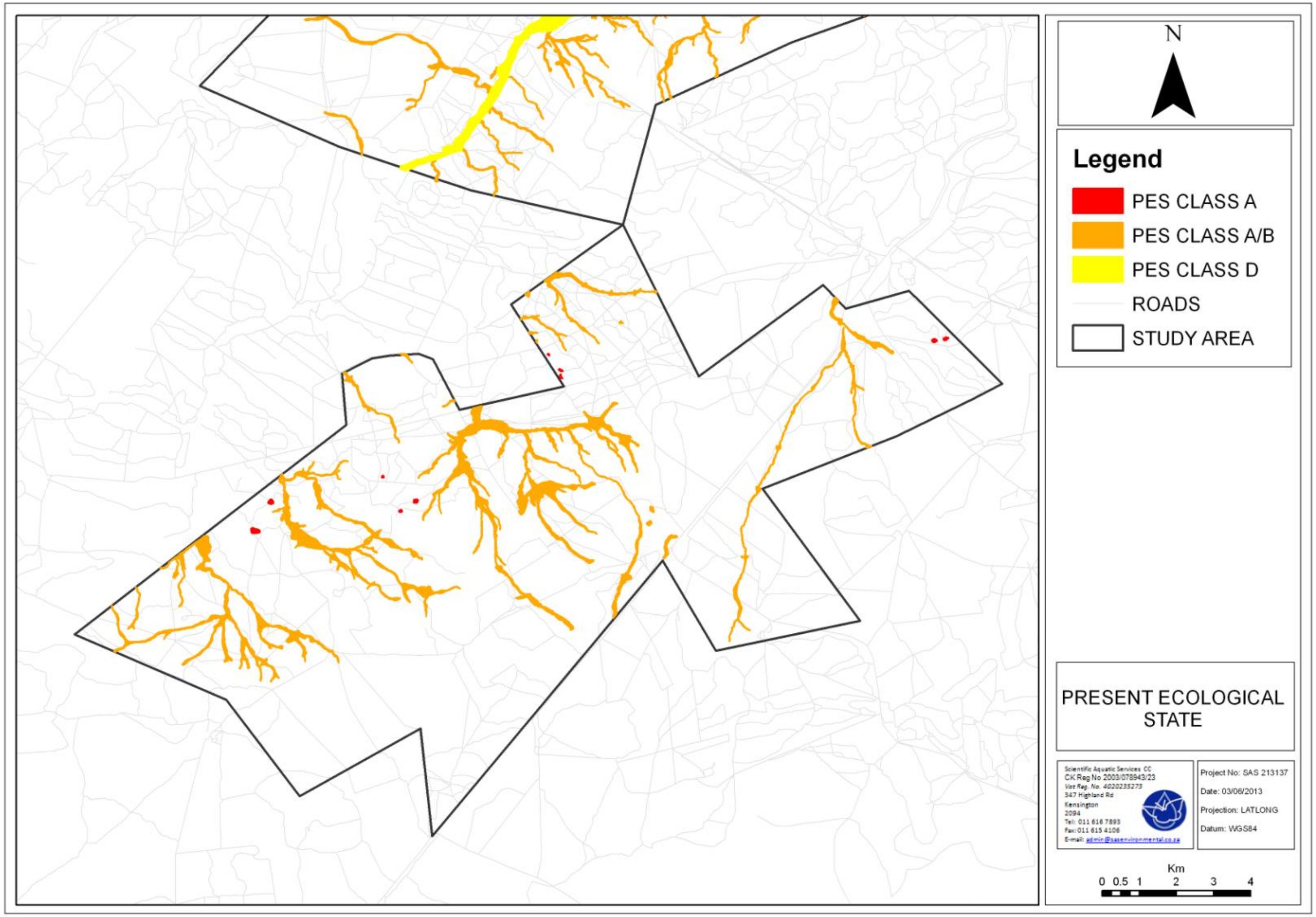


Figure 54: PES category of features within the Jutland section.

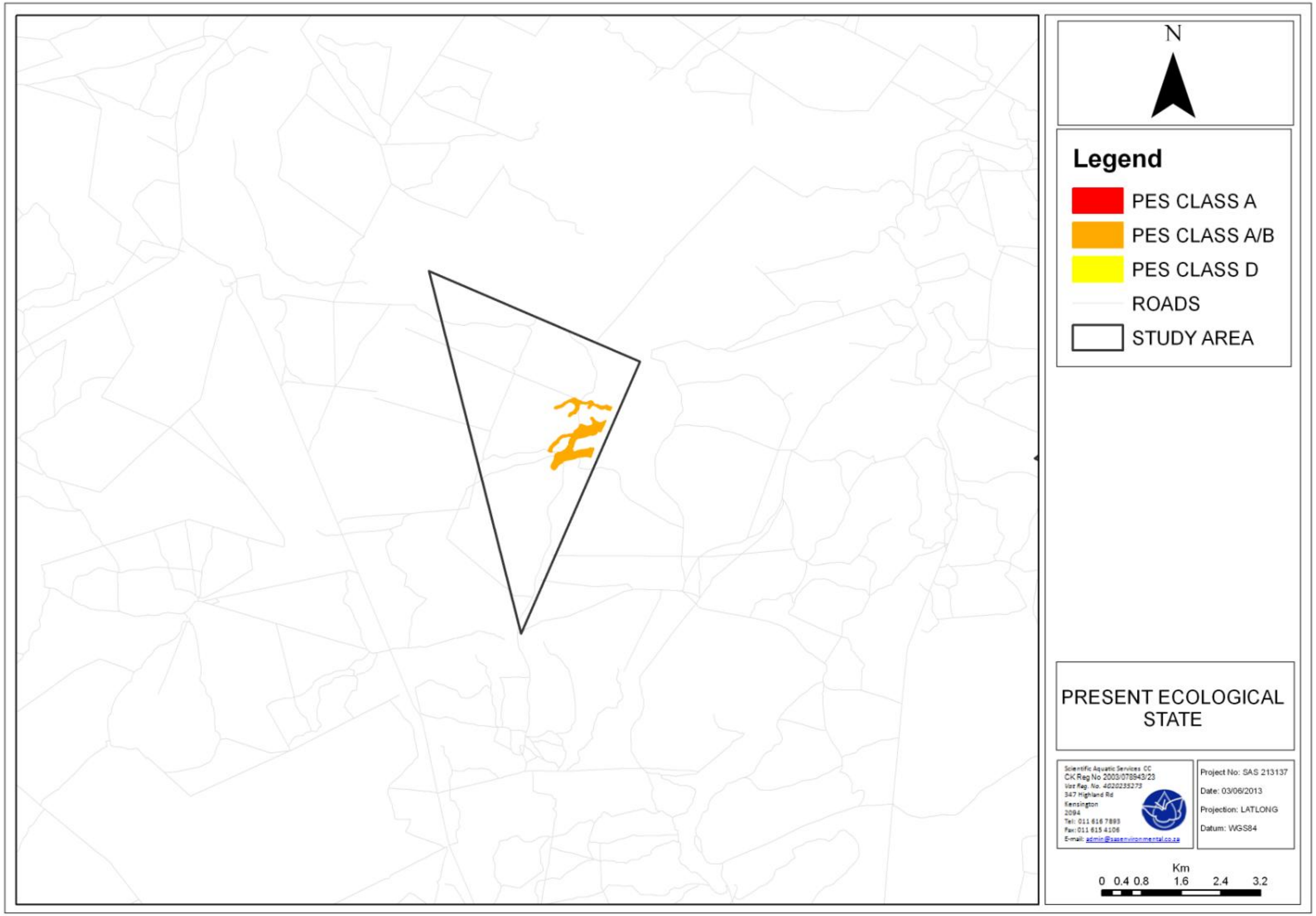


Figure 55: PES category of features within the Ursa Minor section.

5.7 Recommended Ecological Class

According to the resource directed measures for protection of water resources[14] a wetland or river may receive the same class for the PES, as the REC, if the habitat is deemed in good condition, and therefore must stay in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as to enhance the PES of the feature. The results obtained from the assessments indicate a relatively low presence of transformation on all levels of ecology and functionality except for the Sand River which can be considered to be a largely modified system. It is therefore recommended that the features be assigned the same REC as the PES Class calculated.

Table 39: Assigned REC Classes.

Feature	PES Class	REC Class
Sand River	D (combined assessment of wetlands and aquatic ecostatus)	D
Tokwespruit	A/B (IHI)	A/B
Banff Stream	A/B (IHI)	A/B
Voorburg Stream	A/B (IHI)	A/B
Smaller drainage lines	A/B (Wet-Health)	A/B
Wetland depressions	A/B (Wet-Health)	A/B
Pans	A (Wet-Health)	A

6 AQUATIC ECOLOGICAL ASSESSMENT RESULTS

6.1 RESULTS

A photographic record of each site was made in order to provide a visual record of the condition of each assessment site as observed during the field assessment. The photographs taken are presented, followed by a table summarising the observations for the various criteria made during the visual assessment undertaken at each point.

[14] DWA and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources 1999*

6.1.1 The Sand River

Figure 56: Upstream view of the GSP3 site on the Sand River showing the very limited flow at the time of assessment.

Figure 57: Downstream view of the GSP3 site showing the sandy substrates present.

 Figure 58: Upstream view of the GSP2 site on the Sand River.	 Figure 59: Downstream view of the GSP2 site showing the dry river bed
 Figure 60: Upstream view of the GSP1 site on the Sand River showing the lack of surface flow upstream of the point.	 Figure 61: Downstream view of the GSP1 site showing the deep pool at this point.

Figure 62: Upstream view of the GSP6 site on the Sand River showing the good aquatic and bankside vegetation cover at this point.

Figure 63: Downstream view of the GSP6 site on the Sand River showing the limited flow at the point.

Figure 64: Upstream view of the GSP4 site on the Sand River showing the absence of water at this point.

Figure 65: Downstream view of the GSP4 site on the Sand River showing the sandy substrate and presence of reeds along the stream banks.

Table 40: Visual description of the sites selected on the Sand River

ASPECT	GSP1	GSP2	GSP3	GSP4	GSP6
Significance of the point	The site is situated on the downstream boundary of the project area. Future aquatic assessment results for this point can be spatially compared to the results obtained at site GSP6 in order to identify any impacts on the aquatic ecology of the system occurring between the two points.	Site serves as a reference point in the middle of the project area on the Sand River.	This site serves as a future spatial reference point to indicate the condition of the Sand River prior to any effects as a result of the activities of the proposed Mopane mining project and serves as a reference point for sites GSP1 and GSP2.	The site is situated downstream of the boundary of the proposed Chapudi project area and a significant distance upstream of the proposed Mopane area. Future aquatic assessment results for this point can be spatially compared to the results obtained sites further downstream in the vicinity of the Proposed Mopane project.	This site serves as a future spatial reference point to indicate the condition of the Sand River prior to any effects as a result of the activities of the proposed Chapudi and Mopane mining projects and serves as a reference point for all sites further downstream in the catchment.
Surrounding features	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion.	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion.	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion. This point is also affected by a train bridge crossing which has led to some local habitat changes.	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion. This point is also affected by a low water crossing which has led to significant local habitat changes and impacts on streamflow continuity	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion. This point is also affected by an upstream gauging weir which has led to significant local impacts on migratory connectivity.

ASPECT	GSP1	GSP2	GSP3	GSP4	GSP6
Riparian zone characteristics	The riparian zone along the length of this section of the Sand River is steep and narrow due to the effects of erosion taking place during the high flow season. Significant variation in flow is evident between the dry and the rainy seasons. The riparian vegetation is dense and being affected by a number of increasing impacts as a result of water abstraction, grazing, agriculture, alien vegetation encroachment and erosion.	The riparian zone along the length of this section of the Sand River is steep and narrow due to the effects of erosion taking place during the high flow season. Significant variation in flow is evident between the dry and the rainy seasons. The riparian vegetation is dense and being affected by a number of increasing impacts as a result of water abstraction, grazing, agriculture, alien vegetation encroachment and erosion.	The riparian zone along the length of this section of the Sand River is steep and narrow due to the effects of erosion taking place during the high flow season. Significant variation in flow is evident between the dry and the rainy seasons. The riparian vegetation is dense and being affected by a number of increasing impacts as a result of water abstraction, grazing, agriculture, alien vegetation encroachment and erosion.	The riparian zone along the length of this section of the Sand River is steep and narrow due to the effects of erosion taking place during the high flow season. Significant variation in flow is evident between the dry and the rainy seasons. The riparian vegetation is dense and being affected by a number of increasing impacts as a result of water abstraction, grazing, agriculture, alien vegetation encroachment and removal.	The riparian zone along the length of this section of the Sand River is steep and narrow due to topography of the area. Some vegetation removal has occurred and the banks are domintated by reeds and sedges. The riparian zone at this point is being affected by water abstraction, alien vegetation encroachment and removal.
Depth and flow characteristics	The Sand River was dry along most of its course with only subterranean flow present along extensive lengths of the system at the GSP1 point the site consisted of an isolated deep pool	The Sand River was dry along most of its course with only subterranean flow present along extensive lengths of the system, as evidenced at this point.	The Sand River was dry along most of its course with only subterranean flow present along extensive lengths of the system. In many areas only very limited surface flow was present as observed at the GSP3 point.	The Sand River in this area has an increased abundance of surface water present with a relatively large standing pool present at this point. The pool present at this point was generally shallow and had very isolated areas of deeper water present.	The Sand River was flowing at this point and displayed some slow flowing sections. The depth of the river at this point showed substantial variation ranging from very shallow areas to deep sections in the larger pools.
Water clarity	Water was clear.	No surface water present	Water was relatively clear although biological activity leads to some increase in turbidity, especially in the deeper pools.	Water was clear at this point	Water was relatively clear although biological activity leads to some increase in turbidity, especially in the deeper pools.
Impacts and signs of pollution	At the time of assessment limited impacts on the instream ecology were visually evident although some impact due to water abstraction from the system leading to reduced instream flow and loss of refuge	At the time of assessment limited impacts on the instream ecology were visually evident although some impact due to water abstraction from the system leading to reduced instream flow and loss of refuge	At the time of assessment limited impacts on the instream ecology were visually evident although some impact due to water abstraction from the system leading to reduced instream flow and loss of refuge	At the time of assessment limited impacts on the instream ecology were visually evident although some impacts due to water abstraction from the system as well as a small impact on fish migration from	At the time of assessment significant impacts on the instream ecology were visually evident since impacts form water abstraction were deemed likely at this point in addition

ASPECT	GSP1	GSP2	GSP3	GSP4	GSP6
	pools is considered highly likely to be occurring.	pools is considered highly likely to be occurring.	pools is considered highly likely to be occurring.	the upstream gauging weir.	to the impacts from the construction activities at the low water crossing at this point

6.2 Physico-Chemical Water Quality

One of the river assessment points (MOP4) was completely dry at the time of the assessment. Water quality variables were measured at the remaining four river sites.

Table 41: Biota specific water quality data for the assessed river assessment sites

Site	Description	pH (pH units)	Conductivity (mS/m)	DO (mg/L)	Temp (ºC)
GSP6	Sand River – Upstream of GSP4	7.35	18.4	7.51	25.9
GSP4	Sand River – Upstream of GSP3	8.70	92.2	11.44	25.1
GSP3	Sand River – Upstream of proposed Mopane Colliery	8.83	213.3	8.41	26.0
GSP1	Sand River – Downstream of proposed Mopane Colliery	8.32	194.0	7.73	15.5

The following key points on the water quality of the Sand River system both upstream and in the vicinity of the proposed Mopane Colliery were observed:

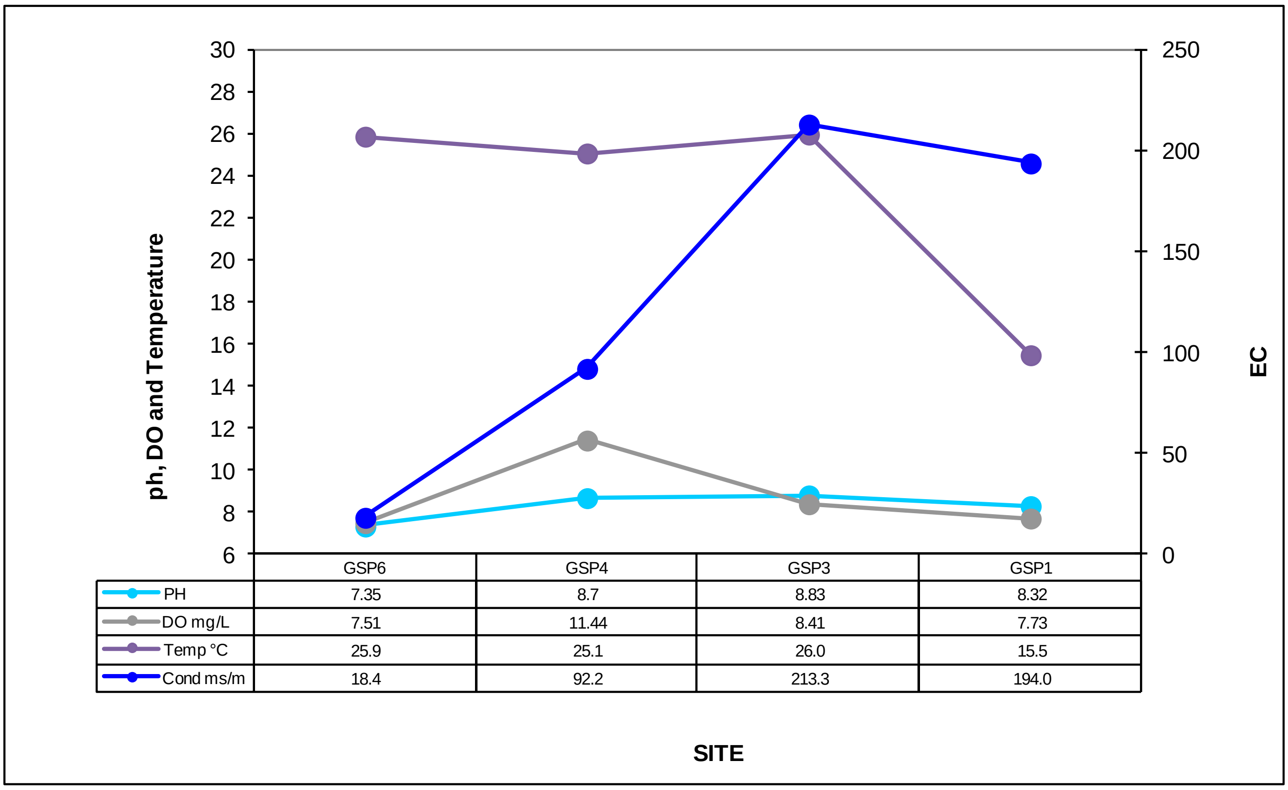
- Increased concentrations of dissolved salts were observed in a downstream direction;
- This was due to lower flow volumes conditions (further compounded by water abstraction from the system for agricultural purposes) and associated high evaporation rates in the area leading to the concentrating of salts in the system;
- Spatially there was a 9.0% decrease in conductivity value in a downstream direction between sites GSP3 and GSP1;
- Compared to site GSP6, conductivity was 5.0 times higher at site GSP4, 11.6 times higher at site GSP3 and 10.5 times higher at site GSP1;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- When viewing upstream site GSP3 as reference site, the spatial change downstream thus falls within the above recommendation;
- However, when using point GSP6 as spatial reference it is clear that changes in EC fall well outside the guideline recommendation indicating that the assimilative capacity of the Sand river for dissolved salts is very low;
- Compared to available historical data (2009), EC increased by 12.9% (from 16.3 to 18.4 mS/m) at site GSP6 and by 51.1% (from 61.0 to 92.2 mS/m) at site GSP4;

- The temporal change in EC at site GSP4 thus falls outside the DWA (2007) guideline recommendation. The observed variation can however be, as a minimum, partially attributed to seasonal variation;
- Spatially there was a 5.8% decrease in pH value in a downstream direction between sites GSP3 and GSP1;
- When using upstream site GSP6 as reference, pH increased by 18.4% at site GSP4, by 20.1% at site GSP3 and by 13.2% at GSP1;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- If the upstream site GSP6 pH value is considered a reference value for the downstream sites, the observed changes in pH value fall outside the recommended percentage change range from a spatial perspective;
- From a temporal perspective (previous assessment 2009) pH at site GSP6 decreased by 0.7% (from 7.40 to 7.35), whilst there was a 7.7% increase in pH (from 8.08 to 8.70) at site GSP4;
- The temporal change in pH at site GSP4 thus falls outside the DWA (2007) guideline recommendation for the GSP4 site. Close monitoring of these trends will be required in future;
- The observed temporal variations can however be, as a minimum, partially attributed to seasonal variation;
- Dissolved oxygen (DO) concentration decreased by 8.1% in a downstream direction between sites GSP3 and GSP1;
- When using upstream site GSP6 as reference, DO increased by 52.3% at site GSP4, by 12.0% at site GSP3 and by 2.9% at GSP1;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that dissolved oxygen concentrations should range between 80% and 120% of saturation. Saturation (i.e. maximum dissolved oxygen concentrations) shall in turn depend on the temperature of the water sampled (USA EPA website accessed 18 May 2013). The current readings can then be expressed as a percentage of the potential maximum as tabulated below.

Table 42: Oxygen measured expressed as a percentage of maximum at the temperature measured.

Site	Oxygen (mg/L)	Temperature when measured (°C)	Maximum oxygen at that temperature (mg/L)	Oxygen measured expressed as percentage of maximum
GSP6	7.51	25.9	8.09	92.8%
GSP4	11.44	25.1	8.24	138.8%
GSP3	8.41	26.0	8.09	104.0%
GSP1	7.73	15.5	9.85	78.5%

- Dissolved oxygen concentration at all three upstream sites (GSP6, GSP4 and GSP3) falls well within the recommended range, whilst that at the downstream site (GSP1) falls slightly below the recommended range;
- When comparing current results to historical (2009) data, oxygen concentration increased by 19.6% (from 6.28 to 7.51 mg/mL) at site GSP6. Oxygen concentration at site GSP4 also increased by 76.3% (from 6.49 to 11.44 mg/mL).
- The observed variation in dissolved oxygen concentration is likely to be attributed largely to natural variation with biological activity within the system at each point considered to be a significant driver of the variation in the system;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the variation in the volume of water in the water bodies sampled and some level of seasonal variation in sampling times.



	GSP6	GSP4	GSP3	GSP1
PH	7.35	8.7	8.83	8.32
DO mg/L	7.51	11.44	8.41	7.73
Temp °C	25.9	25.1	26.0	15.5
Cond ms/m	18.4	92.2	213.3	194.0

Figure 66: Physico-chemical water quality showing spatial trends

6.3 Invertebrate Habitat Integrity Assessment (IHIA)

The IHIA results are tabulated in Appendix 1. The sections below present a description of the conditions at the GSP6, GSP4, GSP3 and GSP1 river sites, with the GSP6 site being considered the most suitable reference site (most upstream site during current assessment).

From the visual representation of impact categories in Appendix 1, it is clear that the severity of impacts generally appear to escalate in a downstream direction.

There is a spectrum of small to critical level impacts on the instream habitat of the system, with the most significant impacts being from water abstraction, flow modification and water quality modifications. All four sites obtained a “D” (“Largely modified”) classification with regard to instream habitat integrity. The only instream habitat variables for which no impact were recorded at both sites, were “inundation”, “exotic macrophytes” and “exotic fauna” at sites GSP3 and GSP1. The impact of water abstraction was also most severe at these two sites.

A similar condition (small to serious impacts) in the riparian zone was observed where the system (all four sites) has been especially affected (large impacts) by vegetation removal and alien encroachment. Bank erosion and water abstraction was considered a large impact at site GSP6. Water abstraction was considered a serious impact at both sites GSP3 and GSP1, with water quality also indicated as serious impact at site GSP3. The only variable for which no negative impact was recorded was “inundation” at both sites GSP3 and GSP1. With regard to riparian zone habitat integrity, sites GSP6 and GSP1 were classified as “D” (largely modified), whilst site GSP4 and GSP3 were classified as “C” (moderately modified) and “E” (extensive loss) respectively.

Overall scores of 43.5% (GSP6), 54.3% (GSP4), 37.5% (GSP3) and 45.1% (GSP1) were calculated, placing sites GSP6, GSP4 and GSP1 in class D (largely modified) whilst site GSP3 was considered class E (Seriously modified).

6.4 Invertebrate Habitat Assessment System (IHAS)

Table 43 is a summary of the results obtained from the application of the Invertebrate Habitat Integrity Assessment (IHAS) Index to four river assessment sites on the Sand River (GSP6, GSP4, GSP3 and GSP1). This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in interpreting the SASS5 results. IHAS scores (McMillan, 1998) are presented in Appendix 2.

Table 43: A summary of the results obtained from the application of and IHAS indices to the assessment sites

SITE	GSP6	GSP4	GSP3	GSP1
IHAS score	76	41	42	46
IHAS Adjustment score (illustrative purposes only)	+14	+35	+37	+32
McMillan, 1998 IHAS description	Habitat diversity and structure is highly suited to supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate to supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate to supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate to supporting a diverse aquatic macro-invertebrate community under the current flow conditions.
Stones habitat characteristics	Adequate loose cobbles and rocks in current present. Stones out of current present.	Loose cobbles, rocks and bedrock were absent (i.e. no stones habitat).	Loose cobbles, rocks and bedrock were absent (i.e. no stones habitat).	Loose cobbles, rocks and bedrock were absent (i.e. no stones habitat).
Vegetation habitat characteristics	Abundant marginal vegetation (mix of reeds and shrubs) on both banks with a high percentage of leafy material. Aquatic vegetation also present and sampled.	Abundant marginal vegetation (mix of reeds and shrubs) was present on both banks with some aquatic vegetation. Limited leafy vegetation was observed (i.e. mostly stems and shoots).	Abundant marginal vegetation (mix of reeds and shrubs) was present on both banks with some aquatic vegetation. Limited leafy vegetation was observed (i.e. mostly stems and shoots).	Marginal vegetation present on both banks (lower percentage compared to GSP3) with aquatic vegetation sampled (greater area compared to GSP3). Limited leafy vegetation observed (higher % compared to GSP3).
Other habitat characteristics	Adequate sand habitat available but no gravel, mud or bedrock substrate present. Isolated clumps of algae.	Some sand and gravel substrate were present for colonisation by suitably adapted organisms. Algae present.	Some sand substrate as well as an algal bed was present for colonisation by suitably adapted organisms.	Some sand substrate was present for colonisation by suitably adapted organisms.
IHAS general stream characteristics	The stream at this point has a fair diversity of flow, is fairly wide and of average depth under the current conditions. Water is clear and bank cover is good, thus limiting the potential for erosion at this point.	The stream at this point has a limited diversity of flow (pool only), is wide but shallow under the current conditions. Water is clear and bank cover is good, thus limiting the potential for erosion at this point. Impact from farming and construction evident.	The stream at this point has a limited diversity of flow (pool only), width (fairly narrow) and depth (shallow) profiles under the current conditions. Water is clear and bank cover is good, thus limiting the potential for erosion at this point.	The stream at this point has limited flow diversity (pool only) but is wide. Depth profile intermediate but significantly deeper than GSP3 under current conditions. Water discoloured and bank cover good, limiting the potential for erosion.

- The GSP4, GSP3 and GSP1 sites on the Sand River were represented largely by non-flowing water in pools;
- Conditions varied between clear water condition (upstream) and discoloured (downstream) at the time of assessment;
- Marginal vegetation was adequate, consisting of a mix of reeds and shrubs, but presenting limited leafy material (i.e. mostly stems and shoots) at the downstream sites at the time of assessment. A clear reduction in vegetation cover suitability was evident in a downstream direction;
- No stones were present in or out of current for sites GSP4, GSP3 and GSP1 but some rocky substrate was present at the GSP6 site increasing the ability to support a diverse and sensitive aquatic community at this point significantly;
- The other habitat types noted were sand and gravel substrate and algae;
- Habitat diversity and structure was considered inadequate for supporting a diversity of aquatic macro-invertebrate communities at all three downstream sites while conditions at the top of the river segment assessed (GSP6) were highly suitable for supporting a diverse and sensitive aquatic macro-invertebrate community. Habitat conditions seem to deteriorate in a downstream direction with impacts from farming and construction evident.

6.5 Aquatic Macro-Invertebrates: SASS5

The results of the aquatic macro-invertebrate assessment, according to the South African Scoring System version 5 (SASS5) index, are summarised in the tables below. Table 44 indicates the results obtained at each site, per biotope sampled. SASS5 and ASPT scores (Dickens and Graham, 2001) are presented in Appendix 3.

Table 44: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 Score	GSP6	76	42	33	100
	GSP4	0	17	19	32
	GSP3	0	61	28	76
	GSP1	0	36	13	37
Number of taxa	GSP6	12	8	7	18
	GSP4	0	5	6	9
	GSP3	0	13	7	16
	GSP1	0	8	3	9
ASPT	GSP6	6.3	5.3	4.7	5.6
	GSP4	0	3.4	3.2	3.6
	GSP3	0	4.7	4	4.8
	GSP1	0	4.5	4	4.1

Table 45: Summary of the results obtained from the application of the SASS5 index to the four assessment sites

Type of Result	GSP6	GSP4	GSP3	GSP1
Biotopes sampled	Sand, stones in current, stones out of current, marginal vegetation, aquatic vegetation, sand.	Sand, gravel, marginal vegetation, aquatic vegetation.	Sand, marginal vegetation, aquatic vegetation	Sand, marginal vegetation, aquatic vegetation
Sensitive taxa present	*Atyidae; Leptophlebiidae; Chlorocyphidae; Gomphidae; Philopotamidae*	None	*Hydracarina, Caenidae, Gomphidae, Corduliidae*	*Gomphidae*
Sensitive taxa absent	*Hydracarina; Caenidae; Corduliidae*	*Atyidae; Leptophlebiidae; Chlorocyphidae; Hydracarina; Caenidae; Gomphidae; Corduliidae; Philopotamidae*	*Atyidae; Leptophlebiidae; Chlorocyphidae; Philopotamidae*	*Atyidae; Leptophlebiidae; Chlorocyphidae; Hydracarina; Caenidae; Corduliidae; Philopotamidae*
SASS5 score	100	32	76	37
Adjusted SASS5 score	114	61	113	69
SASS5 % of theoretical reference score*	69.4	22.2	52.7%	25.7%
ASPT % of theoretical reference score**	96.6	62.1	80.0%	70.6%
Dickens & Graham, 2001 SASS5 classification	Class B	Class E	Class D	Class E
Dallas 2007 Classification	Class B	Class E/F	Class C	Class E/F

***SASS5 reference score = 145; **ASPT reference score = 6**

- At present, conditions in the Sand River show a deteriorating trend in a downstream direction according to both the Dallas (2007) and the Dickens & Graham (2001) classification systems;
- The SASS5 score decreased by 51.3% and the ASPT score by 14.6% between sites GSP3 (upstream) and GSP1 (Downstream);
- Using upstream site GSP6 as a reference, SASS5 score decreased by 74.0% at site GSP4, by 24.0% at site GSP3 and by 63.0% at site GSP1;
- Again using site GSP6 as upstream reference site, ASPT score decreased by 41.1% at site GSP4, by 14.3% at site GSP3 and by 26.8% at site GSP1;
- Similar IHAS scores were recorded at sites GSP4, GSP3 and GSP1 (all inadequate for sustaining a diverse and ecologically sensitive macro-invertebrate community). The presence of an algal bed at site GSP3 combined with clear water conditions may partially explain why more sensitive invertebrates was collected at this site compared to that collected at site GSP1 and some concentration of invertebrates into the small pool is deemed likely;
- The much higher IHAS score recorded for the upstream reference site GSP6 indicates significantly more suitable habitat conditions at this point in relation to the points further downstream and is likely to significantly contribute to the much higher macro-invertebrate recorded at this point in relation to the points further downstream;
- The most significant impact on the system observed is the lack of flow in the system which becomes more exacerbated in a downstream direction. Flow dependent taxa are likely to be largely absent from the lower reaches of the system;
- Habitat limitations are also likely to limit the diversity, abundance and sensitivity of the aquatic community to some degree;
- Water quality is likely to be an additional limiting factor shaping the aquatic community at the downstream points. As more data on the system is collected, better inferences on the ecological condition of the community will be possible;
- At site GSP6, the stream may be considered to be in a class B (Largely Natural) condition according to both the Dickens & Graham (2001) classification system and in the Dallas (2007) classification system;
- In comparison the GSP 4 site indicates that Seriously impaired (Class E) conditions according to both classification systems and indicates that some impact on both water quality and habitat with special mention of reduced instream flow is likely;
- The GSP3 site further downstream and immediately upstream of the proposed Mopane project indicates similar conditions to the GSP4 site. The small refuge pool meant that biota were concentrated in this area leading to a slightly elevated score although conditions could generally be considered poorer at this point in the system;

- The Downstream GSP1 point also had very low levels of macro-invertebrate community integrity indicating that the stressors on the system are persistent at this point in the system;
- From the initial results of the study it is evident that the system, naturally, has broad variability in aquatic community integrity on a temporal scale due to variations in flow and habitat availability in the system. As more data on the system is collected, better inferences on the ecological condition of the community will be possible;
- Any reductions in SASS5 and ASPT in future monitoring should be noted and the causal factors identified. Streamflow reduction activities, water contamination, habitat destruction and instream habitat changes will have a significant effect on the aquatic community within the system and close monitoring of these trends must take place;
- Due to the degree of sensitivity of the system to habitat changes and loss of instream flow careful design and operational procedures will be required to limit the impact on the Sand River.

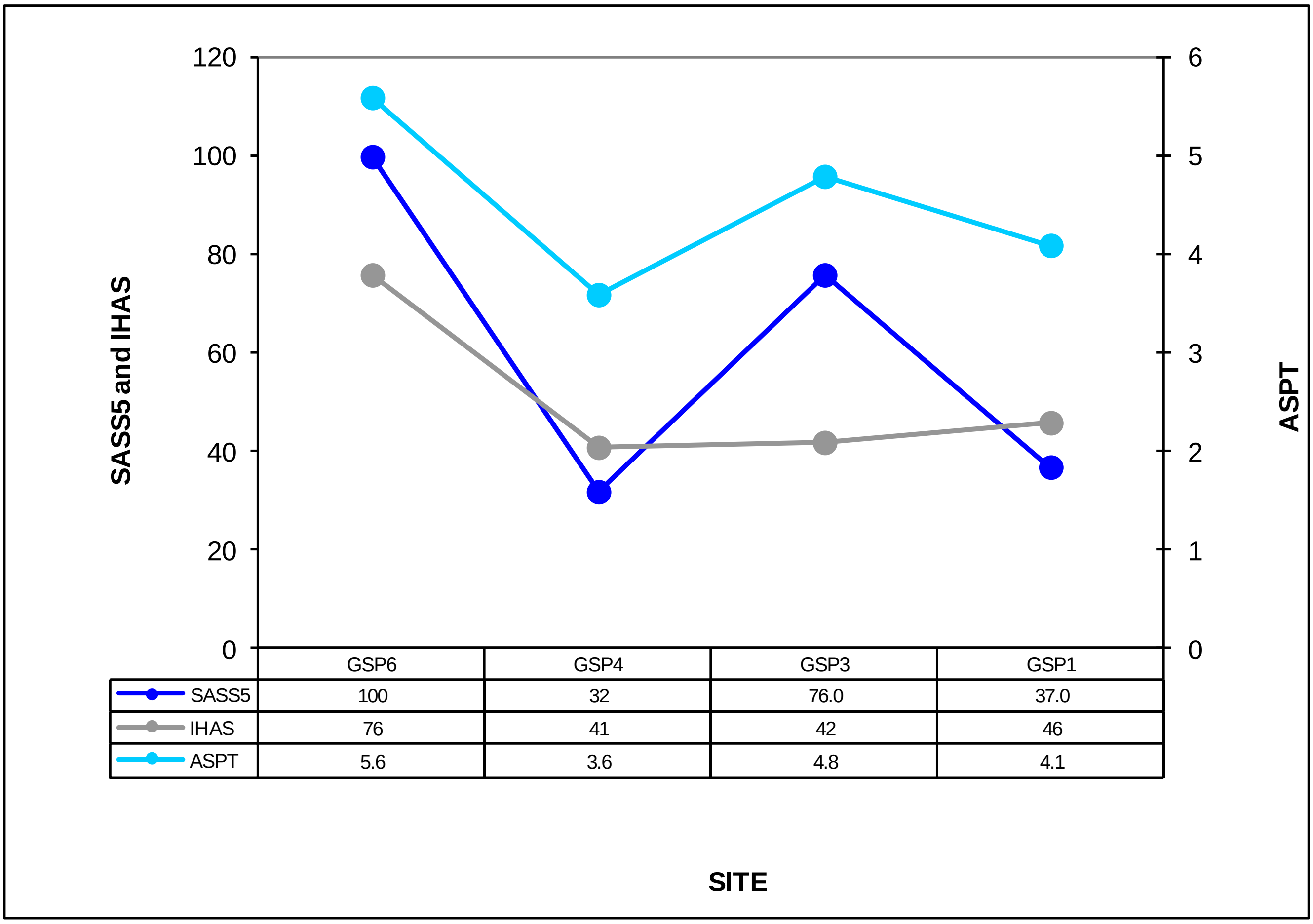


Figure 67: IHAS, SASS5 and ASPT scores showing spatial trends

6.6 Aquatic Macro-Invertebrates: MIRAI

The results obtained after employing the MIRAI are summarised below. For ease of comparison the classifications obtained using SASS5 are also presented in this section.

Table 46: Summary of the results (ecological categories) obtained from the application of the MIRAI to the four assessment sites, compared to classes awarded using SASS5.

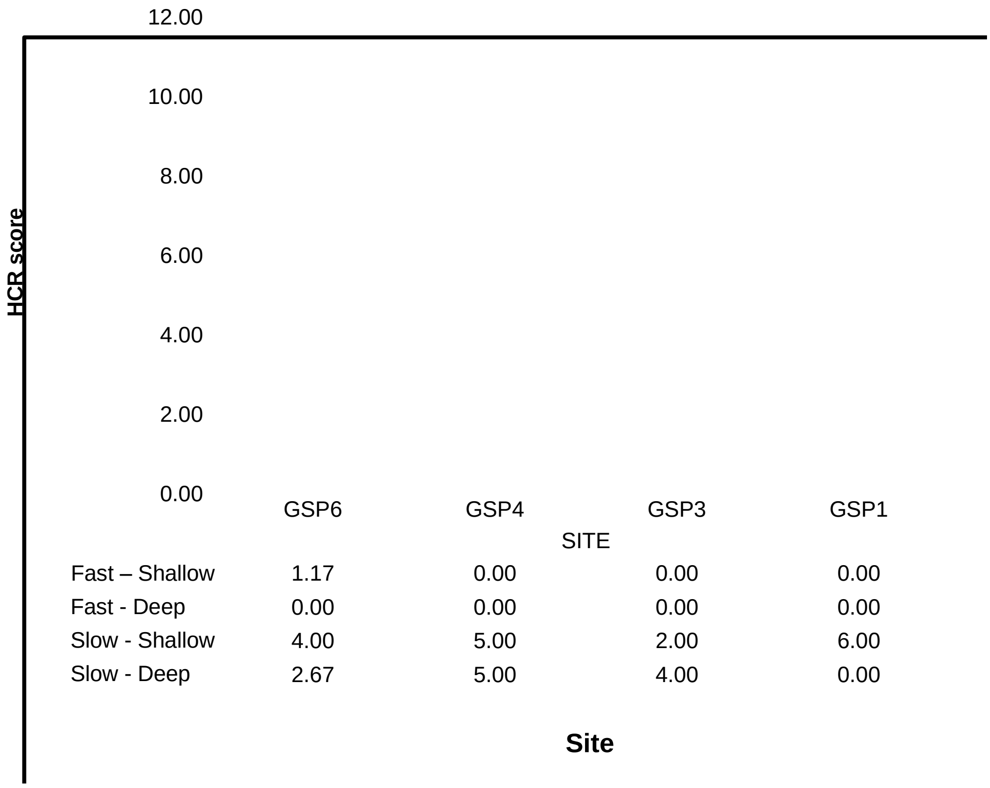
Variable / Index	GSP6	GSP4	GSP3	GSP1
Ecological category (MIRAI)	C	E	D	F
Dickens and Graham (SASS5)	B	E	C	E
Dallas (SASS5)	B	E/F	D	E/F

From the table above it is clear that the MIRAI results in terms of (Ecological Category classification) follow the same trends as that obtained using the SASS class classifications. The general deterioration in trend in terms of macro-invertebrate community integrity is clearly evident.

In terms of general ecological category classification, the values obtained are in congruence with previous studies performed in the same system. A faunal assessment for the Chapudi Project (compiled by Natural Scientific Services CC) previously reported on ecological categories on four sites on the Sand River. MIRAI scores were calculated for three of the four sites with the two sites classified as Class D/E sites and one site a Class E site. In particular the GSP4 site had a MIRAI score of Class D/E. The results of the assessment further indicate that no significant change in the aquatic macro-invertebrate community integrity since 2009 has occurred.

6.7 Fish Community Assessment

The HCR (Habitat Cover Rating) results for the four sites assessed are provided below:



	GSP6	GSP4	GSP3	GSP1
Fast – Shallow	1.17	0.00	0.00	0.00
Fast - Deep	0.00	0.00	0.00	0.00
Slow - Shallow	4.00	5.00	2.00	6.00
Slow - Deep	2.67	5.00	4.00	0.00

Figure 68: HCR scores for the four sites assessed

It is clear that slow-shallow conditions predominate in the system followed by slow-deep conditions. The only site where fast-shallow habitat was observed under current flow conditions, was site GSP6 where limited abundances and suitability of this habitat type were in evidence. The fish expected in the area will therefore be limited to fish with high intolerance values for flowing water and to a lesser degree species with a high intolerance value for deep habitats and water column cover. In general some significant limitations on the fish community can be expected with the degree of impact determined by the severity of the water stress on the system. Based on the HCR ratings, the most diverse and ecologically sensitive community can be expected at the GSP6 site with relatively similar levels of diversity and sensitivity at the remaining three sites although some species may be absent from the GSP3 site with a higher affinity for deeper habitats.

Table 47: Fish species collected at the various sites indicating abundance (i.e. numbers collected used for site score evaluation in the FRAI assessment) with natural ranges included in the Sand River (Limpopo River system) of the study area (Skelton, 2001; Kleynhans, 2003; Kleynhans, Louw and Moolman, 2007).

SPECIES NAME	NUMBERS OF FISH COLLECTED AT THE VARIOUS SITES WITH ASSOCIATED ABUNDANCE SCORE (AS):									FROC[1] score (Sand River segment)
	GSP3		GSP1		GSP6		GSP4		TOTAL	
	No. fish	AS[4]	No. fish	AS[4]	No. fish	AS[4]	No. fish	AS[4]		
Barbus paludinosis [1]	**5**	**1**	0	0	**32**	**4**	**12**	**2**	**49**	1
Barbus trimaculatus [1]	**2**	**1**	**5**	**1**	**28**	**3**	**38**	**4**	**73**	1
Barbus unitaeniatus [1]	**2**	**1**	**72**	**5**	**14**	**2**	**8**	**2**	**96**	1
Clarias gariepinus [1]	0	0	**28**	**3**	0	0	0	0	**28**	3
Labeo cylindricus [3]	0	0	**7**	**2**	**5**	**1**	0	0	**12**	1 [3]
Labeo molybdinus [3]	0	0	0	0	**2**	**1**	**2**	**1**	**4**	1 [3]
Labeo ruddi [3]	0	0	**2**	**1**	0	0	0	0	**2**	1 [3]
Labeobarbus marequensis [1]	0	0	0	0	**8**	**2**	0	0	**8**	1
Mesobola brevianelis [2]	**4**	**1**	0	0	**32**	**4**	0	0	**36**	1 [2]
Micropterus salmoides [3]	0	0	0	0	**3**	**1**	0	0	**3**	1 [3]
Oreochromis mossambicus [1]	**12**	**2**	**32**	**4**	0	0	0	0	**44**	1
Pseudocrenilabrus philander [1]	0	0	0	0	**5**	**1**	**14**	**2**	**19**	1
Tilapia sparrmanii [3]	**1**	**1**	0	0	**7**	**2**	**28**	**3**	**36**	1 [3]

[1] Fish species previously encountered in the Sand River (catchment A71J) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007). Where fish species were collected that were not previously listed, the FROC scores employed were derived as described in the respective footnotes. Only these species (i.e. previously encountered plus actually encountered but not previously listed) were used for application of the FRAI assessment for the system (i.e. pooled for all four sites).
[2] FROC score from Sand River catchment A72A (fish species FROC score not listed in catchment A71J).
[3] FROC score for this species not listed for Sand River catchments – employed a score of 1 for FRAI assessment.
[4] AS = Abundance score. For site specific analyses abundance scores were determined for each site and used as FROC scores in the FRAI assessment. Abundance scores (AS) were classified as follows:
1 to 5 fish = 1
6 to 15 fish = 2
16 to 30 = 3
31 to 60 = 4
61 to 120 = 5

The table below summarises the EC obtained using the FRAI. For ease of comparison the EC values obtained by using the MARAI have again been included.

Table 48: Summary of the results (ecological categories) obtained from the application of the FRAI to the four assessment sites, compared to that obtained using MIRAI.

Variable / Index	GSP6	GSP4	GSP3	GSP1	System
Refined EC (FRAI)	D/E	D/E	D/E	D/E	D/E
Ecological category (MIRAI)	C	E	D	F	N/A

EC = Ecological category

From the above it is clear that the EC calculated for the FRAI largely corresponds to that obtained for the MIRAI which would be expected since the drivers affecting the two assemblages are largely similar. Because the habitat flow and cover conditions (and hence potential drivers) were fairly homogenous between the sites (see section 4.7), the EC values between the sites were also similar.

In terms of general ecological category classification, the FRAI EC's obtained are lower compared to previous studies performed in the same system. A faunal assessment for the Chapudi Project (compiled by Natural Scientific Services CC) previously reported ecological categories ranging between B and C. The most likely reason for the variances observed is the lack of flow in the system at the time of the assessment as well as due to seasonal variations in the system.

6.8 Aquatic Communities of Artificial Impoundments within the Study Area

6.8.1 Visual assessment

Figure 69: Upstream view of the MOP2 site at the inlet to an impoundment.

Figure 70: Downstream view of the MOP2 site.

Figure 71: MOP3 site on a moderate sized impoundment.

Figure 72: MOP1 site showing the large extent of the dam.

Table 49: Visual description of the sites selected as representatives of the artificial impoundments on within the study area.

ASPECT	MOP3	MOP2	MOP1
Surrounding features	These impoundments are located on farms used mostly for game farming. Some commercial agricultural activities also occur in the area		
Significance of the point	These impoundments are representative of the aquatic ecology of the impoundments located throughout the study area		
Surrounding vegetation	The surrounding veld consists mostly of Mopane veld. On the sedges of the dams some additional species of sedges and some tree species with increased affinity for waterlogged soils are present		
Depth and flow characteristics	The dam is reasonably deep in its deeper parts near the dam wall however there are extensive shallows present in the dam. The diversity of depth in the dam can potentially support a diverse aquatic community.	The dam was generally shallow at the time of assessment but can still potentially support a diverse aquatic community although some fish species are unlikely to occur in the system.	The dam is reasonably deep in its deeper parts near the dam wall however there are extensive shallows present in the dam. The diversity of depth in the dam can potentially support a diverse aquatic community.
Water clarity	Water is slightly discoloured as a result of algal proliferation.	Water was very clear.	Water is clear.
Impacts and signs of pollution	None observed.	Some silt deposition as a result of upstream erosion observed.	None observed.

6.8.2 Biota Specific Water Quality Assessment

Table 50: Biota specific water quality data for the assessed river assessment sites

Site	pH (pH units)	Conductivity (mS/m)	DO (mg/L)	Temp (ºC)
MOP1	9.15	8.9	7.20	16.9
MOP2	8.49	10.4	8.76	21.5
MOP3	8.49	18.4	5.82	16.8

- The biota specific water quality data indicates that the impoundments in the area generally have low concentrations of dissolved salts which can be considered highly suitable for supporting a diverse aquatic community;
- pH of the systems is generally alkaline with the smaller systems showing similar pH values while the larger system at MOP1 showed an elevated pH, which may be related to biological activity in the dam. The pH values are on the upper limit of the values generally considered to be suitable for supporting a diverse and sensitive aquatic community and some more sensitive taxa may be absent from the system for this reason;
- Dissolved oxygen values varied significantly which can be attributed to variations in temperature and biological activity.
- The dissolved oxygen concentrations were generally below the required levels for supporting a diverse and sensitive aquatic community. Improved conditions were observed in the MOP2 system.
- Temperature varied based on the time of sampling and the volume of water in the system but values can be considered to be natural for the area and no impact on aquatic biota due to altered temperature is deemed likely.

Table 51: Calculated percentage saturation values for Dissolved oxygen concentrations.

Site	Oxygen (mg/L)	Temperature when measured (°C)	Maximum oxygen at that temperature (mg/L)	Oxygen measured expressed as percentage of maximum
MOP1	7.20	16.9	9.65	74.61%
MOP2	8.76	21.5	8.72	100.46%
MOP3	5.82	16.8	9.65	60.31%

6.8.3 Aquatic Biota

The aquatic biota of the impoundments was found to be largely similar through all the systems with macro-invertebrate taxa such as mayflies of the *Baetidae* family as well as families of the order Odonata (dragonflies and damselflies) such as *Libellulidae* and *Coenagrionidae.* Tolerant Families of the orders *Hemipetra* and *Coleoptera* were relatively abundant in the systems along with tolerant taxa from the order *Diptera.*

The fish species observed in the impoundments were dominated by *Oreochrmis Mossambicus* (blue kurper) while *Clarias Gariepinus* (sharptooth catfish) were also observed at the MOP3 site. Although not captured smaller barbs are also likely to occur in some of the impoundments introduced by waterfowl. In addition some of the larger impoundments may have introduced fish species such as *Labeobarbus marequensis* (largescale yellowfish) and *Cyprinus carpio* (carp) in them which are targeted by recreational anglers.

Overall the aquatic ecology of the impoundments in the study area are considered to be of limited diversity and sensitivity form an aquatic ecological point of view but are considered important from an overall ecological point of view.

7 IMPACT ASSESSMENT

The proposed Mopane Mining project can be defined as consisting of three major "blocks". The degree of impact on the aquatic ecology between the various blocks varies significantly. For this reason the impact assessment was divided into two sections as follows:

- Impact assessment for the more northern areas referred to as the Voorburg Section
- Impact assessment for the more southern areas as well as the Ursa Minor section referred to as the Jutland Section

The tables in the subsections below serve to summarise the activities which will lead to impacts on the aquatic ecology of the Sand River system as well as the significance of perceived impacts on the wetland biodiversity of the study area and indicate the impact significance on aquatic resources. Each impact significance was assessed separately for the pre-construction, construction operational and decommissioning and closure phases of the proposed project.

7.1 IMPACT 1: Loss of Instream Flow, Aquatic Refugia and Flow Dependent Taxa

7.1.1 Discussion

The Sand River, and to a lesser degree the other systems in the vicinity of the Proposed Mopane Project are water stressed. The systems are extensively utilised for the abstraction of water for the production of crops such as peppers, squash and tomatoes. These water uses lead to the lower sections of the Sand River being dry for significant lengths and few refuge pools for aquatic biota occur in these lower areas. Any impact on instream flow will therefore be significant and can have a significant impact on the Sand River Ecology. It is also important to note that the Sand River is designated as a Freshwater Ecosystem Priority Area (FEPA) and therefore impacts on fish ecology are considered to be particularly significant. It is also important to note that the system is considered important as an upstream management area in support of downstream fish FEPA areas

In terms of aquatic and riparian zone ecology in the vicinity of the project area the Sand River is the most significant and requires the most attention when considering impacts on reduced instream flow and aquatic refugia and the loss of flow dependant taxa.

There are however other larger drainage lines in the area which do support low abundances of tolerant aquatic taxa and well established riparian zones. In particular mention is made of the Tokwespruit as well as some smaller systems. For the sake of ease of identification the systems have been named based on the names of the farms on which they are located. Other specific examples of ephemeral rivers of particular concern are the Voorburg River, and the Banff north and South systems.

According to Jacana cc (2013) Mean annual run-off (MAR) from the Project site into the Sand River is anticipated to be primarily affected by the following:

- Direct rainfall in the opencast pits. Rain falling directly into the pits will collect in a sump at the bottom of the pit/s and thus be polluted. This water may be recycled for use, or evaporated in dirty water dams, thereby decreasing the MAR reaching the Sand River system;
- Run-off from stockpiles. Rain falling directly onto the ‘dirty’ stockpiles will either seep into the stockpile or run-off the sides of the stockpile. Any run-off or horizontal seepage from the stockpile will be captured in control dams or a leaching system for water quality control reasons, and thus subsequently be prevented to discharge to tributaries and into the Sand River;
- Concentration of flow when run-off is intercepted by canals. The canal system will intercept run-off that would otherwise have flowed naturally over the ground surface until reaching a defined watercourse. Vegetation and surface topography, particularly in flatter areas, would in the natural state have encouraged interception and infiltration. Once water has been intercepted by a canal however, no further interception or infiltration is likely until the canal discharges the flow into a watercourse. Even once discharged back into a watercourse (if canals are not extended to the Sand River), the concentration of flow would still discourage interception and infiltration. There is thus likely to be a marginal increase in MAR resulting from the construction of the canal system. Streamflow regulation and recharge and a change in flow rates will however occur.

According to (Jacanacc 2013) A substantial increase to the peak flow of flood events in the Sand River could cause erosion and change in channel character and dimensions, destroy riverine vegetation, alter bed roughness and cause eroded sediment to be deposited downstream.

It is expected that Project activities will cause a change to peak flows in the Sand River downstream of the Project site, due to the following factors:

- Change in surface coverage. Development of the Project area will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking), and compacted earth. These new surface types will allow considerably less infiltration into the ground (typically 0-20%) as compared to the natural surface (typically 60-70%), resulting in more surface run-off following storms and consequently higher peak flow rates.
- Capture of run-off and capture of rainfall in the ‘dirty’ area would lower instream flow in the receiving environment.
- Canalisation of run-off. Intercepting run-off from the hill-slopes above the opencast pits and canalising the flow could reduce the amount of time that water would take to reach the Sand River. This is due to the decreased friction on the water associated with concentrated flow in a concrete-lined canal as opposed to sheet flow on the hill slopes, and the consequently lower flow velocities.

In technical terms, the time of concentration would be reduced, reducing the time of concentration results in higher peak flow rates. This effect is dependent on the design of the canalisation system, as increasing the length of flow paths, and implementing other detention measures, could negate this effect.

According to Jacana cc (2013) A cut-off canal system is required to separate unpolluted (‘clean’) and polluted (‘dirty’) water, which is a positive intervention. However, intercepting the tributaries that flow from the water divide across the mining areas, and redirecting them via canals around the pits, will starve those same water courses of water along their reach between the point of interception and the Sand River.

Furthermore, if the canals only extend as far as to route water around the outer edge of the opencast pits, then concentrated volumes of water will be discharged at point locations on the hill slopes. Leading to altered surface and subterranean hydrology.

All the above factors are likely to lead to altered riverine recharge flood peaks and a general loss of runoff volumes successfully reaching the Sand River system as well as the other major drainage systems in the area which in turn lead to the loss of aquatic biota such as fish and aquatic macro-invertebrates which rely on the presence of surface water as well as the riparian zone which relies on base flows as well as recharge by larger rainfall events.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading extensive dirty water areas which need to be managed and reducing the MAR to the drainage systems in the area	Construction of ephemeral water course and small stream diversions	Loss of MAR from dirty water areas	Loss of MAR from latent dirty water areas
Inadequate design of ephemeral stream diversions leading to loss of recharge of the larger systems	Construction of clean and dirty water separation structures for pollution control purposes.	Loss of water through clean and dirty water separation as well as stream diversion systems	Loss of water to inadequately rehabilitated areas such as discard dumps and open pits
Encroachment of open pits into drainage features such as the southern Banff tributary leading to reduced instream flow in downstream areas and potentially the Sand River	Clearing of areas for the initiation of the production pits	The formation of a cone of dewatering created by open pits	The formation of a cone of dewatering created by final voids
The open pits in the being too near to drainage features leading to loss of stream flow and baseflow due to the formation of a cone of dewatering by the open pits	Use of surface water runoff and groundwater as a water supply during construction	Use of surface water runoff and groundwater as a water supply during the operational phase of the mine	Use of surface water runoff and groundwater as a water supply during the closure phase of the mine
Design of canals leading to rapid release of water which in turn will lead to a loss of streamflow regulation capabilities in the area		Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area	Impact on natural streamflow regulation and stream recharge due to altered hydrology in the area
Use of surface runoff and groundwater sources for the supply of production water for the mining project			

Aspects of instream habitat and flow affected

Construction	Operational	Decommissioning & Closure
Loss of instream surface and base flow	Loss of instream surface and base flow	Loss of instream surface and base flow
The drying out of aquatic refugia in the Sand River	The drying out of aquatic refugia in the Sand River	The drying out of aquatic refugia in the Sand River
Loss of streamflow regulation and stream recharge	Loss of streamflow regulation and stream recharge	Loss of streamflow regulation and stream recharge
Loss of aquatic habitats for aquatic macro-invertebrates and fish	Loss of aquatic habitats for aquatic macro-invertebrates and fish	Loss of aquatic habitats for aquatic macro-invertebrates and fish
Increased moisture stress on riparian vegetation	Increased moisture stress on riparian vegetation	Increased moisture stress on riparian vegetation

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	**5**	**4**	**5**	**5**	**5**	**9**	**15**	**135 (Very-high)**
Jutland Section	**4**	**3**	**4**	**5**	**5**	**7**	**14**	**98 (Medium-high)**

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams. In particular mention is made of the need to not encroach on the riparian systems on the Voorburg section of the mine and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area.
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Sand River and the associated larger tributaries;
- Very strict control of water consumption must take place and detailed monitoring must take place. All water usage must continuously be optomised;
- Upstream dewatering boreholes should be utilised to minimise the creation of dirty water and this clean water should be sued to recharge the natural systems downstream/downgradient of the mining footprint areas;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge;
- Permit only essential construction personnel within 32m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Implement alien vegetation control program within wetland areas with special mention of water loving tree species;
- Monitor all affected riparian systems for moisture stress;
- Monitor all potentially affected riparian zones for changes in riparian vegetation structure;
- Ongoing aquatic ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor;

Recommended mitigation measures

- The extent of the operations on the Voorburg Section must be kept to an absolute minimum
- No infrastructure or open pits should encroach into any major drainage lines

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	4	4	4	5	4	8	13	104 (High)
Jutland Section	3	3	3	5	4	6	12	72 (Medium-low)

Probable latent impacts
- Reduced recharge of the Sand River and other riparian systems affected by upstream and adjacent mining;
- Reduced availability of refugia for aquatic biota;
- Altered riparian vegetation structures.

7.2 IMPACT 2: Impacts on Water Quality Affecting Aquatic Ecology

7.2.1 Introductory discussion and Rationale

The philosophy supporting the following section of the report is that if all constituents in the cumulative discharge from the Project site are within the applicable target water quality ranges, then the Project activities will not contribute significantly to an unacceptable cumulative impact. This is the objective for the project as defined in the scoping report for the Mopane Project (Jacana; 2013).

The converse of this statement is not necessarily true, as different activities within the catchment may discharge different pollutants at different concentrations, and the dilution effect may mean that a constituent that is out of the target water quality range in the cumulative discharge from the Project site is within the target water quality range when the discharge is combined with the Sand River flow itself.

However the Precautionary Principle requires that a conservative approach be taken, in this case to account for possible discharge of pollutants by future activities in the river catchment, and therefore the dilution effect of the Sand River cannot be relied upon. It must further be noted that the analyses of biota specific water quality indicated very high salt loads in the low flow season in the Sand River and therefore very limited dilution capacity of salts in the system is deemed likely and any addition of salts to the system is likely to be harmful to the system. The discussions on water quality risks presented below are based on the scoping report of the project (Jacanacc 2013)

7.2.2 Increased sediment load in Sand River

In the natural state of the project site, vegetation cover causes friction to rainfall run-off, that reduces flow velocities and consequently shear forces between the water and the ground surface, resulting in the ground surface remaining intact and not being eroded away. If for any reason flow velocities are increased, there is potential for increased erosion to occur.

Increased erosion of disturbed surfaces means that the run-off contains a higher silt or sediment load, which is discharged to the Sand River. A component of this sediment load is particles fine enough to remain in suspension, ‘clouding’ or ‘muddying’ the water.

The extent of this effect can be quantified by measuring a water quality parameter, suspended solids. If there are too many suspended solids in the water this can negatively affect biological life. In addition, a changed sediment load could have similar morphological effects to the river as changing peak flow rates, such as changes in channel character or dimensions and changes to bed roughness (Jacana; 2013). Severe sediment deposition in the Sand River could lead to reduced surface flows in the system with a larger volume of water moving through a thickened sand layer. All of these changes could potentially affect biological life.
The following activities are likely to cause an increase in flow velocities, or directly increase erosion:

- Stripping (vegetation clearance) of mining areas prior to excavation of pits;
- Construction of hard-standing areas that increase run-off volumes, including roads, buildings and paved areas;
- Canalisation of run-off, particularly if canals do not discharge directly into the Sand River; and
- Construction activities that loosen the ground surface.

Furthermore, if run-off from the stockpiles is uncontrolled, such run-off would likely contain a high sediment load due to the fine particles in the waste product resulting from the ore crushing process. It can thus be stated that without any mitigation measures, the sediment load in the Sand River will increase as a result of mining activities associated with this Project.

7.2.3 Impaired water quality due to pollutants discharged from processing plant

Wastewater from the coal ore beneficiation process would contain pollutants in excess of the target water quality ranges for the water uses of the receiving water body and discharge of this would impact negatively on the surface water quality. A further consideration is the run-off of pollutants from the process plant area following rainfall, due to the activities within that area.

7.2.4 Impaired water quality due to pollutants in run-off from stockpiles

It is likely that run-off from the stockpiles will have a different chemical composition to natural run-off. In this event it is best practice to keep 'dirty' water from stockpile run-off separate from 'clean' water from natural run-off.

7.2.5 Impaired water quality due to pollutants in water discharged from opencast pits

Overflow of water (decant), whether surface or ground, from the pits could release pollutants to the surface water environment if geochemical testing indicates a possible acid mine drainage or other water quality issue.

7.2.6 Impaired water quality due to petrochemical spills

Fuel or oil spills from vehicles could contaminate surface water resources. Leakages, spills or run-off from vehicle wash bays, workshop facilities, fuel depots or storage facilities of potentially polluting substances could contaminate surface water resources.

7.2.7 Heavy metal contamination

Increase in metal concentrations is commonly associated with tillage and blasting of the upper crust of the earth's surface. This releases metals into the associated surface and ground water systems (NSS, 2009). Under alkaline conditions, most of the metals remain biologically unavailable, however in the presence of acid mine drainage the metal-speciation changes and they become available (Bonta et al., 1993). This may alter the species composition of the aquatic biota inhabiting the river, in the vicinity of and downstream of the proposed development.

Activities potentially leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to extensive and complex dirty water areas which need to be managed.	Major earthworks and construction activities.	Mining and the creation of mining waste which needs to be managed to prevent pollution.	Inadequate closure and rehabilitation leading to ongoing pollution from contaminating sources such as discard dumps.
Poor planning leading to placement of polluting structures in drainage lines which would increase mobility of pollutants.	Clean and dirty water systems not being constructed to the required specifications to prevent contamination of clean water areas.	Clean and dirty water systems not being maintained to the required specifications to prevent contamination of clean water areas.	Clean and dirty water systems not being maintained to the required specifications to prevent contamination of clean water areas.
Inadequate separation of clean and dirty water areas leading to contaminated water leaving the defined dirty water area	Poor housekeeping and management	Poor housekeeping and management	Poor housekeeping and management
Clean and dirty water systems not being designed adequately to ensure protection of the water resources.	Spills and other unplanned events	Spills and other unplanned events	Spills and other unplanned events

Aspects of Aquatic ecology affected

Construction	Operational	Decommissioning & Closure
Loss of sensitive fish and aquatic macro-invertebrate species	Loss of sensitive fish and aquatic macro-invertebrate species	Loss of sensitive fish and aquatic macro-invertebrate species due to chronic water quality impacts
Impact on riparian vegetation structures due to impaired water quality	Impact on riparian vegetation structures due to impaired water quality	Impact on riparian vegetation structure due to impaired water quality
Build-up of contaminants in sediments leading to the creation of a sediment sink and chronic source of potential water contamination	Build-up of contaminants in sediments leading to the creation of a sediment sink and chronic source of potential water contamination	Latent release of contaminants in sediments leading to the formation of an ongoing source of potential water contamination
	Impacts on groundwater quality which could manifest in surface water sources	Impacts on groundwater quality which could manifest in surface water sources

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	5	3	4	5	5	8	14	112 (High)
Jutland Section	4	2	3	4	5	6	12	72 (Medium-low)

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams. In particular mention is made of the need to not encroach on the riparian systems on the Voorburg section of the mine and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Very clear and well managed clean and dirty water separation must take place in line with the requirements of regulation GN704 of the national Water Act;
- Pollution control dams must be adequately designed to contain a 1:50 24 hour storm water event;
- All pollution control facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area.
- Permit only essential construction personnel within 32m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- All hazardous chemicals must be stored on bunded surfaces
- Ensure that all spills are immediately cleaned up;
- Monitor all pollution control facilities using toxicological screening methods and implement the calculation of discharge dilution factors by means of the Direct Estimation of Ecological Effect Potential (DEEEP) protocol;
- Ongoing aquatic ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor.

Recommended mitigation measures

- The extent of the operations on the Voorburg Section must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	3	3	3	4	4	6	11	66 (High)
Jutland Section	3	2	2	3	4	5	12	60 (Medium-low)

Probable latent impacts

- Ongoing salinisation of the water courses in the area;
- Impacts on pH
- Impacts on dissolved oxygen concentration and saturation
- Loss of aquatic taxa intolerant to poor quality water;
- Altered riparian vegetation structures.

7.3 IMPACT 3: Loss of Aquatic Habitat

Habitat destruction is the alteration of a natural habitat to the point that it is rendered unfit to support the species dependent upon it as their home territory. Many organisms previously using the area are displaced or destroyed, reducing biodiversity. Globally modification of habitats for agriculture is the chief cause of such habitat loss. Other causes of habitat destruction include surface mining, deforestation, slash-and-burn practices and urban development. Habitat destruction is presently ranked as the most significant cause of species extinction worldwide. Additional causes of habitat destruction include water pollution, introduction of alien species, overgrazing and overfishing.

Riverine systems and particularly ephemeral riverine systems or river systems that have very low flows as part of their annual hydrological cycles are particularly susceptible to changes in habitat condition. The proposed mining activity of the Mopane project has significant potential to lead to habitat loss and/or alteration of the aquatic and riparian resources on the study area.

The risk to the local riverine systems is particularly due to the risk of reduced instream flow in the Sand River and the loss of refugia during periods of low flow. Based on the interaction of surface (incl baseflow in the surface aquifers formed by the thick sands in the local rivers) and groundwater in the area as presented by the professional team a limited impact from the cone of groundwater dewatering will occur on the baseflows in the river. Based on this information a limited impact on instream flow is deemed likely however losses of instream flow may affect the aquatic community within the SAND River and especially fish and aquatic macro-invertebrate species diversity and sensitivity.

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within riverine features with special mention of the waste stockpile areas and the open pit areas themselves as well as road crossings and bridges	Site clearing and the removal of vegetation leading to increased runoff and erosion	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities

Inadequate design of infrastructure leading to changes to instream habitat	Site clearing and road construction and the disturbance of soils leading to increased erosion	Inadequate separation of clean and dirty water areas	Inadequate separation of clean and dirty water areas
Inadequate design of infrastructure leading to changes to system hydrology	Earthworks in the vicinity of drainage systems leading to increased runoff and erosion and altered runoff patterns	Mining leading to increased disturbance of soils and drainage lines	Ongoing pollution from inappropriately decommissioned structures
Inadequate separation of clean and dirty areas and the prevention of the release of sediment rich water into the receiving environment	Construction of bridge crossings altering streamflow patterns and water velocities	Any activities which lead to the reduction in flow in the system with special mention of the open pits and the use of surface and groundwater sources for production water	Alien vegetation encroachment
	Alien vegetation encroachment	Alien vegetation encroachment	

Aspects of instream habitat affected

Construction	Operational	Decommissioning & Closure
Erosion and incision of riparian zone	Erosion and incision of riparian zone	Erosion and incision of riparian zone
Altered wetting patterns leading to impacts on riparian zone continuity	Altered wetting patterns leading to impacts on riparian zone continuity	Altered wetting patterns leading to impacts on riparian zone continuity
Loss of low flow refugia	Loss of low flow refugia	Loss of low flow refugia
Altered substrate conditions from sandy conditions to more muddy conditions	Altered substrate conditions from sandy conditions to more muddy conditions	Altered substrate conditions from sandy conditions to more muddy conditions
Altered depth and flow regimes in the major drainage systems	Altered depth and flow regimes in the major drainage systems	Alien vegetation proliferation
Alien vegetation proliferation	Alien vegetation proliferation	

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg section	4	4	5	4	4	8	12	96 (Medium-high)
Jutland Section	3	2	3	4	4	5	11	55 (Medium-low)

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams. In particular mention is made of the need to not encroach on the riparian systems on the Voorburg section of the mine and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- Limit the footprint area of the construction activity to what is absolutely essential in order to minimise the loss of clean water runoff areas and the concomitant recharge of streams in the area;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation;
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Sand River and the associated larger tributaries;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge;
- Permit only essential construction personnel within 100m of all riparian systems;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Implement alien vegetation control program within wetland areas with special mention of water loving tree species;
- Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment. Monitoring should include assessments of general habitat integrity, habitat for aquatic macro-invertebrates and habitat and cover ratings for fish. All aquatic biomonitoring should be undertaken by a SA RHP Accredited assessor. Aquatic biomonitoring should take place throughout the life cycle of the mine;

Recommended mitigation measures

- The extent of the operations on the Voorburg Section must be kept to an absolute minimum
- No infrastructure or open pits should encroach into any major drainage lines
- Revegetate all disturbed areas with indigenous tree species and make use of indigenous species with an affinity for riparian zones such as *Combretum imberbe*, *Faedherbia albida* and *Xanthocercis zambesiaca*;

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg section	3	4	3	4	4	8	11	88 (Medium-high)
Jutland Section	2	2	2	3	3	4	8	32 (Low)

Probable latent impacts

- Sedimentation of the systems may occur for long after mining is completed;
- Eroded and incised streams are unlikely to be rehabilitated.
- Silted up refuge pools are unlikely to be naturally rehabilitated and are unlikely to be rehabilitated by the mine
- Ongoing loss of instream flow leading to a loss of low flow refugia

7.4 IMPACT 4: Loss of Aquatic Biodiversity and Sensitive Taxa

Aquatic resources in the area can be considered scarce and in addition to being scarce are generally exposed to significant water stress. The aquatic resource in the area do however support, or potentially support, an aquatic community of significant diversity and sensitivity. This statement is considered particularly pertinent to aquatic macro-invertebrates and the fish community. On a national scale the system is also considered to be of importance and the lower sections of the Sand River are considered a FEPA system and a Fish FEPA support system

The aquatic ecology of the area can potentially be impacted by further reductions in instream flow, altered water quality and habitat loss.

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within riverine features with special mention of the overburden stockpile areas as well as the open pits themselves as well as road crossings and bridges	Site clearing and the removal of vegetation	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities
Inadequate design of infrastructure leading to changes to instream habitat	Site clearing and road construction	Inadequate separation of clean and dirty water areas	Inadequate separation of clean and dirty water areas
Inadequate design of infrastructure leading to changes to system hydrology	Earthworks in the vicinity of wetland areas	Loss of instream flow due to abstraction for water for production and the formation of a cone of dewatering from open pits leading to reduced aquifers recharge in the sand river	Seepage from any latent discard dumps and dirty water areas
Inadequate design of infrastructure leading to contamination of water and sediments in the streams	Construction of bridge crossings altering streamflow patterns and water velocities	Seepage from the discard dumps and overburden stockpiles	Inadequate closure leading to post closure impacts on water quality

	placement of infrastructure within riverine features with special mention of the overburden stockpile areas as well as the open pits themselves as well as road crossings and bridges	Discharge from the mine process water system with special mention of the RWD and any PCD's	Ongoing erosion of disturbed areas that have not been adequately rehabilitated
	Inadequate separation of clean and dirty water areas	Sewage discharge from mine offices and camps	
		Nitrates form blasting leading to eutrophication of the receiving environment	

Aspects of biotic integrity affected

Construction	Operational	Decommissioning & Closure
Sedimentation and loss of natural substrates	Sedimentation and loss of natural substrates	Sedimentation and loss of natural substrates
Altered stream channel forms	Altered stream channel forms	Altered stream channel forms
Increased turbidity of water	Increased turbidity of water	Loss of refugia
Loss of refugia	Loss of refugia	Deterioration in water quality with special mention of impacts from cyanide, heavy metals, AMD and salinisation
Deterioration in water quality	Deterioration in water quality with special mention of impacts from cyanide, heavy metals, AMD And salinisation	Eutrophication of the aquatic ecosystems
Loss of flow sensitive macro-invertebrates and fish	Eutrophication of the aquatic ecosystems	Loss of flow sensitive macro-invertebrates and fish
Loss of water quality sensitive macro-invertebrates and fish	Loss of flow sensitive macro-invertebrates and fish	Loss of water quality sensitive macro-invertebrates and fish
Loss of riparian vegetation species	Loss of water quality sensitive macro-invertebrates and fish	Loss of riparian vegetation species
	Loss of riparian vegetation species	

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg section	4	4	4	5	5	8	14	112 (High)
Jutland Section	3	2	3	4	4	5	11	55 (Low)

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts form inundation and siltation;
- Permit only essential construction personnel within 100m of the wetland habitat;
- Keep all demarcated sensitive zones outside of the construction area off limits during the construction phase of the development;
- Use of water must be minimised as far as possible in order to minimise the loss of recharge of the Sand River system
- Limit the footprint area of the construction activity to what is absolutely essential in order to disturbance of soils leading to runoff, erosion and sedimentation and loss of instream flow and stream recharge;
- Prevent run-off from dirty water areas entering stream systems through ensuring clear separation of clean and dirty water areas;
- Ensure that the mine process water system is managed in such a way as to prevent discharge to the receiving environment and to prevent discharge of dirty water;
- Implement measures to contain seepage as far as possible to prevent contamination of the groundwater regime
- Implement alien vegetation control program within wetland areas
- Monitor all systems for erosion and incision;
- Any areas where active erosion is observed must be rehabilitated and berms utilised to slow movement of water;
- Ongoing aquatic biomonitoring should take place in order to identify any emerging issues in the receiving environment. Monitoring should include assessments of riparian vegetation, aquatic macro-invertebrates fish and the associated habitat indices. All aquatic biomonitoring should be undertaken by a SA RHP Accredited assessor. Aquatic biomonitoring should take place throughout the life cycle of the mine;
- Toxicological monitoring of the receiving and process water systems on a quarterly basis.

Recommended mitigation measures

- The extent of the operations on the Voorburg Section must be kept to an absolute minimum
- No infrastructure or open pits should encroach into any major drainage lines
- Monitoring of sediment heavy metal concentrations;

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg section	4	4	4	5	4	8	13	104 (High)
Jutland Section	2	2	2	4	4	4	10	40 (Low)

Probable latent impacts

- Loss of some flow dependent species is likely;
- Loss of some species less tolerant of water quality changes is likely;
- Loss of some low flow refugia is likely;

7.5 IMPACT 5: Loss of Wetland and Riparian Habitat

The main land use constitutes game farming and to a lesser extent crop cultivation. As a result, overall landscape and vegetation transformation in the vicinity of water courses and depressions, within the study area, are considered to be low. Consequently, all features presently provide niche habitat for wetland and aquatic faunal and floral species within a water stressed region.

The ephemeral nature of smaller drainage lines does limit the ability for these features to provide optimum conditions for the formation of an extensive riparian zone. Therefore, larger tree species with root systems that can subtract water from deeper within the soil during winter months such as *Faedherbia albida* and *Xanthocercis zambesiaca* (Nyala) were restricted to river systems within the Voorburg section. None the less, the drainage lines within the Jutland and Ursa Minor sections do provide habitat for species such as *Combretum imberbe* (leadwood) (protected in accordance to the National Forests Act (Act No 84 of 1998 as amended September 2008).

Surface water that would provide habitat for aquatic species as well as drinking water for terrestrial wildlife, was also restricted to the river systems within the Voorburg section. Artificially created impoundments within drainage lines of the Jutland and Ursa Minor sections will however also retain water for longer periods increasing these features importance in terms of niche habitat as well as drinking water for wildlife and habitat for waterfowl.

Loss or impact on wetland and riparian habitat would result in loss of niche habitat for various faunal and floral species within a water stressed region. Due to the sandy nature of the soil it is doubtful that wetland and riparian habitat could be rehabilitated to resemble these unique habitat units presently within the study area.

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within riverine features with special mention of the overburden stockpile areas as well as the open pits themselves as well as road crossings and bridges	Site clearing and the removal of wetland and riparian vegetation	Ongoing disturbance of soils with general operational activities	Disturbance of soils as part of demolition activities

Inadequate design of infrastructure leading to changes to instream habitat	Site clearing and road construction	Inadequate separation of clean and dirty water areas	Seepage from any latent discard dumps and dirty water areas
Inadequate design of infrastructure leading to changes to system hydrology	Earthworks in the vicinity of wetland and riparian areas	Loss of instream flow due to abstraction for water for production and the formation of a cone of dewatering from open pits	Ongoing erosion of disturbed areas that have not been adequately rehabilitated
Inadequate design of infrastructure leading to contamination of water and sediments in the streams	Construction of bridge crossings altering streamflow patterns and water velocities	Seepage from the discard dumps and overburden stockpiles	Ineffective rehabilitation of riparian areas could cause siltation and changes in the hydrological functioning of these areas
Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat	Placement of infrastructure within riverine features with special mention of the overburden stockpile areas as well as the open pits themselves as well as road crossings and bridges	Earthworks in the vicinity of wetland areas may lead to increased run-off and erosion and altered run-off patterns	Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat
	Earthworks in the vicinity of wetland areas may lead to increased run-off and erosion and altered run-off patterns	Topsoil stockpiling adjacent to wetlands and run-off from stockpiles may contaminate wetland features	
	Dumping of hazardous and non-hazardous waste into the wetland areas may result in a loss of wetland habitat and ecological structure	Seepage from mining facilities, general dirty water areas as well as spillages of hydrocarbons, has the potential to contaminate the groundwater environment which in turn can affect water quality in surface water sources in the area	
	Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat	Dumping of hazardous and non-hazardous waste into the wetland areas may result in a loss of wetland habitat and ecological structure	

		Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat	
		Reduced aquifer recharge due to the formation of a cone of dewatering from open pit mining activities	Reduced aquifer recharge due to the formation of a cone of dewatering from open pit voids

Aspects of wetland and riparian habitat affected

Construction	Operational	Decommissioning & Closure
Direct loss of habitat during construction related activities	Direct loss of habitat during operational related activities	Direct loss of habitat during decommissioning and closure activities
Indirect loss through sedimentation and erosion	Indirect loss through sedimentation and erosion	Indirect loss through sedimentation and erosion due to ineffective rehabilitation
Loss of riparian and wetland vegetation species diversity	Indirect loss through cone of dewatering and moisture stress on the riparian zone	Loss of riparian and wetland vegetation species diversity
Loss of endangered and charismatic wetland dependent faunal and floral species	Loss of riparian and wetland vegetation species diversity	Loss of endangered and charismatic wetland dependent faunal and floral species
Contamination of soils and surface water impacting foraging and breeding habitat for wetland/riverine species	Loss of endangered and charismatic wetland dependent faunal and floral species	Contamination of soils and surface water impacting foraging and breeding habitat for wetland/riverine species
Changes to the wetland community due to alien vegetation proliferation within disturbed areas	Contamination of soils and surface water impacting foraging and breeding habitat for wetland/riverine species	Changes to the wetland community due to ineffective alien vegetation control during decommissioning and closure
	Changes to the wetland community due to alien vegetation proliferation within disturbed areas	

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	5	4	5	4	4	9	13	117 (High)
Jutland Section	3	2	3	4	4	5	11	55 (Medium-low)

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams. In particular mention is made of the need to not encroach on the riparian systems on the Voorburg section of the mine and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- A sensitivity map has been developed for the study area, indicating the various wetland and river features which are considered to be of increased EIS. It is recommended that this sensitivity map be considered during the planning of the proposed mining activities to aid in the conservation of wetland and riparian ecology within the study area;
- The mining footprint area must be limited to what is absolutely essential in order to minimise environmental damage;
- The boundaries of footprint areas are to be clearly defined and it should be ensured that all activities remain within defined footprint areas;
- Impacts on the affected wetland features should be managed to minimise impacts on wetland areas not directly affected by or falling within the proposed development;
- Edge effects of activities including erosion and alien/ weed control need to be strictly managed in these areas;
- Access into wetland areas not directly affected by or falling within the proposed development footprint, particularly by vehicles, is to be strictly controlled;
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland areas;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation;
- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Sand River and the associated larger tributaries;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge;
- Implement alien vegetation control program within wetland areas with special mention of water loving tree species; and
- All spills should be immediately cleaned up and treated accordingly
- Ongoing aquatic biomonitoring should take place and include riparian vegetation assessment according to the VEGRAI method and ongoing moisture stress monitoring of riparian vegetation at strategic monitoring reports should take place.

Recommended mitigation measures

- Restrict activities to winter months in order to limit impact on wetland species utilising wetlands as foraging and breeding habitat;
- The extent of the operations on the Voorburg Section must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines; and
- Revegetate all disturbed areas with indigenous tree species and make use of indigenous species with an affinity for riparian zones such as *Combretum imberbe* (leadwood), *Faedherbia albida* (Ana tree) and *Xanthocercis zambesiaca* (Nyala).

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	4	4	3	4	4	8	11	88 (Medium-high)
Jutland Section	2	2	2	3	3	4	8	32 (Low)

Probable latent impacts

- Wetland and riparian habitat within the study area, may be permanently altered or lost if mining activities are undertaken within the features and inadequate rehabilitation takes place;
- Sedimentation of the systems may occur for long after mining is completed;
- Eroded and incised streams are unlikely to be rehabilitated; and
- Silted up refuge pools are unlikely to be naturally rehabilitated and are unlikely to be rehabilitated by the mine.

7.6 IMPACT 6: Changes to Wetland Ecological and Sociocultural Service Provision

To determine feature specific importance in terms of function and service provision, the Sand River, Tokwespruit, Voorburg Steam, Banff Stream, smaller drainage lines as well as pans and wetland depressions were assessed separately. Following the assessment, all features are considered of intermediate importance in terms of function and service provision, with the highest scores calculated for biodiversity, tourism and recreation.

Loss or impact on wetland and riparian habitat would reduce a features importance in terms of function and service provision. Although deemed possible to reduce impact in terms of changes to ecological and sociocultural service provision it is doubtful that the level of importance could be reinstated after mine closure, unless all allocated 100m buffer zones are kept strictly off limits to any mining related activity, including general infrastructure and that water abstraction are kept to a minimum and there is no formation of a cone of dewatering which may be created through the opencast mining methods.

Activities leading to impact

Pre-Construction	Construction	Operational	Decommissioning & Closure
Poor planning leading to the placement of infrastructure within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation	Construction of infrastructure within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation	Operational activities within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation	Closure related activities within wetland and riparian features presently considered important in terms of biodiversity, tourism and recreation
Poor planning leading to the placement of infrastructure within wetland and riparian features leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Site clearing and the removal of vegetation leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Ongoing disturbance leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness	Site clearing and the removal of vegetation leading to loss in ecological and sociocultural services dependent on abundance of vegetation present and surface roughness

Inadequate design of infrastructure leading to changes to instream habitat that would reduce assimilation capability	Construction of infrastructure leading to changes to instream habitat that would reduce assimilation capability	Loss of water volumes for abstraction by farmers due to abstraction for water for production and the formation of a cone of dewatering from open pits	Seepage from any latent discard dumps and dirty water areas leading to a loss in ecological and sociocultural services
	Construction related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping	Operation related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping	Decommissioning and closure related activities resulting in changes to riparian and instream characteristics that are important in terms of flood attenuation, streamflow regulation and sediment trapping

Aspects of Wetland Ecological and Sociocultural Service Provision affected

Construction	Operational	Decommissioning & Closure
Direct loss of biodiversity, tourism and recreational value	Direct loss of biodiversity, tourism and recreational value	Direct loss of biodiversity, tourism and recreational value
Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities	Loss of phosphate, nitrate and toxicant removal abilities
Loss of flood attenuation, streamflow regulation and erosion control abilities	Loss of flood attenuation, streamflow regulation and erosion control abilities	Loss of flood attenuation, streamflow regulation and erosion control abilities

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	9	4	4	4	5	8	13	117 (High)
Jutland Section	3	2	3	2	3	5	8	40 (Low)

Essential mitigation measures:

- Ensure that as far as possible all infrastructure is placed outside of wetland areas and streams. In particular mention is made of the need to not encroach on the riparian systems on the Voorburg section of the mine and a minimum buffer of 100m around all wetland and riparian systems should be maintained in line with the requirements of regulation GN704 of the national Water Act;
- A sensitivity map has been developed for the study area, indicating the various wetland and river features which are considered to be of increased EIS. It is recommended that this sensitivity map be considered during the planning of the proposed mining activities to aid in

the conservation of wetland and riparian ecology within the study area;

- The mining footprint area must be limited to what is absolutely essential in order to minimise environmental damage;
- The boundaries of footprint areas are to be clearly defined and it should be ensured that all activities remain within defined footprint areas;
- Impacts on the affected wetland features should be managed to minimise impacts on wetland areas not directly affected by or falling within the proposed development;
- Edge effects of activities including erosion and alien/ weed control need to be strictly managed in these areas;
- Access into wetland areas not directly affected by or falling within the proposed development footprint, particularly by vehicles, is to be strictly controlled;
- All vehicles should remain on designated roads with no indiscriminate driving through adjacent wetland areas;
- Ensure that all stockpiles are well managed and have measures such as berms and hessian sheets implemented to prevent erosion and sedimentation;

- No use of clean surface water or any groundwater which potentially recharges the watercourses in the area should take place. In this regard specific mention is made of any water use which will affect the instream flow in the Sand River and the associated larger tributaries;
- Pollution control dams should be off stream structures and not within the natural drainage system of the area, thereby minimising impacts loss of instream flow and downstream recharge;
- Implement alien vegetation control program within wetland areas with special mention of water loving tree species; and
- All spills should be immediately cleaned up and treated accordingly.

Recommended mitigation measures

- Restrict activities to winter months in order to limit impact on wetland species utilising wetlands as foraging and breeding habitat;
- The extent of the operations on the Voorburg Section must be kept to an absolute minimum;
- No infrastructure or open pits should encroach into any major drainage lines; and
- Revegetate all disturbed areas with indigenous tree species and make use of indigenous species with an affinity for riparian zones such as *Combretum imberbe*, *Faedherbia albida* and *Xanthocercis zambesiaca*.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Voorburg Section	**4**	**4**	**3**	**4**	**4**	**8**	**11**	**88 (Medium-high)**
Jutland Section	**2**	**2**	**2**	**3**	**3**	**4**	**8**	**32 (Low)**

Probable latent impacts

- Ability for features to provide ecological and sociocultural services may be permanently lost or reduced if mining activities are undertaken within 100 meter of the features and inadequate rehabilitation takes place

7.7 SUMMARY OF AQUATIC AND WETLAND ECOLOGICAL IMPACTS

7.7.1 Impact assessment summary

Based on the above assessment it is evident that there are 4 major impacts on the aquatic ecology of the project area and 2 major impacts on wetland and riparian ecology of the project area. The tables below summarise the findings indicating the significance of the impact before mitigation takes place and the likely impact if management and mitigation takes place table 52 indicates the impact summary for the Voorburg section and Table 53 the impact summery for the Jutland Section. In the consideration of mitigation it is assumed that a high level of mitigation takes place but which does not lead to prohibitive costs.

Table 52: A summary of the results obtained from the assessment of aquatic ecological impacts for the Voorburg section

Impact level	**Prior to mitigation**	**Post mitigation**
IMPACT 1:Loss of instream flow, aquatic refugia and flow dependent taxa	Very high	High
IMPACT 2: Impacts on water quality affecting aquatic ecology	High	High
IMPACT 3: Loss of Aquatic habitat	Medium high	Medium high
IMPACT 4: Loss of Aquatic Biodiversity and sensitive taxa	High	High
IMPACT 5: Loss of wetland and riparian habitat	High	Medium high
IMPACT 6: Loss of wetland ecoservices	High	Medium high
SUMMARY	**High to very high**	**Medium high to High**

From the table it is evident that prior to mitigation the impact on instream flow is very high while impacts due to reduced water quality are high. Impacts due to a loss of aquatic habitat are considered high while the loss of aquatic biodiversity and less tolerant taxa is deemed high. Overall the impact of the proposed Voorburg section of the Mopane project is considered to be very high to high. If mitigation takes place all impacts can be considered to be high level impacts except for the loss of aquatic habitat which will remain a moderately high impact. With mitigation the overall impact is considered to be a high level impact.

Table 53: A summary of the results obtained from the assessment of aquatic ecological impacts for the Jutland section

Impact level	Prior to mitigation	Post mitigation
IMPACT 1:Loss of instream flow, aquatic refugia and flow dependent taxa	Medium high	Medium low
IMPACT 2: Impacts on water quality affecting aquatic ecology	Medium low	Medium low
IMPACT 3: Loss of Aquatic habitat	Medium low	Low
IMPACT 4: Loss of Aquatic Biodiversity and sensitive taxa	Low	Low
IMPACT 5: Loss of wetland and riparian habitat	Medium low	Low
IMPACT 6: Loss of wetland ecoservices	Low	Low
SUMMARY	**Medium low**	**Medium low to low**

From the table it is evident that prior to mitigation all impacts are moderately low level impacts in the Jutland section of the project while the impact on the loss of aquatic biodiversity is considered to be low. Overall the impact of the proposed Jutland section of the Mopane project is considered to be moderately low prior to mitigation. If mitigation takes impacts from loss of stream flow and impacts on water quality can be considered to be moderately low while the impacts on aquatic habitat and aquatic biodiversity and sensitive taxa can be considered low. With mitigation the overall impact is considered to be a medium low to low level impact.

7.7.2 Cumulative impacts

The Sand River is an extremely important system with the system providing potable water as well as large volumes of water for the irrigation of crops to the north of the Soutpansberg mountain range. The irrigation of the crops is critical to their success and the crops produced can be considered to be of high significance as the crops are produced in winter when areas further to the south cannot produce food for the South African consumer. Prior to any large scale mining in the area the system can already be considered to be stressed from a water supply point of view. It is also important to note that no reserve determination has been undertaken for the Sand River. In addition the system has been identified as a FEPA river system and an upstream support area for a fish FEPA and is therefore considered important in fish conservation. For these reasons extreme caution must be used in decision making in the area with regards to any activity which may affect water supply.

As part of the Greater Soutpansberg Project three very large scale mining operations are proposed which include the Mopane Project, the Chapudi project and the Generaal project. The activities of the Generaal project are unlikely to contribute to the cumulative impact on the Sand River although some very small impacts on the Limpopo River system may occur.

There will however be a significant cumulative impact on the Sand River system from both the Chapudi and the Mopane projects with both systems likely to have similar types of impacts on the Sand River system. The combined impact of both these projects is likely to significantly affect the water supply and possibly the water quality in the Sand River which in turn will affect the habitat available in the system as well as the availability of refuge pools in periods of low flow and an impact on aquatic and riparian community diversity sensitivity and abundance is likely to occur. In addition these projects have the potential to affect downstream socio-cultural service provision of the Sand River system.

For these reasons extreme caution and care should take place throughout the entire life cycle of these two projects, should they proceed, in order to ensure that the impact on the Sand River system and other ephemeral systems in the area with riparian vegetation is minimised to levels which would ensure an ongoing acceptable level of functioning and biodiversity in these systems. In each phase of the project specific mention is made of the following:

- **Pre-construction**: ensure that the design of all infrastructure is optimal to minimise impacts on the aquatic and wetland areas within this already water scarce area and within the water stressed systems of the area;
- **Construction:** ensure that the design of all infrastructure is adhered to and ensure that very good housekeeping takes place to prevent impacts on the receiving aquatic and riparian environments;
- **Operation:** ensure that mine planning and original designs are adhered to and ensure that very good housekeeping takes place to prevent impacts on the receiving aquatic and riparian environments. In addition specific attention must be given to keep all streamflow reduction activities to the absolute minimum;
- **Closure:** ensure that long in advance prior to closure that detailed investigations are undertaken and a detailed closure plan is developed in order to ensure that latent impacts are minimised to ensure that an ongoing acceptable level of functioning and biodiversity occurs in the area. It should also be ensured that a suitably qualified team of ecologists are involved in the project to ensure that closure takes place in such a way as to ensure that post closure sustainability is reached.

8 CONCLUSION

Scientific Aquatic Services (SAS) was appointed to undertake a Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) analysis of the wetland, aquatic and riparian resources as part of the environmental assessment and authorisation process for the proposed Greater Soutpansberg Mopane project, located approximately 30km to the south of Musina within the Limpopo Province.

The following general conclusions were drawn upon completion of the literature review:

- The Greater Soutpansberg Mopane Project falls within the Limpopo Plain Ecoregion and is located within the A71J, A71K and A72B quaternary catchments. The bullets below presents the findings for each of the quaternary catchments based on Kleynhans (1999):
  - A71J - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Resilient* system which, in its present state, can be considered a Class B (largely natural) stream;
  - A71K - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Moderately Sensitive* system which, in its present state, can be considered a Class B (largely natural) stream; and
  - A72B - According to the ecological importance classification for the quaternary catchment, the system can be classified as a *Resilient* system which, in its present state, can be considered a Class B (largely natural) stream.
- The SANBI Wetland Inventory (2006) and NFEPA (2011) databases were consulted to define the ecology of the wetland or river systems within the Mopane Project Area that may be of ecological importance. Key findings are listed below:
  - The sub-Water Management Area is not regarded important in terms of fish sanctuaries, rehabilitation or corridors, translocation and relocation zones for fish;
  - The Sand River is a perennial system classified as a Class B (largely natural) river and is not indicated as a free flowing or flagship river. However, the northern portion of the Sand River is indicated as a FEPA river and the southern portion of the Sand River is indicated as an Upstream Management Area;

- River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. Although FEPA status applies to the actual river reach within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and smaller stream network need to be managed in a way that maintains the good condition (A or B ecological category) of the river reach;
- Upstream Management Areas are sub-quaternary catchments in which human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas.

The following general conclusions were drawn upon completion of the wetland assessment:

- ➢ Sites selected with the use of desktop methods, were investigated during the field survey undertaken in July 2013. For the purposes of this investigation, use was made of distinguishing factors as either defined by DWA (2005) for 'wetland habitat' or defined in the Water Act (Act No 36 of 1998) for 'riparian habitat'. Due to the ephemeral nature of many features within the study area they could not be considered true wetland or riparian habitat and was consequently not assessed with the methods used below;
- ➢ Wetland and riparian features within the study area were categorised with the use of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis, 2013). After the field assessment it can be concluded that three main feature groups are present within the study area, namely depressions (pans and wetland depressions), rivers (Sand River, Tokwespruit, Banff Stream and Voorburg Stream) and smaller drainage lines;
- ➢ These groups were then assessed to determine importance in terms of function and service provision as well as PES. The bullets below summarise the key findings:
  - The results obtained indicate that the Sand River can be considered the most important in terms of function and service provision, with the highest scores calculated for water supply, biodiversity and tourism and recreation. The next highest average scores calculated was for the Voorburg Stream, Banff Stream and wetland depressions;
  - Wet-Health was used to determine the PES of smaller drainage lines including wetland depressions and pans. Pans calculated average scores for vegetation, hydrology and geohydrology that fall within a very high PES (unmodified, natural), mainly as a result of their remoteness. Smaller drainage lines calculated the same impact score for

vegetation, however hydrology and geohydrology impact scores are lower as a result of impact from earth works due to the construction of the impoundments (wetland depressions) as well as abstraction of water;

- VEGRAI was used to assess the response of riparian vegetation to impacts within rivers as well as smaller drainage lines. The mean average scores calculated for the Sand River and Tokwespruit both fall within Class C (moderately modified) and mean average scores calculated for the smaller drainage lines, Banff and Voorburg Streams fall within Class B (largely natural); and
- The IHI was used to assess the vegetation, hydrology and geomorphology of the different river systems and drainage lines. All three aspects were used to determine the average PES category for each feature assessed. The smaller drainage lines calculated the highest PES score falling within a Class A (unmodified), followed by the Banff Stream, Voorburg Stream and the Tokwespruit all calculating scores falling between Class A and B (largely natural). The Sand River calculated the lowest score falling between Class B and Class C (moderately modified).

➢ All features were delineated on a desktop level with the use of aerial photographs, digital satellite imagery and topographical maps. Portions of the features were verified during the field survey according to the guidelines advocated by DWA (2005). To comply with legislative requirements as well as to aid with conservation of habitat within the study area, during the proposed mining activities, 100m buffer zones are recommended for all features;

➢ Legislative requirements were used to determine the extent of buffer zone required for each group depending on whether a group is considered wetland/riparian habitat or not:

- The Sand River, Tokwespruit, Banff Stream and Voorburg Stream as well as smaller drainage lines with riparian zones are defined as watercourses. If any activities are to take place within 100 meters or the 1:100 year flood lines exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA will also apply and therefore a Water Use Licence will be required;
- Smaller drainage lines *without* riparian zones are not considered wetlands but are still defined as watercourses. If any activities are to take place with the 1:100 year flood line exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained, however Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA does not apply and therefore no Water Use Licence will be required;

- Wetland depressions form part of smaller drainage lines with riparian zones and as a result are already included within the legislative requirements defined for the smaller drainage lines above; and
- Pans are considered wetland habitat, therefore a Water Use Licence in terms of section 21 c and i of the NWA will be required, and the 500 m zone of applicability of General Notice no. 1199 of 2009 as it relates to the NWA will also apply.

<u>The following general conclusions were drawn upon completion of the aquatic assessment:</u>

- Increased concentrations of dissolved salts were observed in a downstream direction, resulting from low flow conditions compounded by water abstraction from the system for agricultural purposes);
- pH values also increased in a downstream direction;
- The most significant impacts (instream habitat) are from water abstraction, flow modification and water quality modifications. Both sites obtained a “D” (“Largely modified”) classification with regard to instream habitat integrity;
- In the riparian zone the system has been affected by vegetation removal, alien encroachment and bank erosion;
- With regard to riparian zone habitat integrity, site GSP3 was classified as “D” (largely modified), whilst site GSP1 was classified as “C” (moderately modified);
- Overall scores of 55.9 % (GSP3) and 56.5% (GSP1) were calculated, placing both sites GSP3 and GSP1 in class D (largely modified);
- Habitat diversity and structure was considered inadequate for supporting a diversity of aquatic macro-invertebrate communities at all three downstream sites (GSP1, GSP3 and GSP4);
- Habitat conditions seem to deteriorate in a downstream direction with impacts from farming and construction evident;
- Conditions (macro-invertebrate community) in the Sand River have deteriorated in a downstream direction according to both the Dallas (2007) and the Dickens & Graham (2001) classification systems;
- At site GSP6, the stream may be considered to be in a class C (moderately impaired) condition according to the Dickens & Graham (2001) classification system and in a class D (largely impaired) condition according to the Dallas (2007) classification system;
- In comparison the downstream sites vary between class C (moderately impaired) and class E (severely impaired) conditions according to the Dickens & Graham (2001) classification

system. With the Dallas (2007) classification system conditions vary between class D and class and in a class E/F for the three downstream sites (Biocon S7, GSP3 and GSP1);

- The MIRAI results in terms of (ecological category classification) follow the same trends as that obtained using the SASS class classifications (C for GSP6, E for GSP4, D for GSP3 and F for GSP1);
- The EC classification obtained are in congruence with previous studies performed in the same system;
- The automated EC calculated for the FRAI (C/D for GSP6, E for GSP4, E for GSP3, D for GSP1 and F for the system as a whole) largely corresponds to that obtained for the MIRAI.

The impact assessment of the project highlighted that the potential impacts on the envisaged Voorburg section of the project are very high to high and with very careful mitigation can be reduced to high to moderately high levels while impacts on the Jutland section are moderately low and can be slightly reduced to lower levels.

On a larger scale there is likely to be a very significant cumulative impact on the Sand River system from both the Chapudi and the Mopane projects with both systems likely to have similar types of impacts on the Sand River system. The combined impact of both these projects is likely to significantly affect the water supply and possibly the water quality in the Sand River which in turn will affect the habitat available in the system as well as the availability of refuge pools in periods of low flow and an impact on aquatic and riparian community diversity sensitivity and abundance is likely to occur. In addition these projects have the potential to affect downstream socio-cultural service provision of the Sand River system.

For these reasons extreme caution and care should take place throughout the entire life cycle of these two projects, should they proceed, in order to ensure that the impact on the Sand River system and other ephemeral systems in the area with riparian vegetation is minimised to levels which would ensure an ongoing acceptable level of functioning and biodiversity in these systems. The mitigation measures highlighted in this report are considered extremely important and all effort to implement these measures should take place in order to minimise the impacts to levels that will ensure the sustainability of the ecology of the local area and downstream areas.

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Appendix 1: IHIA data

Instream Zone Habitat Integrity

Reach	ASSESSMENT DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
	Weights	14	13	13	13	14	10	9	8	6		
GSP 6	July 2013	16	16	12	8	14	3	3	2	7	39.7	D: Largely modified
GSP 4	July 2013	16	14	9	7	4	9	2	6	1	48.6	D: Largely modified
GSP 3	July 2013	21	12	4	4	12	0	0	0	1	48.0	D: Largely modified
GSP 1	July 2013	19	13	8	7	12	0	0	0	2	49.5	D: Largely modified

None	Small	Moderate	Large	Serious	Critical

Riparian Zone Habitat Integrity

Reach	ASSESSMENT DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
	Weights	13	12	14	12	13	11	12	13		
GSP 6	July 2013	14	13	12	11	9	9	3	2	47.3	D: Largely modified
GSP 4	July 2013	13	11	8	7	9	7	1	8	60.0	C: Moderately modified
GSP 3	July 2013	12	11	12	19	9	7	19	0	27.1	E: Extensive loss
GSP 1	July 2013	12	11	8	16	9	9	14	0	40.8	D: Largely modified

None	Small	Moderate	Large	Serious	Critical

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
GSP6	Jul 2013	39.7	47.3	43.5	D: Largely modified
GSP4	Jul 2013	48.6	60.0	54.3	D: Largely modified
GSP3	Jul 2013	48.0	27.1	37.5	E: Extensive loss
GSP1	Jul 2013	49.5	40.8	45.1	D: Largely modified

Appendix 2: IHAS Score sheets July 2013

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: SAND						
Site Name: GSP1	**Date**: 23/07/2013					
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	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	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		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				11	
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	
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	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m²' = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	$>2m^2$	rocks	$1\text{-}2m^2$	$<1m^2$	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				12	
	HABITAT TOTAL (MAX 55):				23	
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
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
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
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX				23	
	TOTAL IHAS SCORE (%):				46	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SAND
Site Name: GSP3
Date: 24/07/2013

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	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	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		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				9	
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	
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	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				9	
	HABITAT TOTAL (MAX 55):				18	
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
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
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
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					24
	TOTAL IHAS SCORE (%):				42	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SAND
Site Name: GSP4
Date: 12/09/2013

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	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	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		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				12	
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	
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	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				8	
	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
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
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
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 45):				21	
	TOTAL IHAS SCORE (%):				41	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: SAND						
Site Name: GSP6	**Date**: 23/07/2013					
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	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			13		
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		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				15	
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	
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	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				13	
	HABITAT TOTAL (MAX 55):				41	
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
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
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
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					35
	TOTAL IHAS SCORE (%):				76	

Appendix 3: SASS5 Score sheets July 2013

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/07/2013	**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					Blepharoceridae	15				
SITE CODE: GSP1	**ANNELIDA:**						Gerridae*	5		A		A	Ceratopogonidae	5			A	A
RIVER: SAND	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2		A	A	B
SITE DESCRIPTION: DS project area	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: Warm, dry low flow	**CRUSTACEA:**						Nepidae*	3		1		1	Dixidae*	10				
TEMP: 15.5 °C	Amphipoda	13					Notonectidae*	3		A		A	Empididae	6				
Ph: 8.32	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.73 mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 194 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		A		A	Hydropsychidae 1sp	4					Ancylidae	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: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: MEDIUM	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	36	13	37
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	8	3	9
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	4.5	4	4.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	46%				
	Coenagrionidae	4		A		A	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		1		1	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6			A	A	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/07/2013	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		B	B		Blepharoceridae	15				
SITE CODE: GSP3	**ANNELIDA:**						Gerridae*	5		A		A	Ceratopogonidae	5				
RIVER: SAND	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2			A	A
SITE DESCRIPTION: US project area	Leeches	3					Naucoridae*	7					Culicidae*	1		1		1
WEATHER CONDITION: Warm, dry low flow	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 26.0 °C	Amphipoda	13					Notonectidae*	3		1	A	A	Empididae	6				
Ph: 8.83	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 8.41 mg/l	Atyidae	8					Veliidae/M..veliidae*	5		1		1	Muscidae	1				
Cond: 213.3 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8		A		A	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			1		Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: 2 DOM SP:	Baetidae 2 sp	6		B		B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 4	Caenidae	6		A		A	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3		B		B
TURBIDITY: LOW	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	61	28	76
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	13	7	16
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	4.7	4	4.8
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		42%			
	Coenagrionidae	4		1		1	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		1		1	**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5			B	B	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8		1		1	Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6			A	A	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4		1		A	Hydrophilidae*	5			1	1	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/07/2013	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		B	A	B	Blepharoceridae	15				
SITE CODE: GSP4	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5		1		1
RIVER: SAND	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2			B	B
SITE DESCRIPTION: DS Proposed mine	Leeches	3					Naucoridae*	7					Culicidae*	1		A	A	A
WEATHER CONDITION: Hot, dry, no rain	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 25.1°C	Amphipoda	13					Notonectidae*	3		B		B	Empididae	6				
Ph: 8.70	Potamonautidae*	3			1	1	Pleidae*	4					Ephydridae	3				
DO: 11.44 mg/l (155.14%)	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 92.2 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: 2 DOM SP: Algae	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4			1	1	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: 2 DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 5	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW: LOW	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	17	19	32
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	5	6	9
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0	3.4	3.2	3.6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	41%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**S**					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		A		A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6			A	A	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 24/07/2013	**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	A	Blepharoceridae	15				
SITE CODE: GSP6	**ANNELIDA:**						Gerridae*	5	1				Ceratopogonidae	5				
RIVER: SAND	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	B		A	B
SITE DESCRIPTION: DS Proposed mine	Leeches	3					Naucoridae*	7					Culicidae*	1		A		A
WEATHER CONDITION: Hot, dry, clear	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 25.9 °C	Amphipoda	13					Notonectidae*	3		B		B	Empididae	6				
Ph: 7.35	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.51 mg/l (1017%)	Atyidae	8	B		A	B	Veliidae/M..veliidae*	5		A		A	Muscidae	1				
Cond: 18.4 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: 3 TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5	1		1	A
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: 3 DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4	1			1	Ancylidae	6				
M VEG OOC: 3 DOM SP:	Baetidae 2 sp	6	B				Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL: 1	Baetidae >2 sp	12		B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 4	Caenidae	6	A		A	A	Philopotamidae	10	1			1	Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS: YES	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3			1	1
FLOW: LOW	Leptophlebiidae	9	B			B	**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY: LOW	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		76	42	33	100
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		12	8	7	18
	Chlorocyphidae	10	A	A		A	Petrothrincidae SWC	11					**ASPT:**		6.3	5.3	4.7	5.6
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		76%			
	Coenagrionidae	4		1		1	Sericostomatidae SWC	13					**S**					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	A			A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6	A		B	B	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4		1		1	Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					