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

Prepared for

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FINAL REPORT

Declaration of Independence

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 Chapudi 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 Chapudi Project Area falls within the Limpopo Plain Ecoregion and is located within the A71J and A80F quaternary catchments and negligibly in the A71H quaternary catchment. The most important systems in the A71 quaternary catchment is the Sand River and the most significant riverine resource within the Chapudi Project area within the A80F quaternary catchment is the Mutamba River, a major tributary of the Nzhelele River. The RSA Wetland Types (2010) and National Freshwater Ecosystem Priority Areas (NFEPA) (2011) databases were consulted to define the ecology of the wetland or river systems within the Chapudi Project Area that may be of ecological importance. Aspects applicable to the Chapudi Project Area and surroundings are discussed below:

- The subWMA is not listed as a fish Freshwater Ecosystem Priority Area (FEPA).
- The portions of the rivers which flow through the Chapudi Project Area are indicated as Upstream Management Areas.
- The Sand River is a perennial system and the Moleletsane River is an ephemeral system. Both rivers are classified as Class B (largely natural) rivers and are not indicated as free flowing or flagship rivers.
- 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 Mutamba River is a perennial system classified as a Class D (largely modified) river
- The Mutamba is not indicated as a free flowing, flagship or FEPA river.
- Several wetland features are located within the Chapudi Project Area. Three different wetland types, valley floor, bench and slope wetlands, occur within the Chapudi Project Area.
- Three wetland features within the Chapudi Project Area (in the western project area) which are indicated as wetland FEPAs. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.

- Two wetland clusters are indicated within the Chapudi Project Area. Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands.
- No RAMSAR wetlands are located within or close to the Chapudi Project Area.

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

- 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). Three main feature groups are present within the study area, namely depressions (GSPC W1, GSPC W2, GSPC W3 and smaller pans), rivers (Sand River, Mutamba River and Moleletsane Stream) and smaller drainage lines. Within the area several artificial earth dams were also observed, some of which are perennial with others that only seasonally or ephemerally hold surface water and support vegetation adapted to life in saturated soils. The results of the classification of the systems are illustrated in the tables below;
- The riverine resources are of significant importance in terms of wetland function and service provision with special mention of biodiversity as well as water provision to farmers within a water stressed region. Game farming is also the present land use of the majority of the farms investigated with limited areas utilised for crop cultivation, consequently the river systems have remained largely undisturbed and are therefore important in terms of biodiversity value. The Sand River and the Nzhelele River, of which the Mutamba River is a major tributary, have 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 and Mutamba Rivers 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 significantly impact on the Moleletsane River, Sand River and Mutamba River. 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 Mutamba River. 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 in the aquifers associated with these water courses, 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 adverse impacts on the ecology of the area.
- The Sand and Mutamba rivers are also considered to be of increased significance with regards to biodiversity maintenance due to the presence of fish that would be restricted to river corridors and refugia 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, as a result of the project, 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 on the Sand River and a moderate to high risk on the Mutamba River.
- 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 agriculturally 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 limited levels of present impact, which can be considered important in terms of biodiversity conservation;
- GSPC W2 and GSPC W3 as well as smaller 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. 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;
- The results obtained from the assessment of wetland ecoservices 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 Mutamba River and to a lesser degree the Moleletsane Stream. The GSPC W1 wetland on the Black Stone Edge Farm is considered to be a depression feature of high ecological significance while all other depression features in the area are considered to be of lower significance;

- Wet-Health was used to determine the PES of the wetland depressions and pans within the study area. The pans have been impacted by anthropogenic activities, but can still generally be considered to be in good condition and are considered to be important in terms of biodiversity support in the area;
- The VEGRAI ecostatus was used to assess the response of riparian vegetation to impacts within rivers as well as smaller drainage lines. The mean scores calculated for the Sand River, Mutamba River and the Moleletsane River. The Sand River can be defined as a Class C (moderately modified) system with the upper Mutamba river being less impacted in a Class A and B (natural to largely natural) range and the lower area slightly more modified in the Class C (moderately modified) and mean scores calculated for the smaller drainage lines, fall within Class B (largely natural) category. The Moleletsane river was classified as a Class C (moderately modified) system;
- Based on the findings of the study it is evident that from a wetland point of view, the EIS of the river systems are largely similar. All the systems can be defined as Class B systems indicating a high EIS. The Moleletsane River had the lowest EIS with a borderline (B/C) condition indicating a moderate to high EIS. When the aquatic ecology of the Sand River is considered, from where several assessment points are available it is evident that the aquatic ecology of the system is in a poorer condition than the wetland EIS assessment indicates. Based on the consideration of both the wetland EIS and the aquatic ecostatus indices, the most appropriate EIS for the upper reaches of the Sand River have been defined as a Class B system with the lower areas more likened to a Class D resource.
- The wetland features within the subject property showed a more significant variation in the EIS. The GSPC W1 (Wetland on the Black Stone Edge Farm) had the highest EIS being defined as a Class A system, indicating a very high EIS.
- The GSPC W2 and GSPC W3 wetlands had lower values (Class C) and can be defined as having a moderate EIS. The smaller natural depression wetlands were considered to have a high (Class B) EIS. The artificial wetlands formed through the construction of small earth dams were defined as having a borderline Class C/D EIS indicating a moderate to low EIS.
- 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 License 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;
- The bulk of the mining support structure such as the plant ROM facilities and the associated pollution control facilities are planned in this area on the Black Stone Edge Farm. These activities in the area are likely to severely impact on the GSPC W1 wetland leading to the permanent destruction of the wetland features. Since the infrastructure in this area is not resource dependent, the infrastructure could be moved to an alternative location without compromising on the mining resource. Due to the unique nature of this feature and the biodiversity it supports, with special mention of the known presence of protected species and the high probability of occurrence of other species of conservation concern, it is strongly recommended that the infrastructure be moved from this area to an area which where these activities will have a significantly lower impact on wetland resources;

<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 both the Sand and Mutamba Rivers or 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.
- An overall IHIA score of 86.7% was obtained for the upstream site on the Mutamba River (GSP9) was calculated, defining the system class A (unmodified/natural). Some reductions in integrity are however evident in a downstream direction on the system;
- Habitat diversity and structure was considered highly suitable for supporting a diverse and sensitive aquatic macro-invertebrate community
- 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 between six sites. For five of these sites classifications varied between D and E with only one site achieving a C ecological classification. For site GSP9 (M1 historically) specifically, an ecological classification of D was achieved (compared to C obtained in the current assessment).
- From the fish community assessments it is clear that the EC calculated for the FRAI largely corresponds to that obtained for the MIRAI. Because the habitat (and hence potential drivers) was fairly homogenous between the sites, the refined EC was 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 variation in results may be attributed to the low flows at the time of assessment and potential migratory movement of fish in the system.
- The Sand River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. The Sand River can be considered to be a system of high aquatic Ecological Importance and Sensitivity due to the provision of refugia and in the local area and the support it provides to the aquatic ecology of the area. The system is also deemed important in terms of the provision of services to the terrestrial fauna, such as the provision of drinking water of the area as well as a high significance from a socio-cultural point of view, with special mention of water provision for agriculture. It is deemed essential that all effort is made to ensure that impacts on the Sand River as a result of the proposed Chapudi Project are minimised.
- Based on the findings of the aquatic study the Mutamba River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. Some recovery of the system does however occur in the lower reaches but impacts on the aquatic ecology of the lower reaches of the system are still considered to be likely. The Mutamba River can be considered to be a system of reduced Ecological Importance and Sensitivity in relation to the Sand River due to the limited provision of refugia and in the local area and the limited support it provides to the aquatic ecology of the area. The system is however deemed important in terms of riparian vegetation habitat and the provision of services to the terrestrial fauna of the area as well as fair significance form a socio-cultural point of view. It is deemed essential that all effort is made to ensure that impacts on the Mutamba River as a result of the proposed Chapudi Project are minimised.

The proposed Chapudi 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 addressing the Chapudi West Section and the Chapudi Main and Wildebeest sections:

- From the results of the impact assessment 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 Chapudi main and Wildebeest section of the Chapudi Project is considered to be 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 medium high level impact.
- From the table it is evident that prior to mitigation all impacts are moderately low level impacts in the Chapudi West section of the project while the impact on the loss of wetland ecoservices is considered to be low. Overall the impact of the proposed Chapudi West section of the Chapudi Project is considered to be moderately low prior to mitigation. If mitigation takes place all impacts except impacts due to impaired water quality and loss of aquatic habitats considered to be low while latter impacts can be considered moderately low. With mitigation the overall impact is considered to be a medium low to low level impact.
- The Sand River and to a lesser degree the Mutamba are extremely important systems with these systems 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 both these systems 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. According to DWA (2004), the Nzhelele River is a water stressed region and therefore, the implementation of the ecological Reserve may require compulsory licensing to deal with the over-allocation to the irrigation sector.
- The Sand River 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 in the Sand system.
- 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 Chapudi and Generaal projects are likely to contribute to the cumulative impact on the Mutamba River as well as the cumulative impact on the Nzhelele River although some very small impacts on the Limpopo River system may occur.
- There will also 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 three projects, should they proceed, in order to ensure that the impact on the Sand River system as well as the Nzhelele River system with special mention of the Mutamba River 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 and ensure the implementation of the ecological reserve.

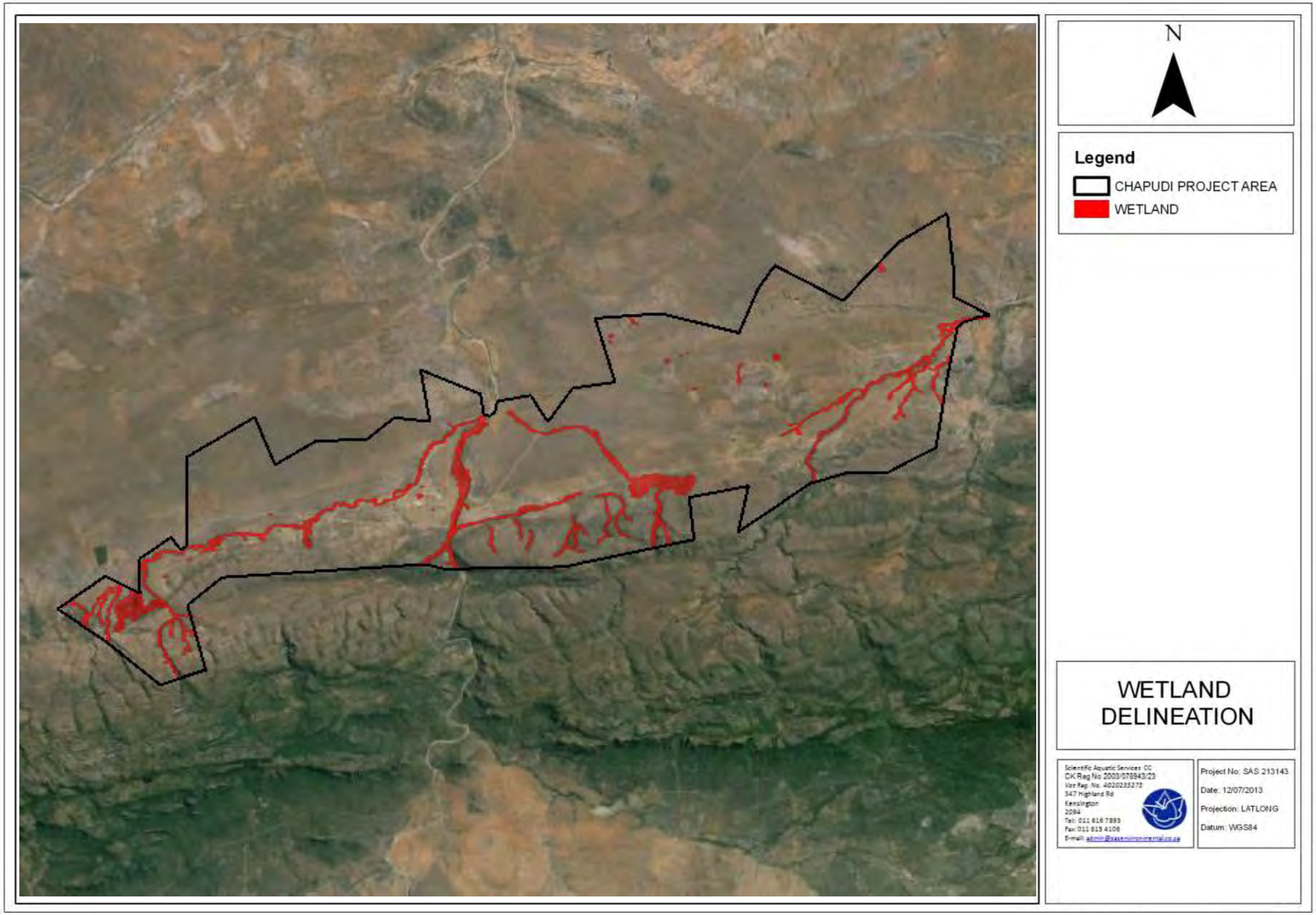

Figure A: Wetland and riparian areas in relation to the study area.

TABLE OF CONTENTS

List of Figures

List of Tables

Acronyms

BGIS	-	Biodiversity Geographic Information Systems
°C	-	Degrees Celsius.
DEMC	-	Desired Ecological Management Class
DWA	-	Department of Water Affairs
EAP	-	Environmental Assessment Practitioner
EC	-	Ecological Class or Electrical Conductivity (use to be defined in relevant sections)
EIA	-	Environmental Impact Assessment
EIS	-	Ecological Importance and Sensitivity
EMC	-	Ecological Management Class
EMP	-	Environmental Management Program
FRAI	-	Fish Response Assessment Index
GIS	-	Geographic Information System
GN	-	General Notice
GSP	-	Greater Soutpansberg Projects
HCR	-	Habitat Cover Ratings
HG	-	Hydrogeomorphic
HGM	-	Hydrogeomorphic Units
IHAS	-	Invertebrate Habitat assessment System
IHIA	-	Intermediate Habitat Integrity Assessment
IH	-	Index of Habitat Integrity
m	-	Meter
MIRAI	-	Macro-invertebrate Response Assessment Index
MPRDA	-	Mineral and Petroleum Resources Development
NAEHMP	-	National Aquatic Ecosystem Health Monitoring Programme
NEMA	-	National Environmental Management Act
NBA	-	National Biodiversity Assessment
NFEPA	-	National Freshwater Ecosystem Priority Areas
NOMR	-	New Order Mining Rights
NSBA	-	National Spatial Biodiversity Assessment
NWA	-	National Water Act
NWCS	-	National Wetland Classification System
PEMC	-	Present Ecological Management Class
PPP	-	Public Participation Process
REC	-	Recommended Ecological Category
RHP	-	River Health Program
SACNASP	-	South African Council for Natural Scientific Professions
SANBI	-	South African National Biodiversity Institute
SAS	-	Scientific Aquatic Services
SASSA	-	South African Soil Surveyors Association
SASS5	-	South African Scoring System 5
VEGRAI	-	Vegetation Response Assessment Index
WMA	-	Water Management Areas
subWMA	-	Sub-Water Management Area
WetVeg Groups	-	Wetland Vegetation Groups

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 Chapudi Project, located approximately 30km to the south of Musina within the Limpopo Province (hereafter referred to as the „study area") and extends over approximately 40,448ha (depicted in Figure 1 and Figure 2 below).

The Chapudi Project forms part of the Greater Soutpansberg Projects (GSP) situated to the north of the Soutpansberg in the Limpopo Province. It is evident that they are within close vicinity of each other, permitting possible rationalisation of infrastructure. Based on the prospecting rights held in the Chapudi Project area, Chapudi Coal (Pty) Ltd (Chapudi) and Kwezi Mining Exploration (Pty) Ltd (Kwezi) submitted 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). The objective is to have a consolidated project with economically minable blocks which are contiguous. Therefore, in parallel to the NOMR applications, the applicants will be applying for the consent of the Minister of Mineral Resources, to simultaneously with the granting of the NOMRs, cede certain of the mining rights from Kwezi to Chapudi in terms of Section 11 of the MPRDA; and after cession of the mining rights, consolidate these into one mining right for the Chapudi Project in terms of Section 102 of the MPRDA.

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.

The Chapudi Project is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 20 km (direct) and 35 km (via road) north-west of the town Makhado in the Makhado Local Municipal area. Musina is situated approximately 65 km to the north – refer to Figure 2 and Figure 3. Musina and Makhado are connected by well-developed road infrastructure. The N1 national road pass the mining right application (MRA) area (Wildebeesthoek and Chapudi Sections) in the east with the R523 running through the site from east to west. Both of these roads carry sufficient traffic to impact on the ambient sound levels a distance away from these roads. There is an undefined road just west of the Waterpoort Station that appears to carry heavy traffic. The Makhado-Musina railway line runs in a north-south direction through the Chapudi Project area.

The land coverage in the Chapudi Project area is mixed between intensive irrigated agriculture, hunting and tourism. The intensive irrigated agricultural activities are focused along the Sand River catchment and neighbouring areas. The land use in the Wildebeesthoek Section of the Chapudi Project is predominantly hunting, game farming and ecotourism. The Chapudi Section has a combination of hunting/game farming and irrigated / dry land agriculture. The Chapudi West Section has portions of intensive agriculture, while the further south-west portions are utilised for conservation, hunting and ecotourism.

The majority of the intensive agricultural area is utilised for predominantly vegetable production and is known as the winter pantry (production area) of South Africa. Some of the properties are also focused on mixed farming, with a mixture of livestock, game and irrigated agriculture. A number of pack houses for fresh commodities are operational in the region. The fresh produce markets remain a major outlet for fresh produce. Direct marketing is also a popular marketing outlet and producers deliver direct to chain stores such as Woolworths, Pick „n Pay etc.

Hunting, game trading and eco-tourism is an established socio-economic driver in the area. There are a number of properties utilised for trophy (for local and foreign tourists) and biltong hunting with ecotourism spin-off activities.

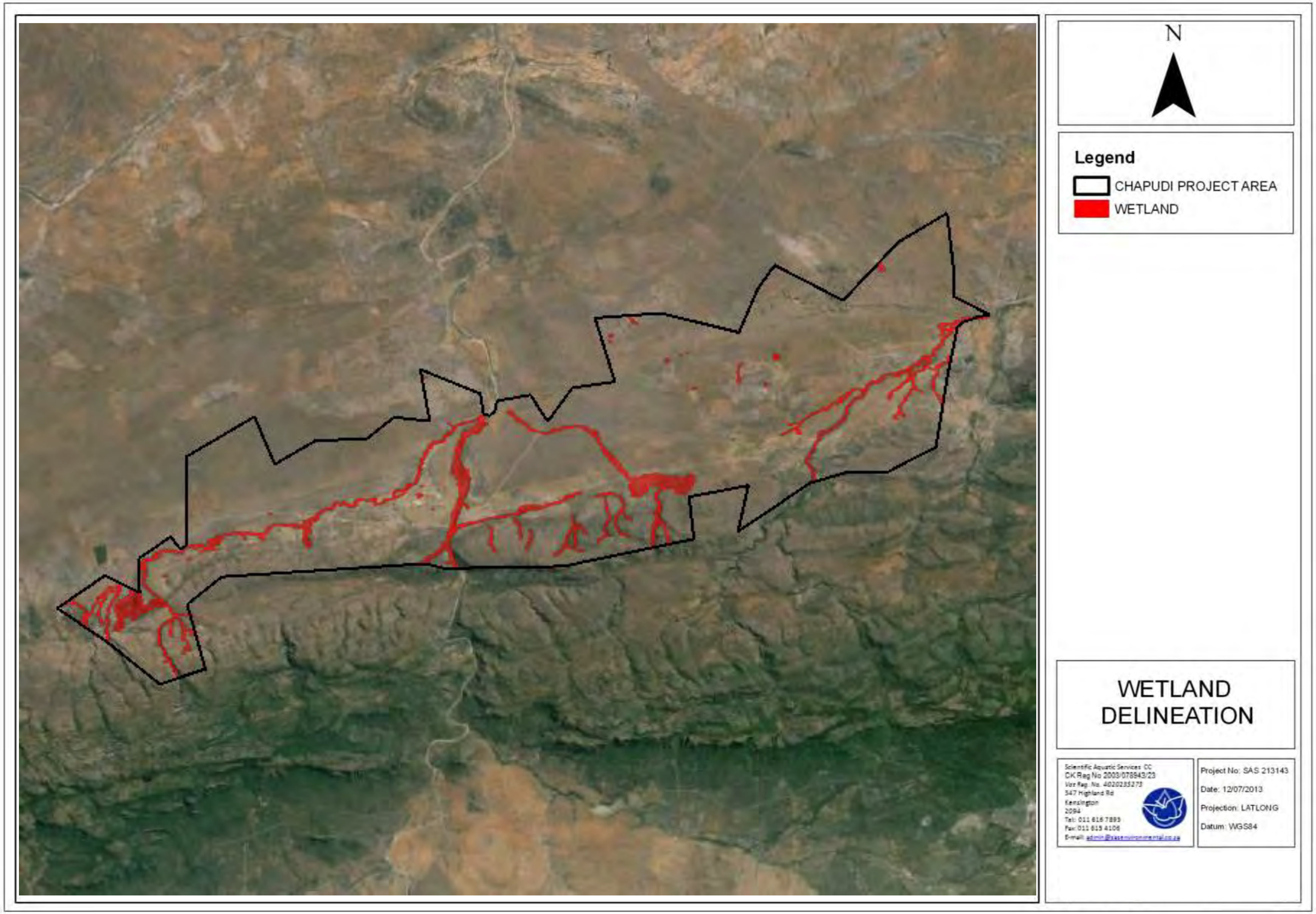

Figure 1: Location of the study area depicted on an aerial photograph in relation to surrounding areas.

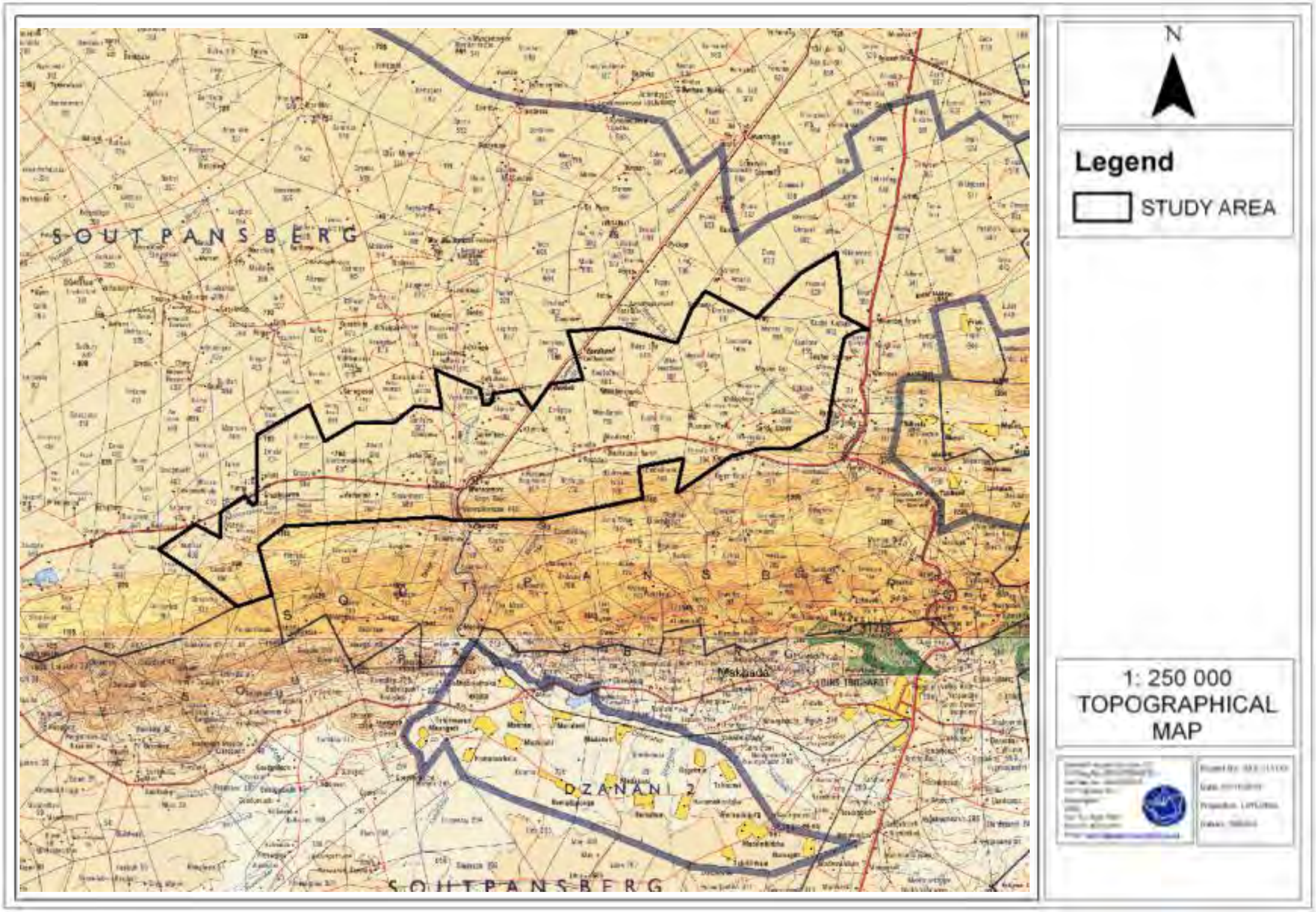

Figure 2: 1:250 000 Topographic map depicting the location of the study area in relation to surrounding areas.

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, arachnids, 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 the entire period has 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 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.

Dionne Crafford

Dionne Crafford matriculated in 1993 and obtained a BSc Ecology degree from the University of Pretoria in 1996. He obtained his BSc (Hons) Zoology degree with distinction at the same university in 1997, where he was awarded the Zoological Society of Southern Africa (ZSSA) award for the best honours student in Zoology. His honours project focused on behavioural ecology (grass owl acoustics).

He spent 1998 in the United States of America exploring various warm water fly fishing opportunities, before returning to enroll for an MSc in Zoology at the Rand Afrikaans University in 1999. He obtained the degree with distinction in 2000 and was awarded the Neitz Medallion for the best MSc in Zoology by the Parasitological Society of Southern Africa (PARSA). His MSc project was on aquatic environmental management/biological monitoring using catfish and their parasites as indicators of water quality.

From 2001 to 2006 he was first employed as "Veterinary Researcher" and later "Specialist Veterinary Researcher" by former Intervet at their Malelane research facility. From 2003 to 2006 he also performed part-time fly fishing guiding services for the former Fly Fishing Outfitters (Nelspruit). He moved to Bloemfontein in 2007 where he was employed as "Assistant Manager: Endoparasitology" at ClinVet International (Pty) Ltd from 2007 to 2012. In 2009 he enrolled for a part-time PhD in Zoology (monogenean parasites of freshwater fish) at the University of Johannesburg and received his degree in 2013. As from 2013 he is employed as Associate Scientific Writing Manager at ClinVet and also performs scientific writing services for Scientific Aquatic Services. In the latter capacity he has participated in a number of studies relating to aquatic biomonitoring and toxicity testing.

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.

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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 floodline 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 waterlogged 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 numerous farms, especially in the western areas of the proposed project, area was not granted and therefore these farms were not ground truthed. However, the precautionary principle was applied and all features identified on a desktop level, included in the specialist study as well as sensitivity mapping as part of this report. As best as possible the observations made through the rest of the project area as well as other projects in the area were extrapolated to allow for characterisation of the riparian and wetland resources on the subject property;
- 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 and added to the number of survey points. Although all possible measures were undertaken to ensure all wetland features, riparian zones and drainage lines were assessed and delineated, 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 and Mutamba Rivers, within and in the vicinity of the study area, was available from which additional inferences could be made about the drainage systems of the area in different seasons.

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 1: 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 wwetland 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 key sites at points along the Sand River system in order to characterise the aquatic ecology of the system. Three sites (GSPC W1 to GSPC W3) represented wetland areas which were assessed in order to obtain an indication of the ecology of these systems. Only the GSPC W2 had sufficient surface water present to allow for meaningful aquatic assessments to be undertaken.

Table 2 below present geographic information with regards to the monitoring points on the Sand River and Mutamba River system as well as the wetland systems assessed. Figure 4 visually presents the locations of the various points along the Sand River and Mutamba River, assessed either in the current assessment or by accessing information available from the literature review and historical data collected. Figure 4 also indicates assessment points on the Nzelele and Doli Doli Rivers not presented in this report

Table 2: 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 and downstream of the Chapudi Project Area.	-22.5280	29.8925
GSP2	Sand River: Midpoint of the Mopane Project area and downstream of the Chapudi 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 and downstream of the Chapudi 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 upstream 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
GSP8	Mutamba River upstream of the project area. only historical data available	-22.9322	29.7499
GSP9	Mutamba River on upstream border of the project area	-22.8828	29.7964
GSP10	Mutamba River halfway between the R523 and the N1	-22.8374	29.8325
GSP11	Mutamba River halfway where it crosses the N1	-22.8053	29.8921
GSP12	Mutamba River halfway between the R523 and the N1	-22.7043	30.0464
GSP13	Mutamba River in the lower areas to the west of the N1 where more dense riparian vegetation was observed	-22.6828	30.0806
GSP14	Mutamba River a short distance upstream of the confluence with the Nzelele River at a dirt road crossing	-22.6833	30.0943
Wetland assessment points			
GSPC W1	A large wetland complex with depressions on the Black stone Edge Farm	-22.8863	29.7291
GSPC W2	A large pan with no vegetation in the temporarily inundated areas	-22.665797	29.8312
GSPC W3	A wetland created by a exploration drilling borehole which creates an artesian spring	-22.8217	29.8612

The sites assessed were all visually assessed. The Invertebrate Habitat Assessment System (IHAS), Intermediate Habitat 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 of the GSPC W1 site 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 (SA RHP) accredited assessor.

The use of additional sites beyond the site boundary was undertaken as historical information on these points was available for previous environmental baseline studies undertaken for the Chapudi Project in addition points further downstream were also used to consider the impacts that the proposed development could have on the lower sections of the river systems and to assist in the overall characterization of the rivers in the area on a broader scale

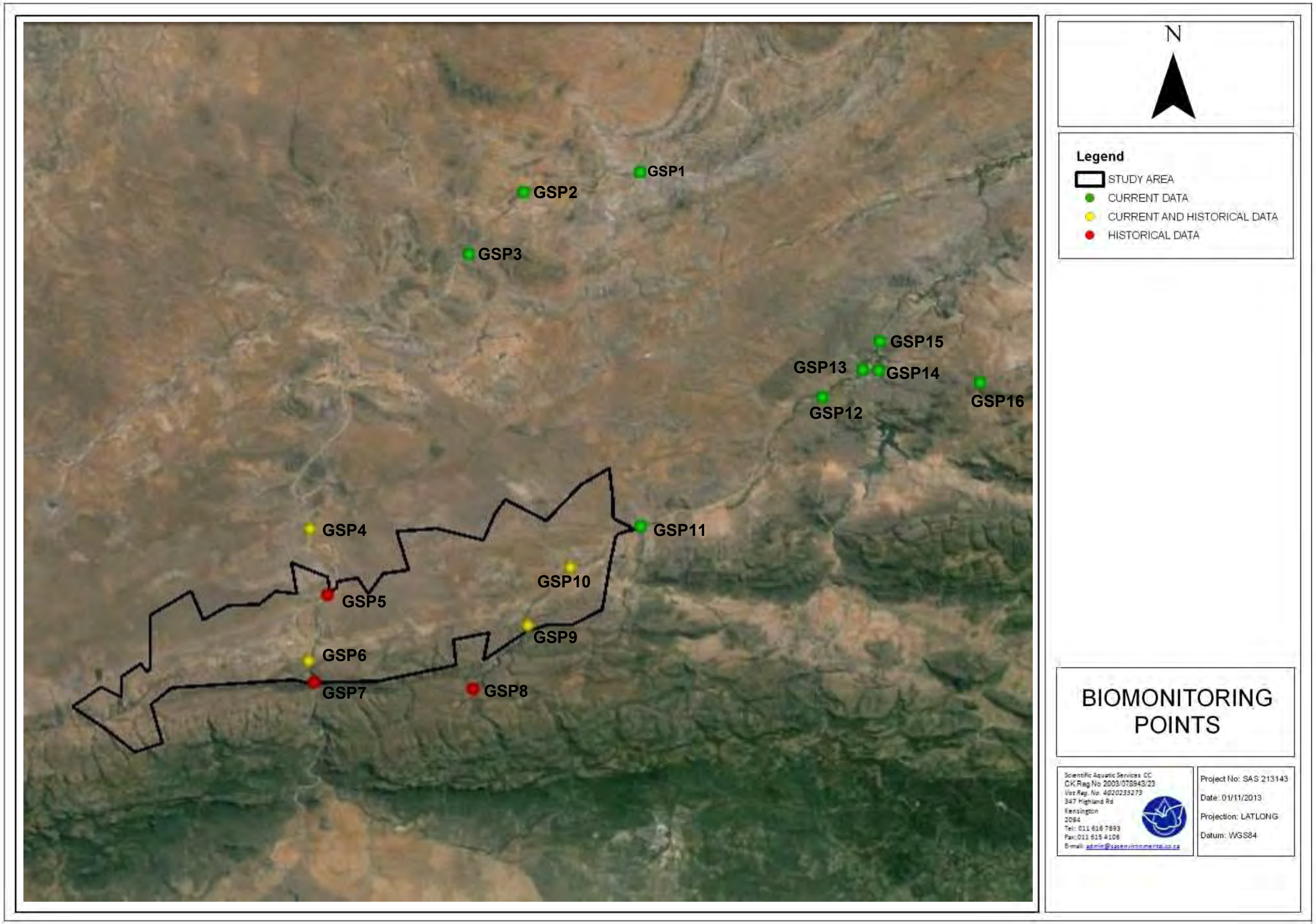

Figure 4: Aquatic ecological assessment points presented on a digital satellite image.

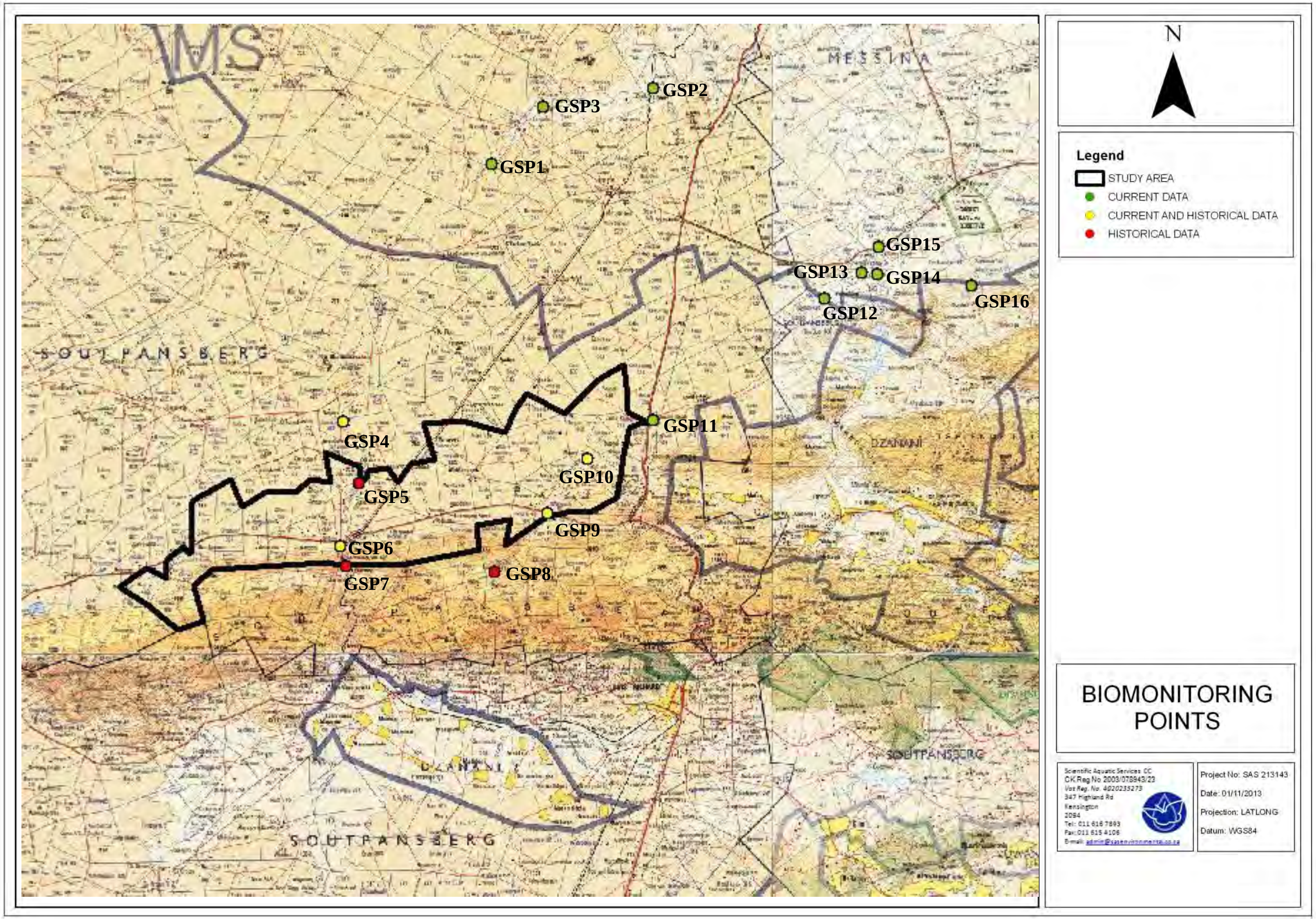

Figure 5: Riverine aquatic ecological assessment points presented on a 1:50 000 topographical map.

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 3 and 4, below.

Table 3: 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 4: 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
	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)

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
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.

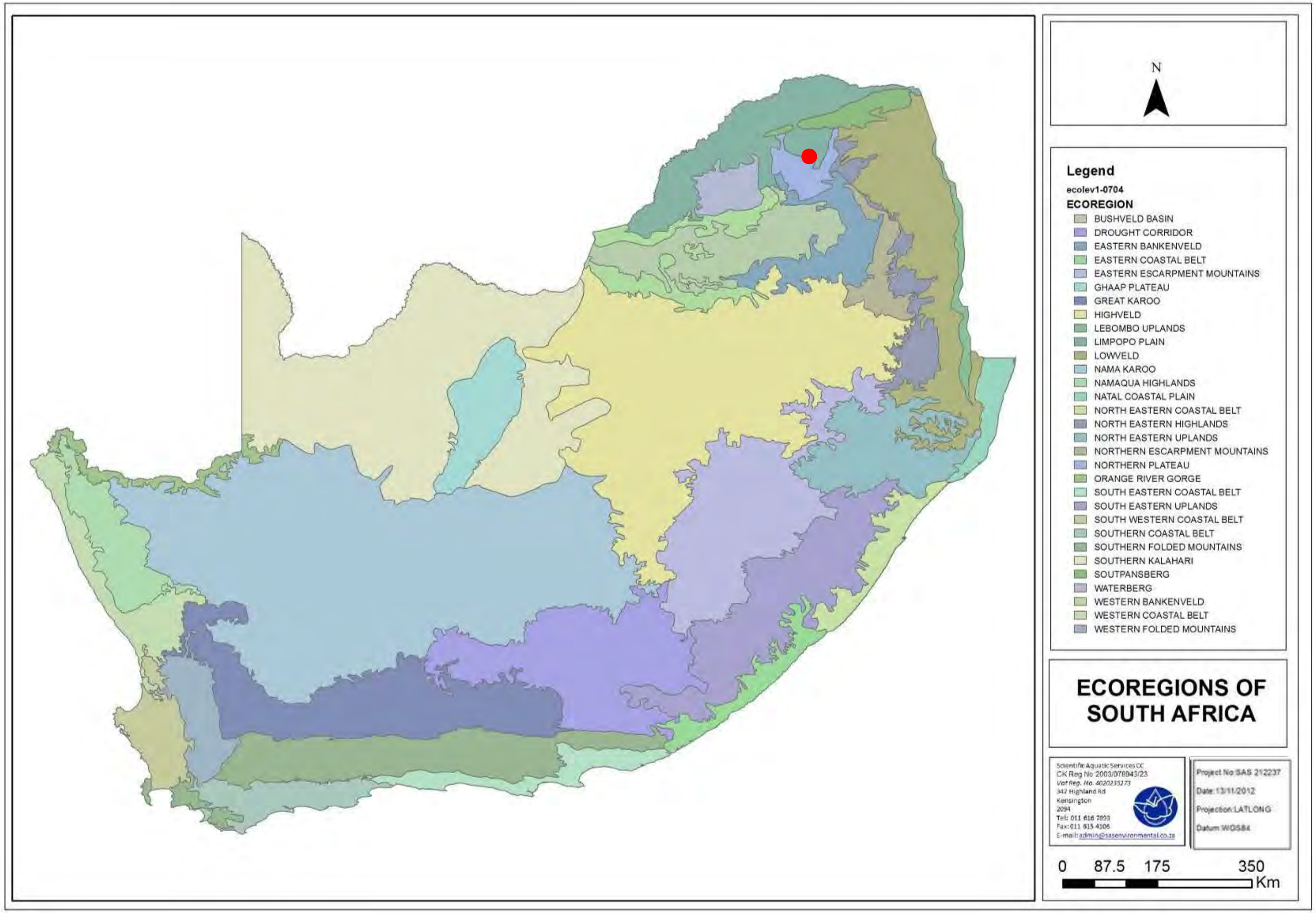

Figure 6: Map of Level 1 Ecoregions of South Africa, with the approximate position of the study area indicated in red.

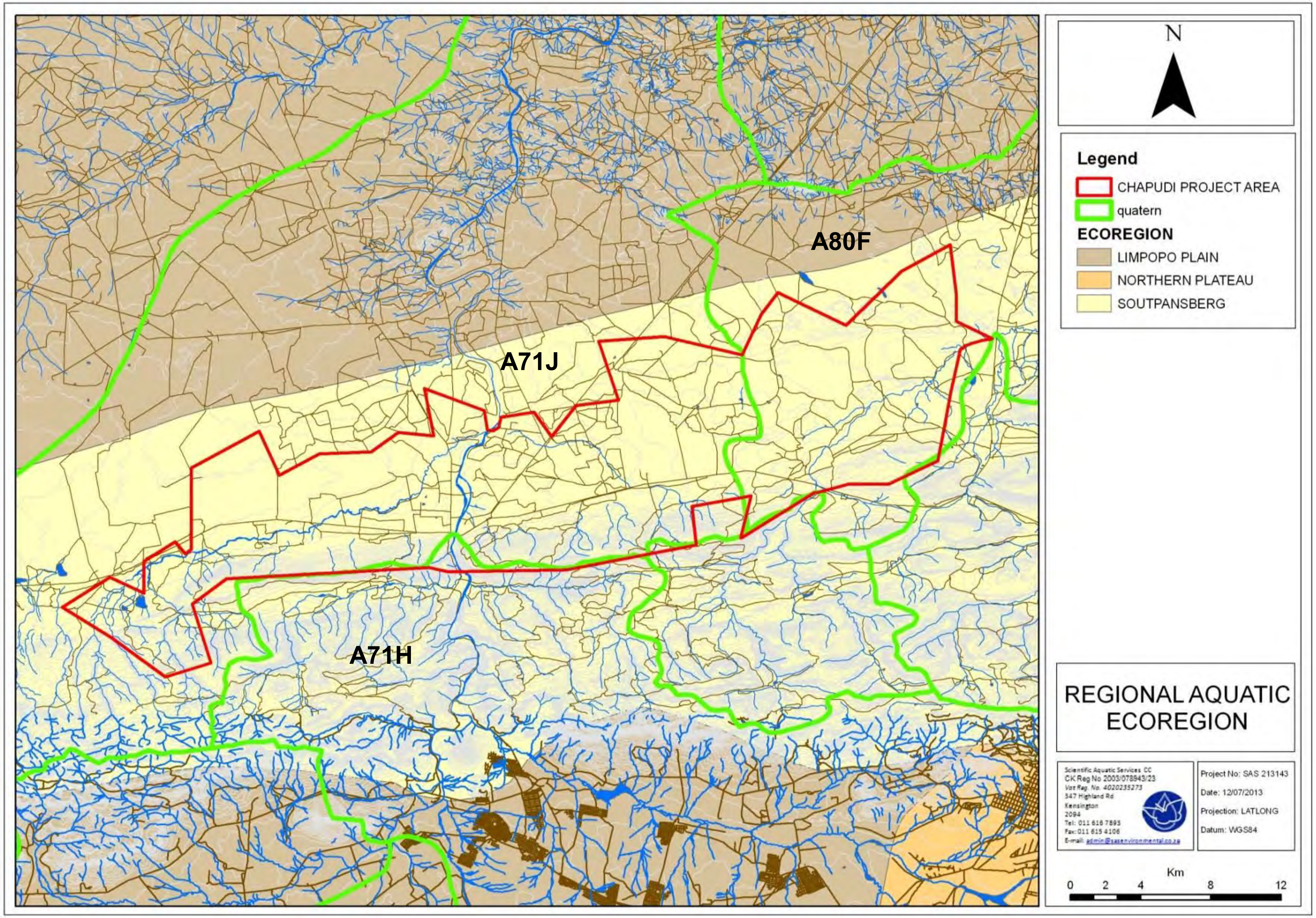

Figure 7: Map of Level 1 Ecoregions of South Africa, with the study area and aquatic ecological assessment points.

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 3) 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 perpendicular 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 4), 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;
- 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.

[2] Kleynhans et al., 2007

Table 5: 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 6).

Table 6: 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 7: 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

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

[3] Kleynhans et al, 2007
[4] DWA and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999*

- · 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 also 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 8: 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

2.8 Defining Ecological Importance and sensitivity (EIS)

The method used for the EIS determination was adapted from the method as provided by DWA (1999) for floodplains. The method takes into consideration PES scores obtained for WET-Health as well as function and service provision to enable the assessor to determine the most representative EIS category for the wetland feature or group being assessed.

A series of determinants for EIS are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to assign the EIS category.

Table 9: Wetland EIS category definitions, (1999).

EIS Category	Range of Median	Recommended Ecological Management Class[1]
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications.	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications.	>2 and <=3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications.	>1 and <=2	C
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications.	>0 and <=1	D

[1] Ed's note: Author to confirm exact wording for version 1.1

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). This was followed by realistic recommendations, mitigation, and rehabilitation measures to achieve the desired REC.

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.

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.

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*

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 11: 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

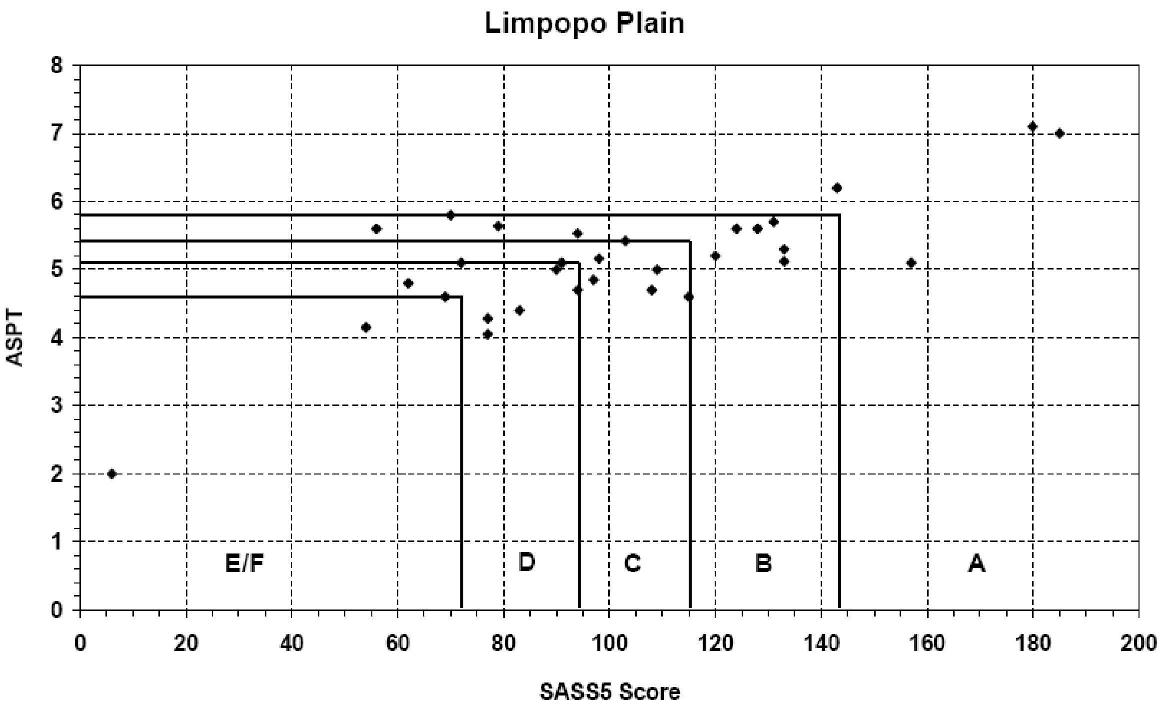

Figure 8: SASS5 Classification using biological bands calculated form percentiles for the Limpopo plain ecoregion, Dallas, 2007

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 Tables 12 and 13.

Table 12: 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).

Table 13: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the Mutamba River [4] (Limpopo River system) of the study area (Skelton, 2001; Kleynhans, 2003; Kleynhans, Louw and Moolman, 2007).

SPECIES NAME	COMMON NAME	INTOLERANCE RATING [3]	COMMENTS
Amphilius uranoscopus [2]	Stargazer (mountain catfish)	4.8	Okovango and Zambezi systems, east coast rivers south to Mkuze in northern Kwa-Zulu Natal
Barbus eutaenia [2]	Orangefin barb	4.3	Cunene, Okovango and Zambezi, east coast systems south to the Phongolo
Barbus paludinosis [1]	Straightfin barb	1.8	Widespread
Barbus trimaculatus [2]	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 viviparus [1]	Bowstripe barb	2.4	East coastal rivers from the Ruvuma south to Vungu in KwaZulu-Natal.
Chiloglanis pretoriae [1]	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.
Gambusia affinis	Mosquito fish	2.0	Widespread
Labeo cylindricus [1]	Redeye labeo	3.1	Widespread East-African rivers down to Phongolo system in KwaZulu-Natal
Labeo molybdinus [1]	Leaden labeo	3.2	Middle and lower Zambezi down to Tugela system in KwaZulu-Natal
Labeo rosae [1]	Rednose labeo	2.4	Lowveld region of the Limpopo, Incomati and Phongolo systems
Mesobola brevianelis [1]	River sardine	2.3	East coastal rivers from Limpopo to Umfolozi in KwaZulu-Natal
Micralestes acutidens [1]	Silver robbers	2.3	Cunene, Okavango, Zambezi and east coast rivers south to Phongolo.
Oreochromis mossambicus [1]	Blue Kurper	1.3	Widespread
Pseudocrenilabrus philander [1]	Southern mouthbrooder	1.3	Widespread
Tilapia sparrmanii [1]	Banded Tilapia	1.3	Widespread
Tilapia rendalli [1]	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

[4] Note: The Mutamba River is a main tributary of the Nzhelelele River. No FROC data are available for the Mutamba River so available data for the Nzhelelele River was used instead as described below:
[1] Fish species previously encountered below the Nzhelelele Dam (catchment A80G) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007).
[2] Fish species previously encountered above the Nzhelelele Dam (catchment A80B) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007). Given the position of the assessment sites these species are unlikely to occur. However, as they do occur in the same river system, they have been included in the list.
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.
[3] 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.
- **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. Initially, 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,

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

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

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.

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

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	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.

➢ 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 Chapudi 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 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.

9 Mitigation measures should address both positive and negative impacts

The Chapudi Project Area falls within the Limpopo Plain Ecoregion and is located within the A71J and A80F quaternary catchments and negligibly in the A71H quaternary catchment. The most important systems in the A71 quaternary catchment is the Sand River and the most significant riverine resource within the Chapudi Project area within the A80F quaternary catchment is the Mutamba River, a major tributary of the Nzhelele River. 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)

3.1.2 Ecostatus Classification

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 future field studies.

Table 18: 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.

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 Ecological Importance and Sensitivity (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, 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 19: Summary of the ecological status of quaternary catchments A71J, A71H and A80F based on Kleynhans (1999)

Catchment	Resource	EIS	PESC	DEMC
A71J	Sand River	Low/Marginal	Class B	D: Resilient system
A71H	Sand River	Moderate	Class B	D: Resilient system
A80F	Nzhelele River	High	Class D	B: Sensitive 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.

A71H

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 A71H quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been moderately affected by bed modification as a result of sedimentation within the catchment.
- Impacts as a result of flow modification within the catchment due to agricultural activity are considered 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 marginally impacted as a result of grazing and erosion.
- A very low impact occurs as a result of the introduction of instream biota.
- Impacts on water quality due to agricultural activities within the catchment 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 pools, rapids and a kloof in the Soutpans River.
- The site has a moderate importance in terms of conservation.
- The riverine resources in this system have a moderate intolerance to flow and flow related water quality changes with special mention of *Labeo* (mudfish) species.
- 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 moderate important in terms of the provision of refuge areas.
- The riverine resources in this system have a moderate 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 14 different species present.
- The system is of no importance with regards to unique or endemic species.

A80F

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

The points below summarise the impacts on the aquatic resources in the A80F quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been marginally affected by scouring of the system.
- Flow modification within the catchment is considered very high due to the control of flow by a dam upstream.
- Marginal impacts from inundation of the system occur.
- Riparian zones and stream bank conditions are considered to be moderately impacted by erosion.
- A low impact occurs as a result of the introduction of instream biota with special mention of *Azzola* sp. (Water Fern) and *Cyprinus* sp. (Carp).
- Impacts on water quality in the system are considered high as water released by the dam has a modified temperature and quality.

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 high diversity of habitat types.
- The site has a moderate importance in terms of conservation with special mention of a gorge in the system.
- The riverine resources in this system have a moderate intolerance to flow and flow related water quality changes.
- The aquatic resources in the area have a high importance in terms of migration of species and form a transition zone between mountain and lowveld. Special mention is made of the migration of eels, fish and birds.
- The system is considered to be of high importance in terms of rare and endemic species conservation. Some species may occur upstream of Nzhele Dam.
- 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 moderate sensitivity to changes in water quality and flow. The gorge area is particularly sensitive to changes in flow.
- The aquatic resources in this area are of high importance in terms of Species/Taxon richness with up to 16 different species present.

- The system is of high importance with regards to unique or endemic species with special mention of *Barbus eutenea* (Orangefin Barb), *Barbus lineamaculatus* (Line-spotted Barb) and *Barbus maculatus*.

3.1.3 Importance according to the RSA wetland types database (2010) and the National Freshwater Ecosystem Priority Areas (2011) database

The RSA Wetland Types (2010) and National Freshwater Ecosystem Priority Areas (NFEPA) (2011) databases were consulted to define the ecology of the wetland or river systems within the Chapudi Project Area that may be of ecological importance. Aspects applicable to the Chapudi Project Area and surroundings are discussed below:

- Each Water Management Area is divided into several sub-Water Management Areas (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 Chapudi 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 Freshwater Ecosystem Priority Area (FEPA).
- The Sand River is a perennial system and the Moleletsane River is an ephemeral system. Both rivers are classified as Class B (largely natural) rivers and are not indicated as free flowing or flagship rivers. However, the portions of the rivers which flow through the Chapudi Project Area are indicated as Upstream Management Areas.
- 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 Mutamba River is a perennial system classified as a Class D (largely modified) river however it is not indicated as a free flowing, flagship or FEPA river.

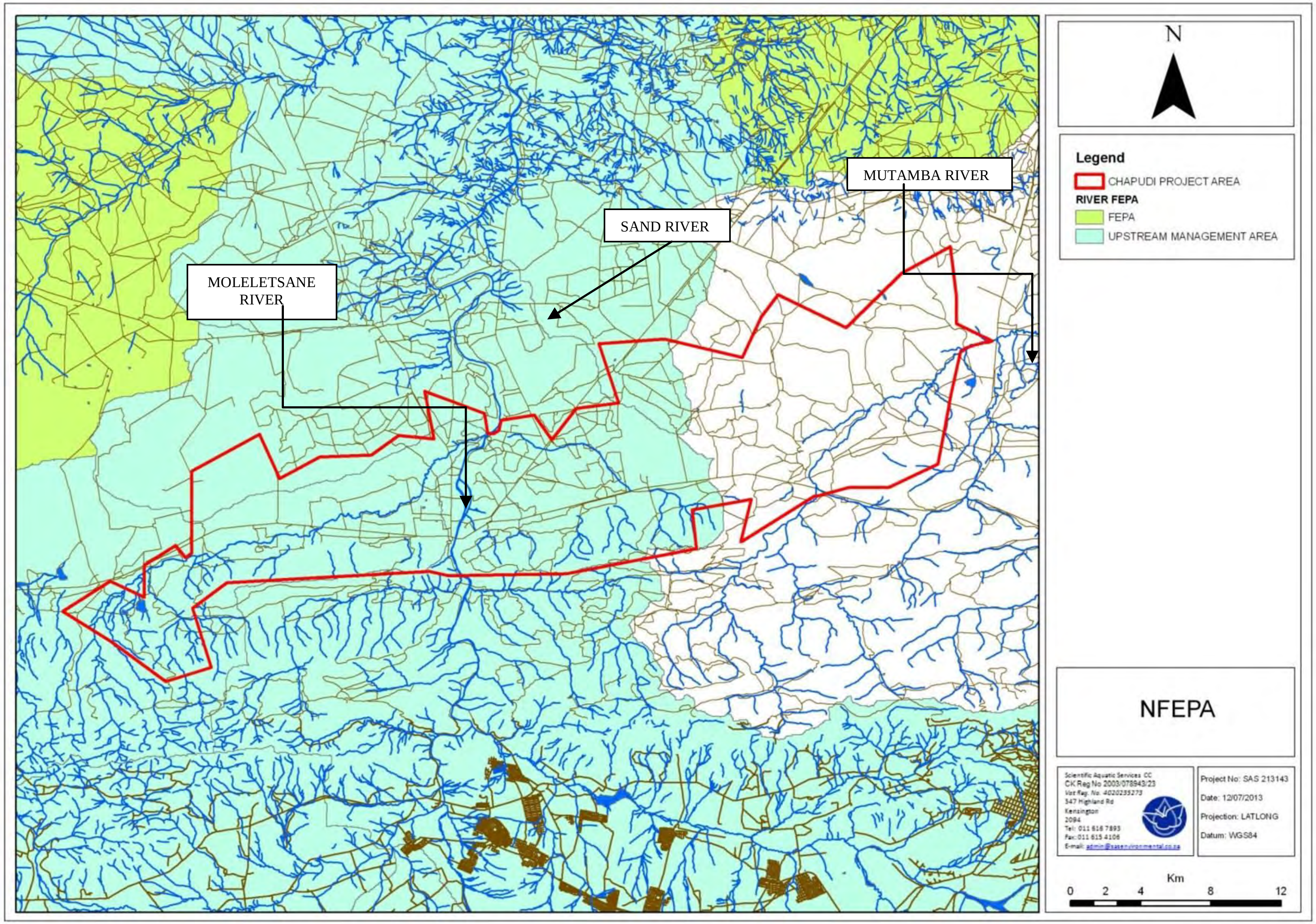

Figure 9: **Map depicting the rivers located within the study area.**

- Several wetland features are located within the Chapudi Project Area. Three different wetland types, valley floor, bench and slope wetlands, occur within the Chapudi Project Area (Figure 10).
- Both natural and artificial wetland features occur within the Chapudi Project Area (Figure 11).
- The condition of the wetland features within the Chapudi Project Area is depicted in Figure 12 to follow:
    - Category AB – Percentage natural land cover ≥ 75%;
    - Category C – Percentage natural land cover 25 – 75%;
    - 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;
    - Category Z3 - Percentage natural land cover smaller than 25%;
- Wetlands within the Chapudi Project Area were ranked according to general importance (Figure 13 below):
    - Rank 3 – Wetlands within a sub quaternary catchment identified by experts at the regional review workshop as containing wetlands of biodiversity importance, but with no valid reasons documented;
    - Rank 6 – No importance indicated.
- Three wetland features within the Chapudi Project Area (in the western project area) which are indicated as wetland FEPAs. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.
- Two wetland clusters are indicated within the Chapudi Project Area. Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands. In many areas of the country, wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts.
- Wetlands located within the Chapudi Project Area are not shown to have sighting or breeding areas for cranes.
- No RAMSAR wetlands are located within or close to the Chapudi Project Area.
- No wetlands are indicated to fall within 500m of an IUCN threatened frog point locality.
- According to the NFEPA database (2011), three wetland features (to the west of the project area) are considered of significant biodiversity importance. These wetland features are natural wetlands which are considered to be in a good condition and have been identified by experts at the regional review workshop as wetlands of biodiversity importance.

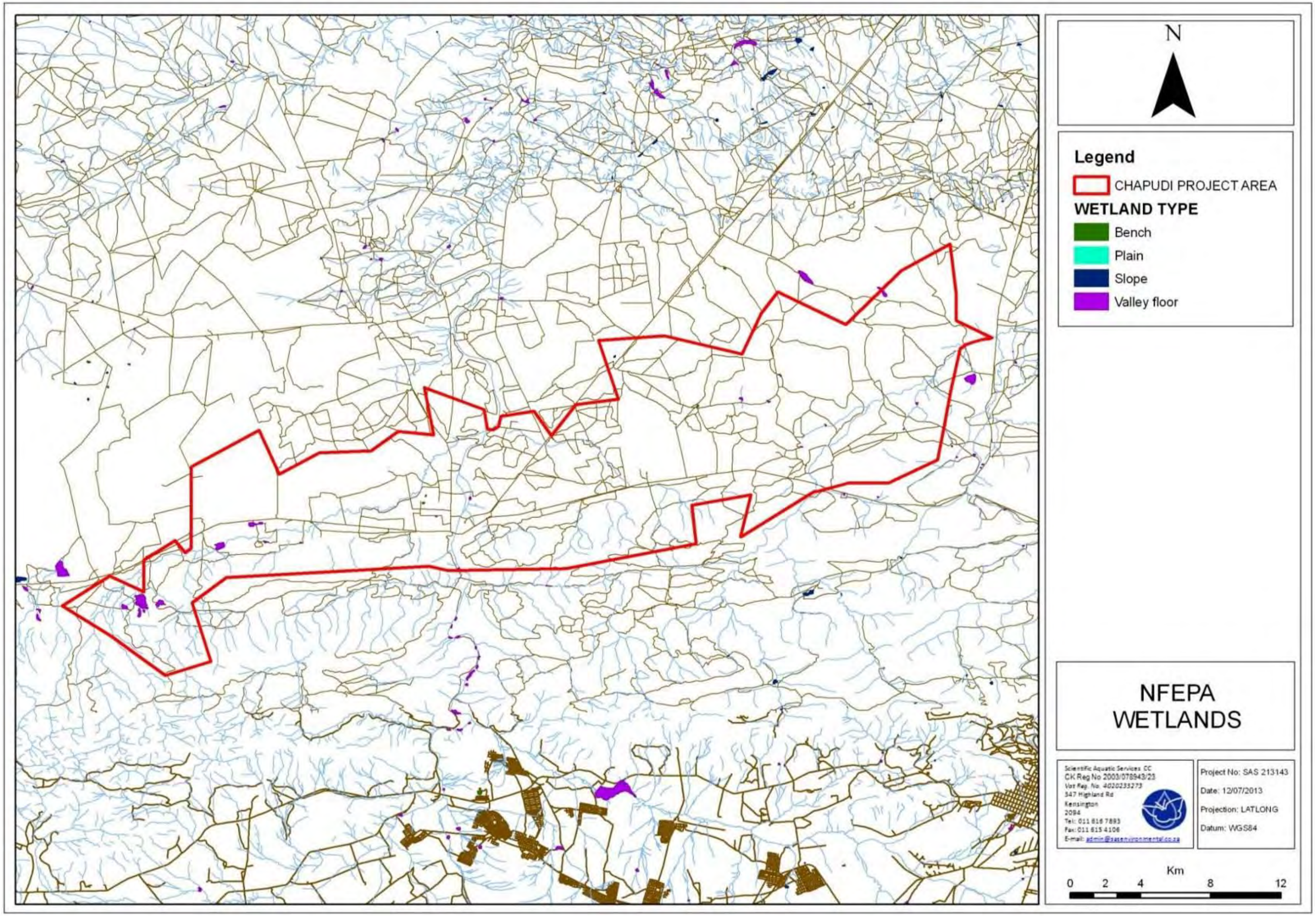

Figure 10: Wetland types within the Chapudi Project Area.

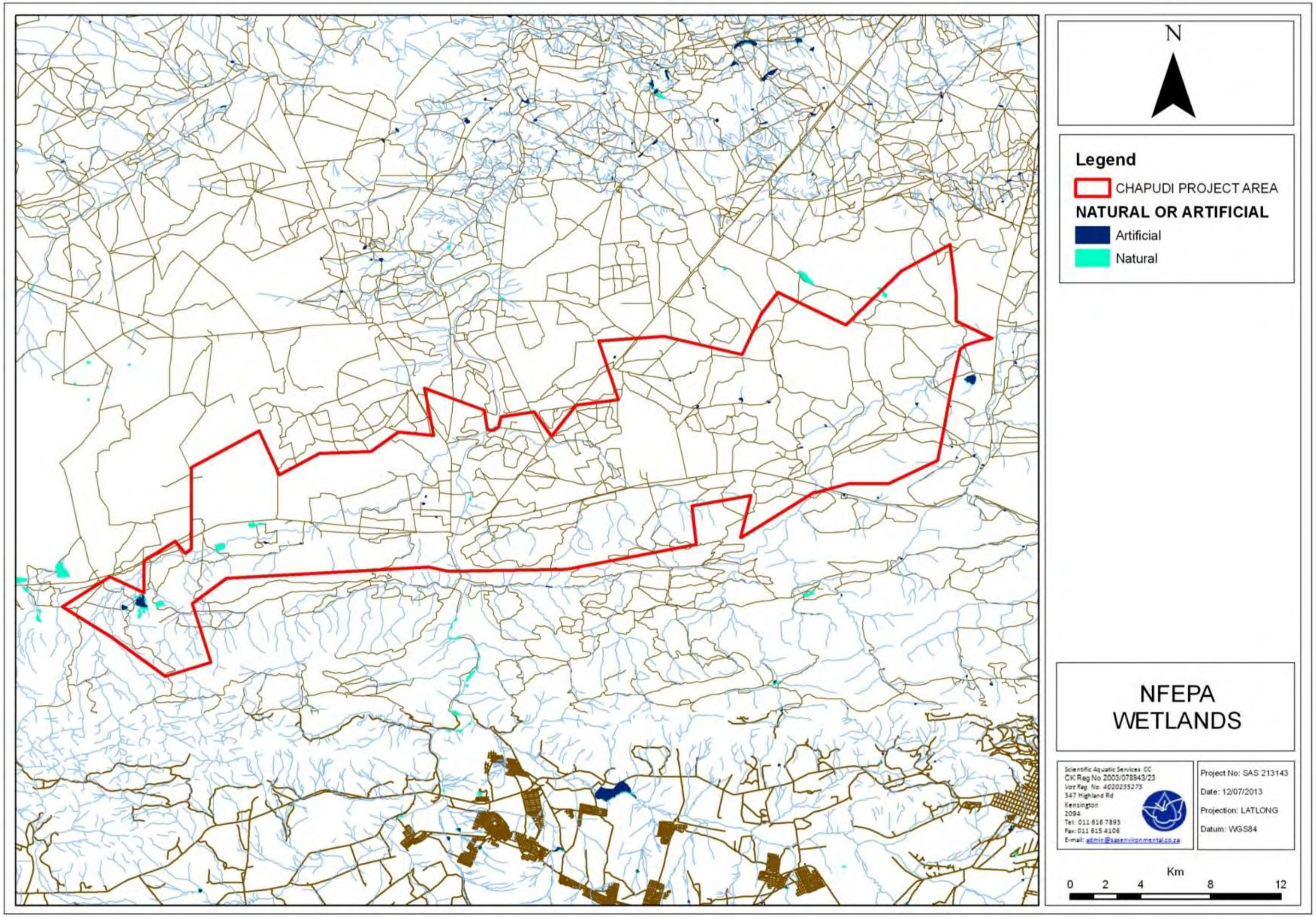

Figure 11: Natural and Artificial wetlands within the Chapudi Project Area.

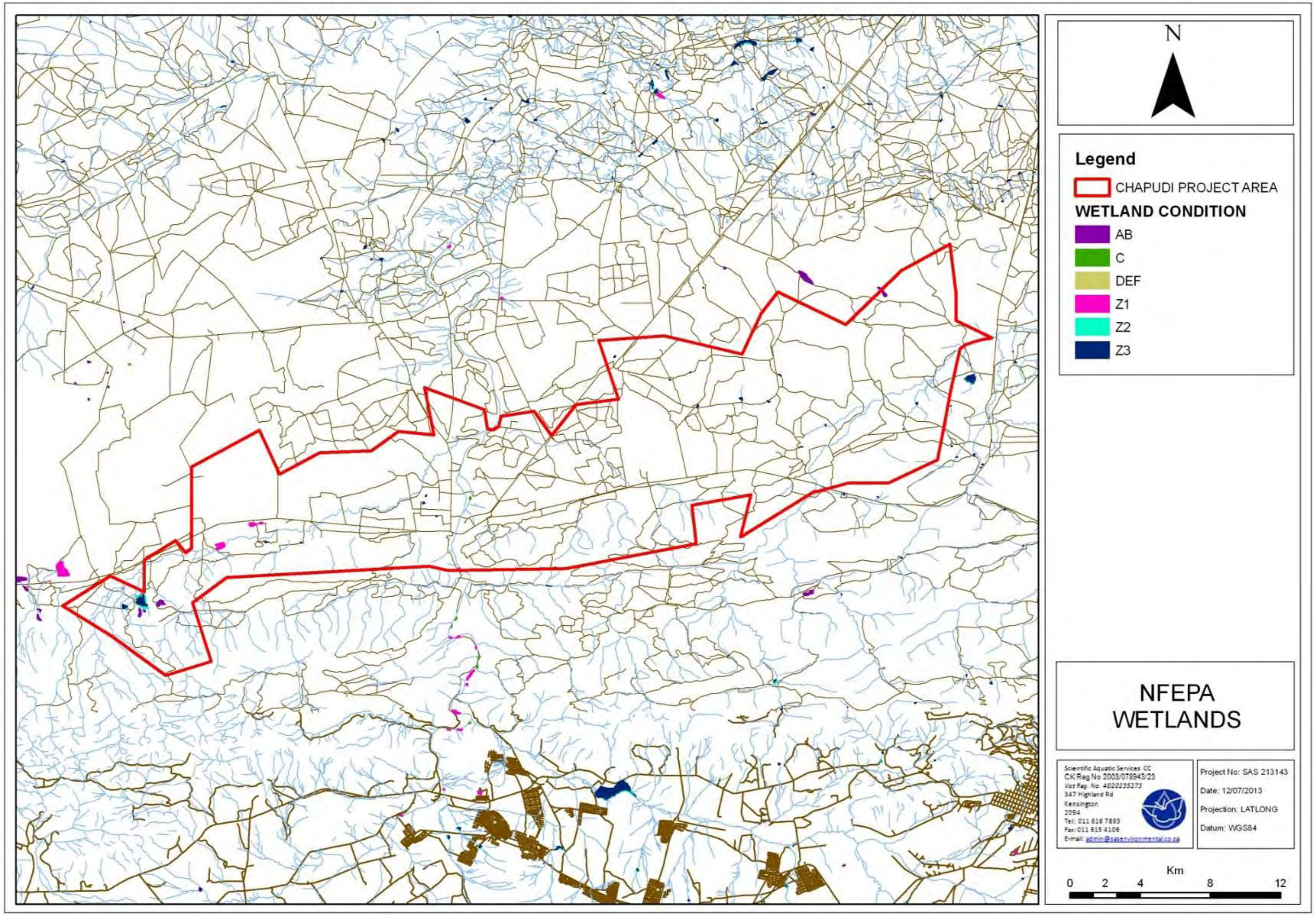

Figure 12: NFEPA wetland conditions within the Chapudi Project Area.

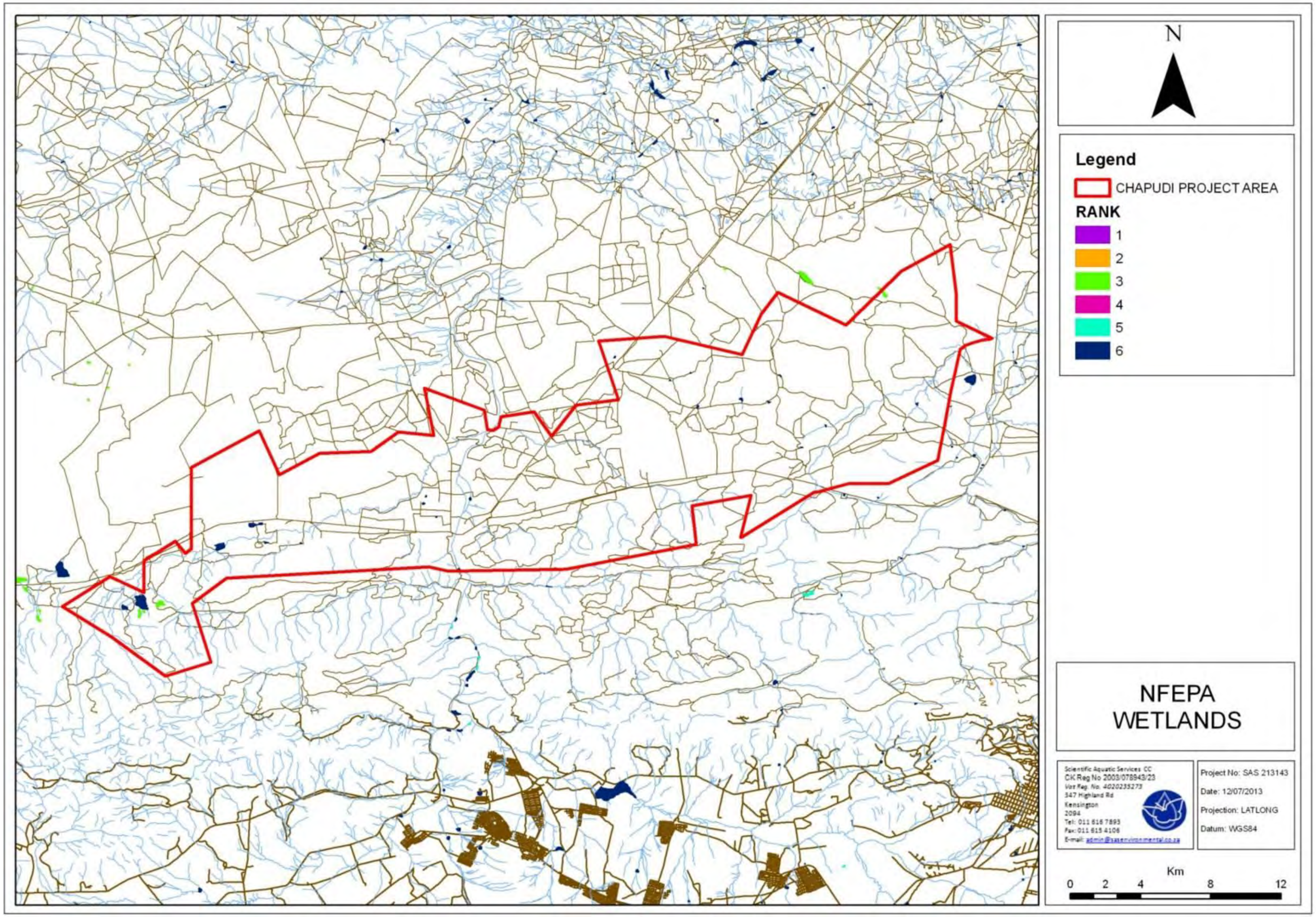

Figure 13: NFEPA wetland ranks within the Chapudi Project Area.

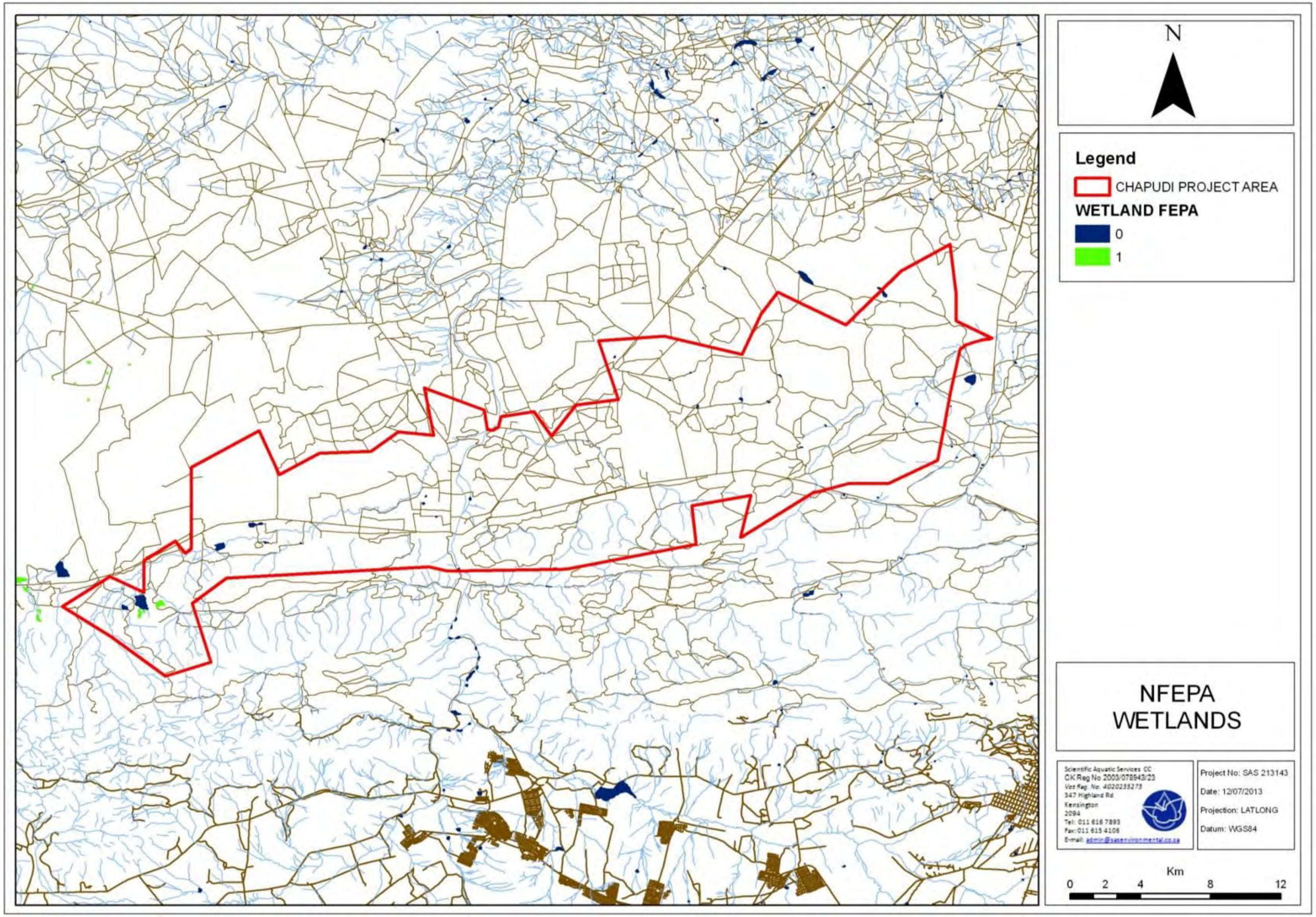

Figure 14: **Wetland FEPAs within the Chapudi Project Area.**

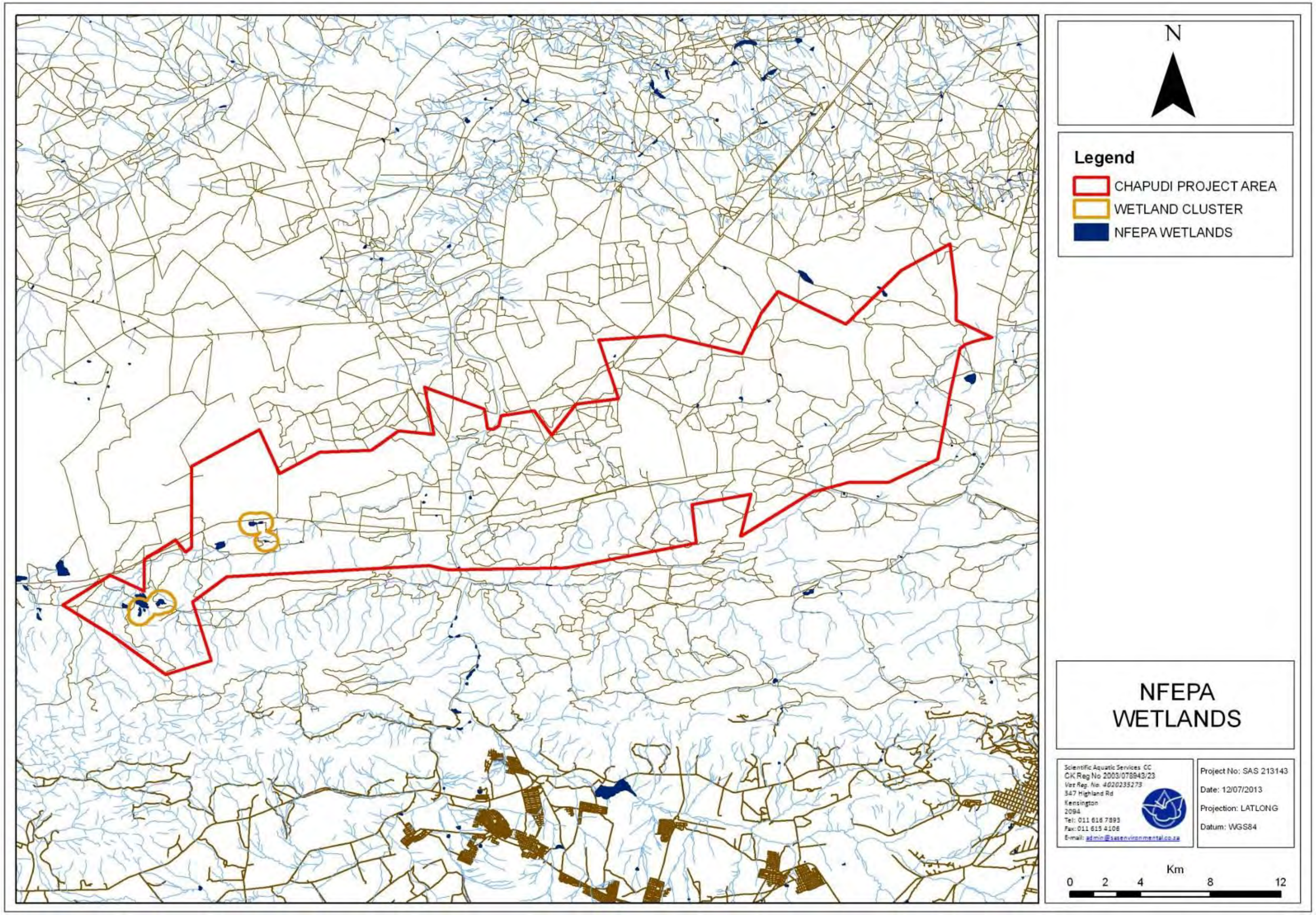

Figure 15: Wetland clusters within the Chapudi Project Area.

4 WETLAND ASSESSMENT SITE SELECTION RESULTS

Due to the extent of the study area as well as restricted access to many farms, with special mention of the western area of the project, sites considered to be representative of the characteristics of the features within the study area were selected. 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 features. 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 was considered informative; and
    - Texture: with areas displaying various textures, created by varying vegetation cover and soil conditions being identified.

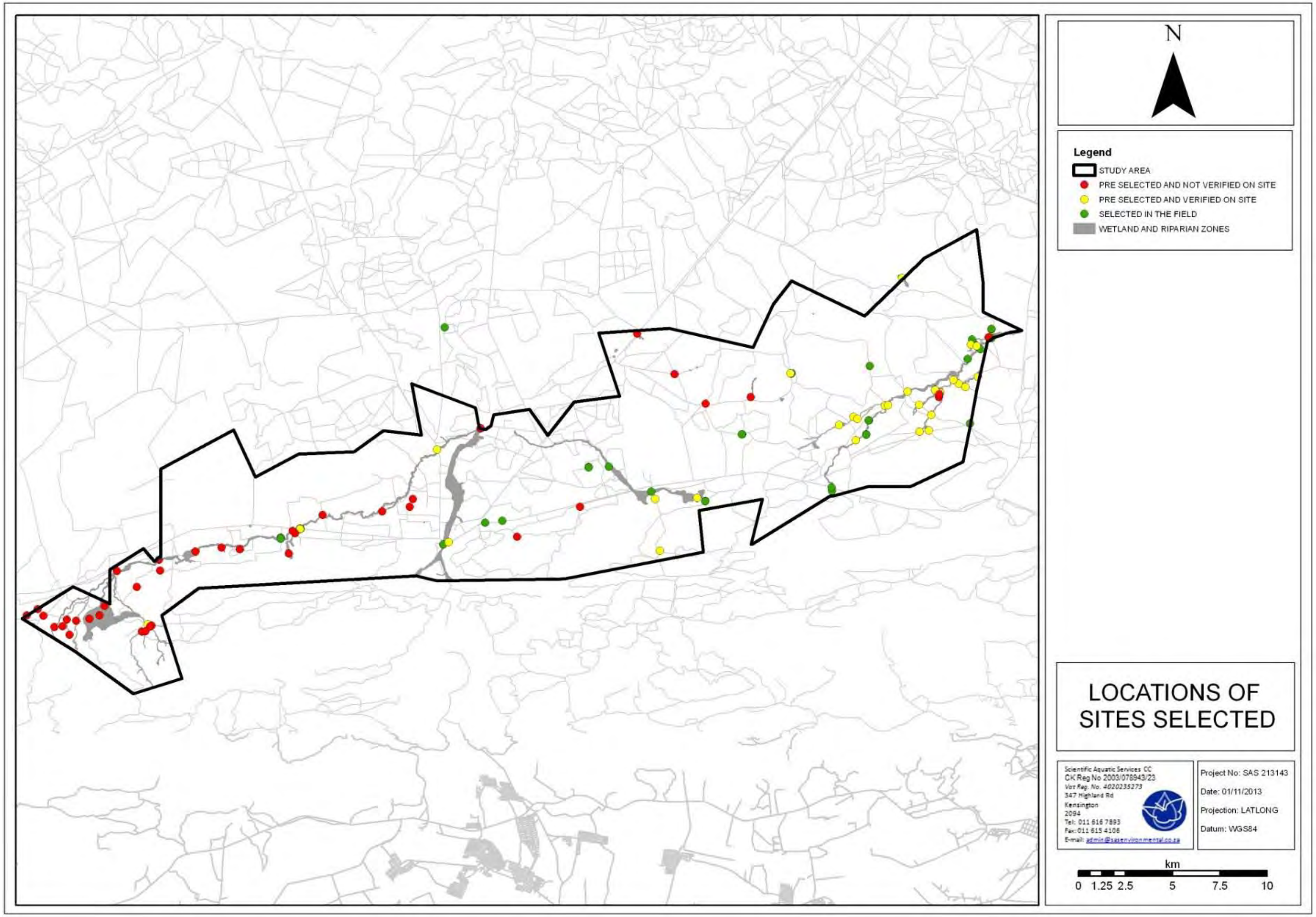

Figure 16: Areas of interest selected for assessment during the field survey.

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 (GSPC W1, GSPC W2, GSPC W3 and smaller pans), rivers (Sand River, Mutamba River and Moleletsane Stream) and smaller drainage lines. Within the area several artificial earth dams were also observed, some of which are perennial with others that only seasonally or ephemerally hold surface water and support vegetation adapted to life in saturated soils. The results of the classification of the systems are illustrated in the tables below.

Table 20: Classification for 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.	Endorheic.

Table 21: Classification for the Rivers (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 22: 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

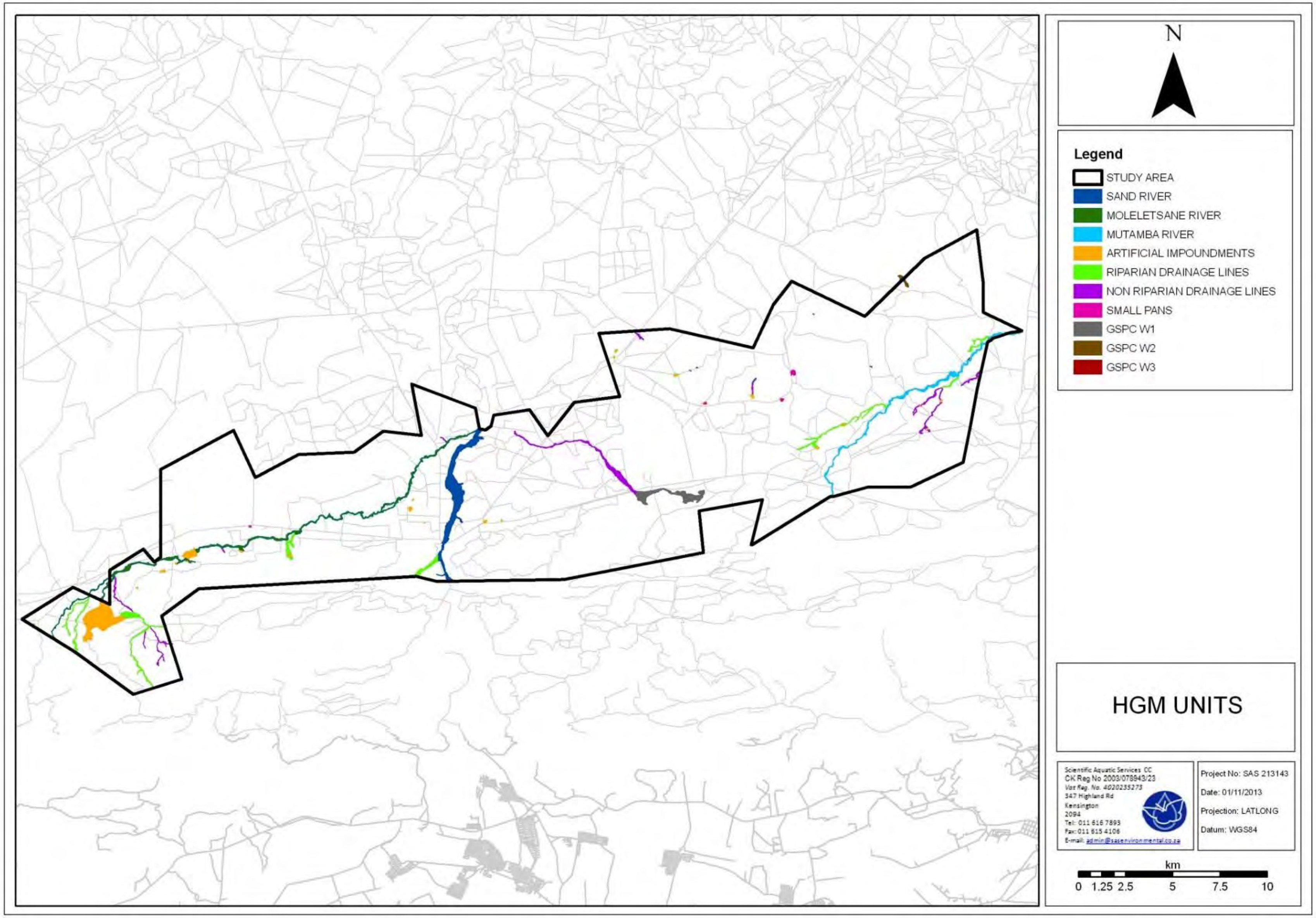

Figure 17: Locations of the wetland types in relation to the study area.

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, Mutamba River and Moleletsane Stream) were defined as systems containing 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 defined as systems with riparian habitat. The 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 ephemeral drainage lines.

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. The artificial impoundments that contained surface water observed in the area were located on portions of the study area where access was restricted and therefore no site specific assessment of these systems could take place. Some general inferences are, however, presented based on regional information on permanently inundated artificial impoundments as well as the GSPC W1 pan.

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

Three main river systems namely the Sand River, Mutamba River and Moleletsane Stream flow through the study area with numerous tributaries and drainage lines also identified throughout the study area.

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 18: **Sand River.**

Figure 19: **Mutamba River.**

Figure 20: **Moleletsane Stream.**

5.1.1 Terrain Units

The sandy nature of the soil within the region, makes 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 Sand River and Mutamba River showed significant incision and obvious stream banks.

5.1.2 Soil

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 and the runoff received by the system. Water movement for prolonged periods has resulted in leaching of soil components such as iron and manganese from the soil resulting in alluvial sands with a low chroma. A distinct increase in chroma is evident on the banks where significantly less leaching has taken place and where soil material is more related to the local parent material and less associated with alluvium washed in from areas further upstream.

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.

Abundance and diversity of vegetation were assessed at each site selected for a river system giving attention to zonation of the wetland assessment. 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 Mutamba River hosted *Cyperus spp*. and *Phragmites australis* (common reed) not identified within any of the marginal zones of the other smaller river systems. Both these taxa are obligate wetland/riparian floral species and are therefore adapted to the anaerobic soil conditions found within the active channel of larger river systems. Therefore their presence is directly related to the availability of baseflow within a system for the largest part of the year. The additional permanent and seasonal habitat provided by the Sand River and Mutamba River do increase the importance of both systems in terms of wetland biodiversity. 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 may occur. 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 ongoing and/or increased abstraction.

Figure 21: Alluvial soil within the active channel of rivers.

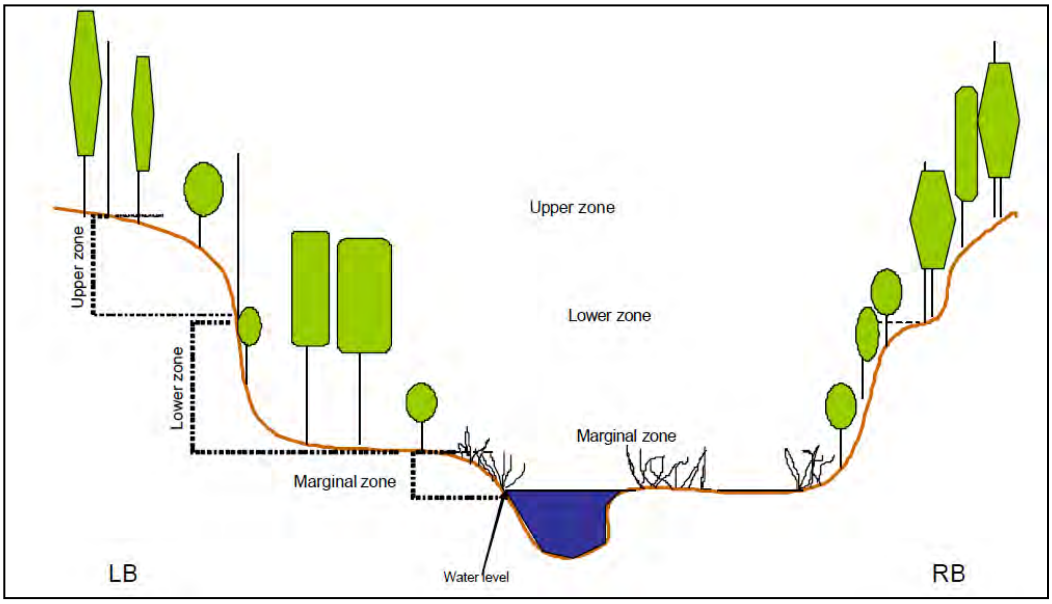

Figure 22: Cross sectional sketch[10] of a river system and associated riparian zone.

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 Mutamba River.

[10] Kleynhans et al., 2007

Table 23: 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 clusterleaf)	*Heliotropium sp.*	
Ziziphus mucronata (Buffalothorn)		
Combretum mossambicense (Kobbly creeper)		
Sclerocarya birrea subsp. *Caffra* (Marula)		
Euclea undulata (Common guarri)		
Grewia bicolor (White raisin)		
Gymnosporia senegalensis (Red spike thorn)		
Combretum imberbe (Leadwood)		
Xanthocercis zambesiaca (Nyala tree)		
Searsia lancea (Karree)		

5.1.3.1 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 23: From left to right: Lower areas on the Sand River (Aquatic assessment point GSP3 on the upper boundary of the proposed Mopane Project); Middle of the Mopane Project (GSP2); downstream boundary of the Mopane project (GSP1).

Figure 24: Two sites assessed on the Sand River downstream of the Chapudi Project area (GSP4 left and upstream of the project area GSP6 right).

Table 24: VEGRAI Ecological Category Description Scores for the Sand River.

Name	VEGRAI %	EC	Definition
GSP1	54%	D	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.
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.
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.

Name	VEGRAI %	EC	Definition
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, provides a significant volume of the water used for agriculture and in some instances domestic water. As a result water quantity in the river, both as baseflow and surface flow 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.

The data obtained on the Sand River also clearly indicates that there is a reduction in Riparian vegetation community integrity in a downstream direction on the Sand River. In the upper reaches the system can be defined as being largely natural while towards the lower reaches of the system the system is considered to have a moderately modified riparian zone and the lowest point can be defined as having as largely modified riparian zone.

5.1.3.1.2 Mutamba River

Figure 25: Representative points on the Mutamba River.

Table 25: VEGRAI Ecological Category Description Scores for the Mutamba River.

Name	VEGRAI %	EC	Definition
GSP 9	87%	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.
GSP 10	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.
GSP 11	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.
GSP 12	88%	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.
GSP 13	69%	C	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
Mean	83%	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.

Agriculture near the Mutamba River is not as extensive as it is along the Sand River and therefore the riparian vegetation has remained largely untransformed for the majority of the points assessed. 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 lower score calculated at GSP 13 is as a result of agriculture in the immediate surroundings, that resulted in an increase in non woody species and a significant loss of tree diversity within the riparian zone and the presence of some alien forbes. It is also considered highly likely that the water abstracted from along the river for agricultural purposes, leads to increasing stress on the riparian zone in a downstream direction.

5.1.3.1.3 Moleletsane Stream

Figure 26: Upper reaches of the Moleletsane stream.

Two points were assessed along the Moleletsane stream considered representative of areas with extensive agriculture and one within a less disturbed area.

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

Point	VEGRAI %	EC	Definition
Lower Moleletsane Stream	87 %	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.
Upper Moleletsane Stream	57%	D	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.
Mean	72%	C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.

The mean percentage calculated indicates the Moleletsane Stream as a class C (moderately modified) system. The Moletsane River however showed a significant degree of variation between the areas upstream and downstream of the R523. Areas upstream (south of the R523 were significantly more impacted than the areas downstream of the R523. The most significant impacts in the upstream areas were alien vegetation encroachment and vegetation removal.

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 Mutamba River. Evidence of faunal species burrowing for water was also encountered and indicates substantial sub-surface flow within these features during the drier months. Such sub-surface flow increases 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 Moleletsane Stream, this system and similar 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 Mutamba River, the Moleletsane Stream 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, 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], have been identified within seasonally rain filled depressions within wetlands of neighbouring 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 the Sand River should remain in a good condition in order to contribute to national biodiversity goals and support sustainable

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

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.

The Mutamba River is not defined as a FEPA river and neither is the Nzhelele River of which the Mutamba river is a major tributary.

5.1.6 Wetland Function Assessment

The function and service provision was calculated for the Sand River, Mutamba River and the Moleletsane Stream 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 27: Wetland service and function assessment.

Ecosystem service	Sand River	Mutamba River	Moleletsane Stream
Flood attenuation	1.8	1.8	1.4
Streamflow regulation	2.5	1.5	1.2
Sediment trapping	3	3	3.2
Phosphate assimilation	2.1	1.8	2.2
Nitrate assimilation	2.2	1.6	1.6
Toxicant assimilation	2.1	2	2
Erosion control	2	1.7	2
Biodiversity maintenance	3.2	2.6	2.6
Carbon Storage	1	1.3	0.6
Water Supply	3.6	2.8	0.8
Harvestable resources	0	0	0
Cultural value	0	0	0
Cultivated foods	0	0	0
Tourism and recreation	3.1	2.8	2.8
Education and research	2.5	2.7	2.7
SUM	**29.1**	**25.6**	**23.1**
Average score	**1.9**	**1.7**	**1.5**

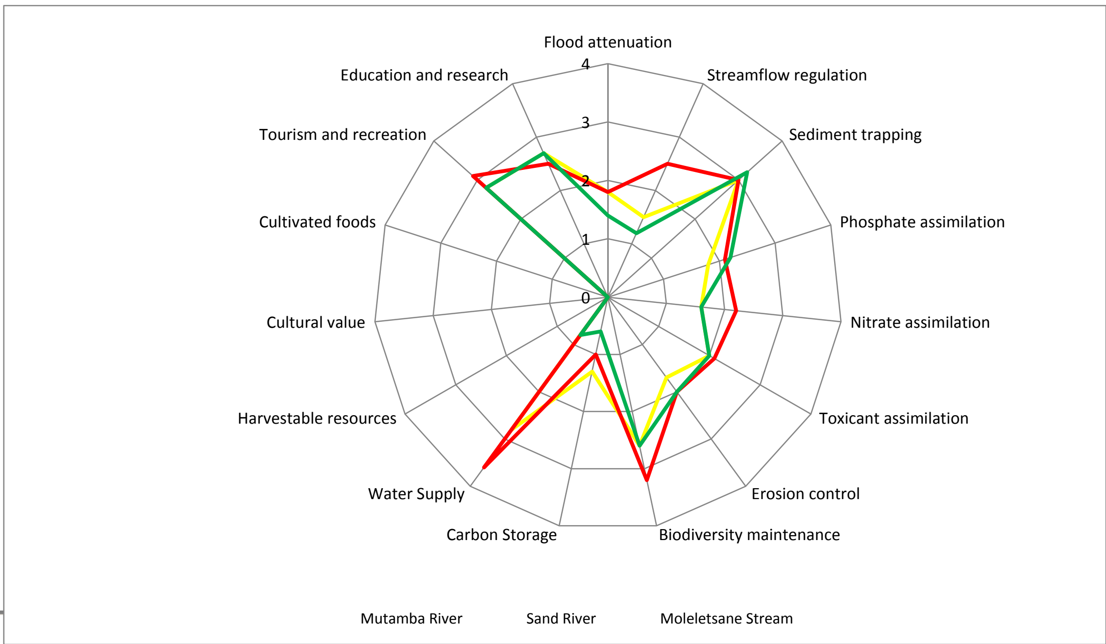

Figure 27: Radar plot of wetland services.

All the features are considered to be of intermediate importance in terms of wetland function and service provision. From the table and figure it is however evident that the systems in the area are most important in terms of ecological service provision. In this regard specific mention is made of sediment trapping and biodiversity maintenance. The most significant socio-services of the systems are the provision of surface water as well as recreation and tourism and tourism and research. From the figure is evident that the Sand River and the Mutamba River have similar levels of importance in terms of ecological service provision while the Mutamba River generally has a lower importance.

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 Mutamba River

Table 29: GSP 8

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	Confidence Rating	PES Category
DRIVING PROCESSES:		100	0.3		
Hydrology	1	100	0.4	2.7	A
Geomorphology	2	80	0.4	2.9	A/B
Water Quality	3	30	0.0	3.9	A
WETLAND LANDUSE ACTIVITIES:		80	0.2	3.1	
Vegetation Alteration Score	1	100	0.2	3.1	A
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					
OVERALL SCORE:			0.3	Confidence Rating	
	PES %		94.6		
	PES Category:		A	1.4	

Table 30: GSP 9

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.8**		
Hydrology	1	100	1.3	*2.7*	**C**
Geomorphology	2	80	0.4	*2.9*	**A/B**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.2**	***3.1***	
Vegetation Alteration Score	1	100	0.2	*3.1*	**A**
OVERALL SCORE:			**0.5**	***Confidence Rating***	
	PES %		**89.3**		
	PES Category:		**A/B**	***1.4***	

Table 31: GSP 11

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.8**		
Hydrology	1	100	0.6	*2.8*	**A/B**
Geomorphology	2	80	1.4	*2.9*	**C**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.2**	***3.1***	
Vegetation Alteration Score	1	100	0.2	*3.1*	**A**
OVERALL SCORE:			**0.6**	***Confidence Rating***	
	PES %		**88.6**		
	PES Category:		**A/B**	***1.4***	

Table 32: GSP 12

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.5**		
Hydrology	1	100	0.7	*2.7*	**B**
Geomorphology	2	80	0.4	*2.9*	**A/B**
Water Quality	3	30	0.0	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.0**	***3.0***	
Vegetation Alteration Score	1	100	0.0	*3.0*	**A**
OVERALL SCORE:			**0.3**	***Confidence Rating***	
	PES %		**94.2**		
	PES Category:		**A**	***1.3***	

Table 33: GSP 13

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.8**		
Hydrology	1	100	0.6	*2.8*	**A/B**
Geomorphology	2	80	1.4	*2.9*	**C**
Water Quality	3	30	0.1	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.9**	***3.3***	
Vegetation Alteration Score	1	100	0.9	*3.3*	**B**
Weighting needs to consider the sensitivity of the type of wetland *(e.g.: nutrient poor wetlands will be more sensitive to nutrient loading)*					
OVERALL SCORE:			**0.8**	***Confidence Rating***	
	PES %		**83.1**		
	PES Category:		**B**	***1.5***	

The average score calculated for the Mutamba River with the use of the IHI, indicates that the feature can be considered to fall within PES Category A (Unmodified). 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 Mutamba River 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 Moleletsane Stream

Table 34: Moleletsane Stream IHI

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	Weighting	Score	*Confidence Rating*	PES Category
DRIVING PROCESSES:		**100**	**0.5**		
Hydrology	1	100	0.4	*2.7*	**A**
Geomorphology	2	80	0.9	*2.9*	**B**
Water Quality	3	30	0.0	*3.9*	**A**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.8**	***3.4***	
Vegetation Alteration Score	1	100	0.8	*3.4*	**B**
OVERALL SCORE:			**0.6**	***Confidence Rating***	
	PES %		**87.2**		
	PES Category:		**B**	***1.5***	

The average score calculated for the Moleletsane Stream with the use of the IHI, indicates that the feature can be considered to fall within PES Category 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.

5.1.8 Conclusion

After the assessment it can be concluded that the riverine resources are of significant importance in terms of function and service provision with special mention of biodiversity as well as water provision to farmers within a water stressed region. Game farming is also the present land use of the majority of the farms investigated with limited areas utilised for crop cultivation, consequently the river systems have remained largely undisturbed and are therefore important in terms of biodiversity value. The Sand River and the Nzhelele River, of which the Mutamba River is a major tributary, have 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 and Mutamba Rivers 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 significantly impact on the Moleletsane River, Sand River and Mutamba River. 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 Mutamba River. 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 in the aquifers associated with these water courses, 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 adverse impacts on the ecology of the area. The Sand and Mutamba rivers 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 refugia 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, as a result of the project, 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 on the Sand River and a moderate to high risk on the Mutamba River. Alternatives should thus 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 which would affect these water courses.

5.2 Smaller Drainage Lines

The Chapudi project area had a low drainage density in relation to areas further to the north of the Soutpansberg mountain range. However, 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 for watering of livestock and game. Within the Chapudi project area, however these features cannot be defined as wetland features

Features resembling drainage lines were also encountered, however many of these features were considered to be mainly as a result of roads or other anthropogenic activity that canalised streamflow and consequently resulted in erosion canals being formed and cannot be defined as true wetland or riparian features.

Figure 28: Example of a drainage line within the study area.

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 results from the sandy nature of the soil that is prone to erosion during rainfall events.

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. This is 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. Soils in riparian systems had a characteristically clear alluvial substrates.

5.2.3 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 35: 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 clusterleaf)	*Panicum maximum* (Guinea grass)
Sclerocarya birrea subsp. *Caffra* (Marula)	
Acacia karroo (Sweet thorn)	
Ziziphus mucronata (Buffalothorn)	
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 36: 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 early spring. 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. Amphibians and waterfowl may however opportunistically utilise these systems in times of increased rainfall.

Furthermore, these features provide 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 37: 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**

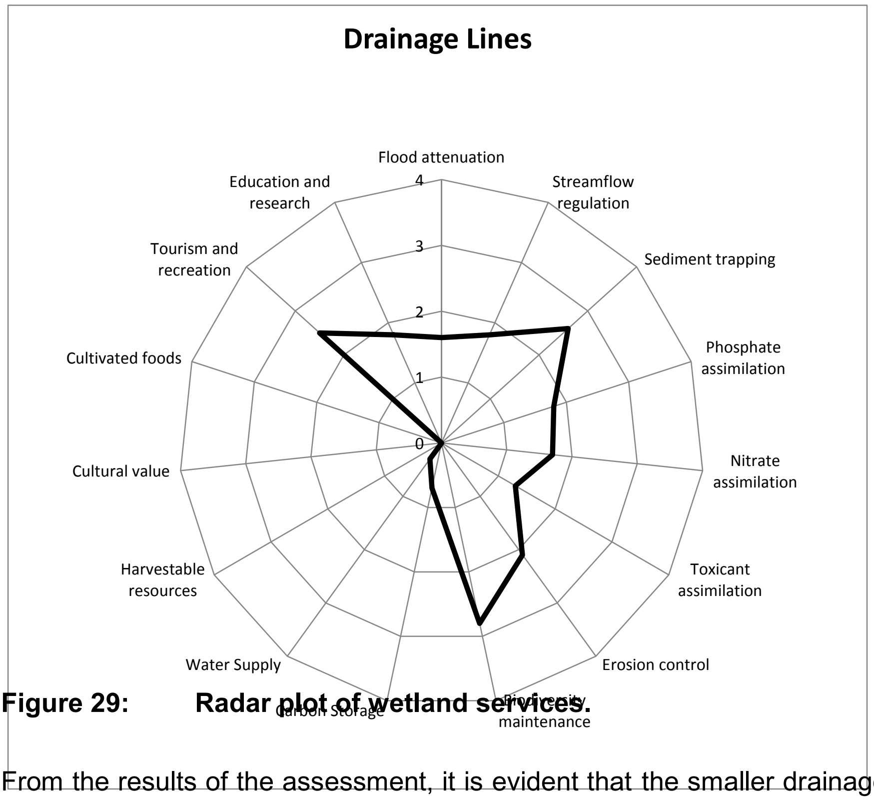

Figure 29: Radar plot of wetland services.

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 surface 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 Index of Habitat Integrity (IHI)

Table 38: 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.

5.2.8 Conclusion

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 agriculturally 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 limited levels of 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 Black Stone Edge Depression

A significant wetland depression feature was encountered on the farm Black Stone Edge. This feature was considered of increased EIS and was therefore assessed separately from other depressions identified within the study area. The wetland was referred to as GSPC W1.

5.3.1 Terrain Units

Although the wetland assessed shows very poor connectivity to a non-riparian drainage line, the HGM unit assessed was best defined as a depression (Ollis *et al*., 2013). The feature is located at the foot of the Soutpansberg mountain range and during rainfall events runoff from the range will recharge the system. An elevated ridge located on the northern side of the wetland feature limits outflow of surface water to the remainder of the system, as a result retaining sufficient water volumes to allow for the formation of wetland habitat. It has been reported by local farmers that after rainfall events there is an increase in the number of artisanal springs which lead to pans with surface water, some of which persist perennially in years of good rainfall. Therefore the unique wetland habitat mainly persists due to the unique topography of surrounding areas. The GSPC W1 is considered a unique feature in the area and potentially supports a diverse and relatively unique aquatic, wetland and terrestrial ecology. In this regard specific mention is made of the sparsely wooded *Terminalia prunioides* (lowveld cluster leaf) shrubland as well as high densities of trees such as *Spirostachys africana* (Tambotie)*, Xanthocercis zambesiaca* (Nyala) *and Schotia brachypetala* (boer bean). The system also provides ideal habitat for a diversity of amphibians including common species such as *Amietophrynus gutturalis* (gutteral toad) and more ecologically important species such as *Pyxicephalus adspersus* (giant bullfrog).

5.3.2 Soil

Figure 30: Soil profile and vegetation at the Black Stone Depression.

The soil samples within the area investigated did not show any signs of hydromorpy. However, the presence of both wetland floral species such as *Setaria verticillata; Cynodon dactylon and Urochloa mosambicensis* as well as surface water do indicate that water is present within the feature for long enough for the formation of wetland conditions. The lack of soil indicators as defined by DWA (2005) is most likely as a result of the sandy nature of the soil that would allow for the rapid vertical flow of water which is only retained near the surface, where springs have formed.

5.3.3 Vegetation

The permanent zone of the wetland feature was either dominated by grass or lacked vegetation completely. The abundance of *Terminalia prunioides* increased significantly between the temporary and terrestrial transition zone.

According to Bredenkamp (2009) this system, contains exceptionally sweet veld and is utilised for grazing. The herbaceous layer is quite bare, due to the brackish soils and sweet grazing, and is considered to be ecologically highly sensitive. The woody layer is well developed, containing several woody species. Bredenkamp (2009) further noted that this system does not have a high species richness, but some of the species are restricted to this area. The overall wetland vegetation community was considered largely undisturbed within the majority of the feature, except where present sand mining activities are taking place that has resulted in a decrease of indigenous species.

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 39 below, and includes the terrestrial species identified near the wetland zones.

Table 39: Dominant floral species identified during the assessment of the GSPC W1.

Terrestrial zone	Seasonal	Temporary	Permanent
Colophospermum mopane (Mopane)	*Terminalia prunioides* (Lowveld clusterleaf)	*Cynodon dactylon* (Couch grass)	*Setaria verticillata* (Bur Bristle grass)
Terminalia prunioides (Lowveld clusterleaf)	*Spirostachys africana* (Tambotie),	*Panicum maximum* (Guinea grass)	*Cynodon dactylon* (Couch grass)
Ziziphus mucronata (Buffalo thorn)	*Xanthocercis zambesiaca* (Nyala)	*Urochloa mosambicensis (bushveld signal grass)*	*Panicum maximum* (Guinea grass)
Euclea undulate (Common guarri)	Schotia brachypetala (boer bean).		*Urochloa mosambicensis (bushveld signal grass)*
Grewia flava (velvet raisin)	*Cynodon dactylon* couch grass)		
Acacia nigrecens (Knob thorn)	*Urochloa mosambicensis (bushveld signal grass)*		
Dichrostachys cinerea (Sickle bush)			

5.3.4 Surface Water

Figure 31: Surface water in the GSPC W1 wetland.

The feature is located at the foot of the Soutpansberg mountain range and during rainfall events runoff from the range will recharge the system. An elevated ridge located on the northern side of the wetland feature limits outflow of surface water to the remainder of the system, as a result retaining sufficient water volumes to allow for the formation of wetland habitat. It has been reported by local farmers that after rainfall events there is an increase in the number of artisanal springs which lead to pans with surface water, some of which persist perennially in years of good rainfall.

5.3.5 Biodiversity

The unique wetland habitat mainly persists due to the unique topography of surrounding areas. The GSPC W1 is considered a unique feature in the area and potentially supports a diverse and relatively unique aquatic, wetland and terrestrial ecology. GSPC W1 is considered the most important wetland habitat within the study area. The surface water that remains for extended periods throughout the year provides drinking water for terrestrial faunal species as well as breeding habitat for aquatic invertebrates, avifuana and amphibians. Furthermore specific mention is made of the sparsely wooded *Terminalia prunioides* (lowveld cluster leaf) shrubland as well as high densities of trees such as *Spirostachys africana* (Tambotie), *Xanthocercis zambesiaca* (Nyala) *and* Schotia brachypetala (boer bean). The system also provides ideal habitat for a diversity of amphibians including common species such as *Amietophrynus gutturalis* (gutteral toad) and more ecologically important species such as *Pyxicephalus adspersus (*giant bullfrog). Other species of conservation concern observed in the vicinity of these wetland features include *Metacatharsius sp. (cf. transvaalensis)* (Tribe: Coprini, dung beetle); African wildcat (*Felis silvestris*) and brown hyena (*Hyaena brunnea*).

P. adspersus species is listed as Least Concern by the IUCN (2013) because, although it is losing breeding habitat in places due to urbanisation and it is also consumed by humans in parts of its range, it has a wide distribution, is tolerant of a broad range of habitats, has a presumed large population and is unlikely to be declining fast enough to qualify for listing in a more threatened category (IUCN, 2013). Although it is common in many of the southern parts of its range, it has apparently declined in South Africa, especially in Gauteng Province, but it is still locally common in some places (IUCN, 2013). *P. adspersus* is a species of drier savannahs and is fossorial for most of the year, remaining buried in cocoons (Carruthers, 2001). They emerge at the start of the rainy season, and breed in shallow, temporary waters in pools, pans and ditches (Cook, 1996). They are active by day during the breeding season and can travel vast distances in search of undisturbed wetlands for better breeding conditions. Therefore, mining of GSPC W1 are likely to result in loss of habitat for this species and if migratory connectivity is not catered for during the layout of the mining infrastructure, would most likely result in impact on individuals that need to migrate during the breeding season.

5.3.6 Wetland Function and Service Provision

The function and service provision was calculated for GSPC W1 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 40: Wetland service and function assessment.

Ecosystem service	GSPC W1
Flood attenuation	1.4
Streamflow regulation	0
Sediment trapping	1.4
Phosphate assimilation	1.6
Nitrate assimilation	2
Toxicant assimilation	1.8
Erosion control	2
Biodiversity maintenance	3.2
Carbon Storage	1.6
Water Supply	2
Harvestable resources	1.4
Cultural value	0
Cultivated foods	0
Tourism and recreation	2.8
Education and research	2.5
SUM	**25.4**
Average score	**1.7**

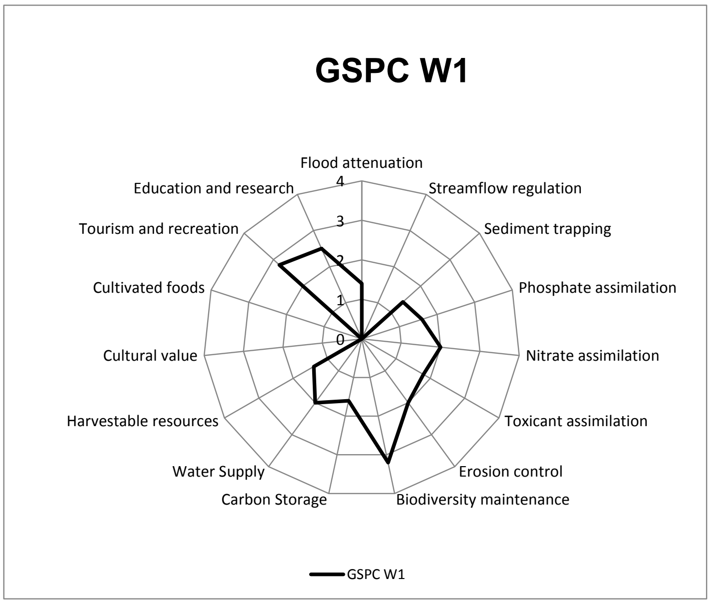

Figure 32: Radar plot of wetland services.

GSPC W1 can be considered of intermediate importance in terms of function and service provision. The highest score calculated was for biodiversity maintenance due to provision of habitat for several aquatic faunal and floral species as well as provision of drinking water for terrestrial faunal species.

Due to the feature being a depression and therefore hydrologically isolated the HGM unit will not be in a position to augment streamflow. The system does have some function in cycling of nutrients. The system has limited importance in terms of harvestable resource provision and water supply. The system has limited importance for tourism and related activities.

GSPC W1 has remained largely undisturbed, with the exception of areas presently used for mining of sand. The system generally can be considered to provide a low level of socio-cultural services.

5.3.7 Wet-Health

The Wet-Health of GSPC W1 was assessed with the method provided in section 2.5, Results are presented in the table below. During the site assessment it was evident that the wetland vegetation has remained intact for the larger extent of the feature with the most significant impact being as a result of sand mining activity within the western portion. Change of the natural hydrological regime will also be restricted to areas where mining has taken place. As a result, of the habitat transformation associated with the mining activity, the scores calculated for vegetation as well as the hydrology modules were lower than expected. However, it should be noted that the calculations take into consideration all impacts within a HGM unit, therefore the Category C would be representative of the overall vegetation and hydrology of GSPC W1. However, a Category B is expected within areas where less anthropogenic activity has taken place. Due to ongoing sand mining, the vegetation as well as the hydrology is expected to deteriorate substantially over the next 5 years.

The geomorphological module focusses on wetlands that are connected to a drainage network, as a result, present geomorphic state of GSPC W1, that was regarded to be representative of a depression, was not assessed.

Table 41: Summary of the overall health of GSPC W1 based on impact score and change score.

Feature type	Hydrology		Vegetation	
	Impact Score	Change Score	Impact Score	Change Score
Depression	C	↓↓	C	↓↓

5.3.8 Conclusion

The bulk of the mining support structure such as the plant ROM facilities and the associated pollution control facilities are planned in this area on the Black Stone Edge Farm. These activities in the area are likely to severely impact on the GSPC W1 wetland leading to the permanent destruction of the wetland features. Since the infrastructure in this area is not resource dependent, the infrastructure could be moved to an alternative location without compromising on the mining resource. Due to the unique nature of this feature and the biodiversity it supports, with special mention of the known presence of protected species and the high probability of occurrence of other species of conservation concern, it is strongly recommended that the infrastructure be moved from this area to an area which where these activities will have a significantly lower impact on wetland resources.

5.4 Depressions

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, most of the depressions encountered, could not be considered true wetland habitat and therefore were not investigated as part of the wetland assessment.

Several small earth dams were observed in the area on digital Satellite imagery. However, most were not accessible due to the restricted access on many farms. These small dams are generally used for irrigation and livestock watering. Although none of these dams were assessed during the field visit, based on observed conditions in the local region it can be expected that the dams will contain a relatively tolerant aquatic macro-invertebrate community

The aquatic biota of the impoundments in the area 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* being present. 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 likely to occur in the impoundments are *Oreochromis mossambicus* (blue kurper), and *Clarias gariepinus* (sharptooth catfish). Smaller barbs (introduced by waterfowl) may also possibly occur in some of the impoundments.

Natural depressions encountered within the study area that were considered wetland habitat included a large pan located on the northern boundary of the study area, referred to as „GSPC W2" below, smaller pans as well as a feature that resulted due to formation of an artesian well associated with a prospecting borehole referred to as „GSPC W3".

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Figure 33: GSPC W2, a large depression on the northern boundary of the study area (left) and a smaller depression with less developed characteristics (right).

Figure 34: GSPC W3 at a point where a prospecting borehole has led to the formation of an artesian well which in turn has created a small wetland.

5.4.1 Terrain Units

GSPC W2, GSPC W3 as well as smaller pans can be considered endorheic depressions.

5.4.2 Soil

The depressions hold water long enough for hydromorphic soil formation. 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.

5.4.3 Vegetation

Obligate and facultative wetland species were only identified within GSPC W3. GSPC W2 completely lacked a vegetation layer, except for the edges of the feature where grasses dominated followed by mopane veld higher up the in the sequence. The smaller pans were also generally devoid of vegetation cover and were surrounded by mopane veld.

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 42 below, and includes the terrestrial species identified near the wetland zones. Obligate as well as facultative wetlands species such as *Cyperus fastigiatus* (sedge) were the dominant species within permanent zones of wetland depressions and are therefore not related to pans.

Table 42: Dominant floral species identified during the assessment of the GSPC W2, GSPC W3 and smaller 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*	*Cyperus sexangularis*
Dichrostachys cinerea (Sickle bush)	*Grewia flava* (Velvet raisin)	*Panicum maximum* (Guinea grass)	*Cyperus esculentus*
	Colophospermum mopane (Mopane)		

5.4.4 Surface Water

The field assessment was undertaken during winter, therefore only GSPC W3 had surface water. The natural pans in the area are expected to be seasonally wet.

5.4.5 Biodiversity

Wetland depressions 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 dependent 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. The pans are generally devoid of vegetation cover in the seasonally inundated areas. The lack of vegetation reduces the ecological significance of these features. The lack of cover within the features also reduces the significance in terms of faunal conservation. Some faunal species may however utilise the larger pans for overnighting in order to avoid predators which can be spotted from longer distances away in the open landscape.

5.4.6 Wetland Function Assessment

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

Table 43: Wetland service and function assessment.

Ecosystem service	Smaller Pans	GSPC W3	GSPC W2
Flood attenuation	0.8	1.3	1.9
Streamflow regulation	0	0	0
Sediment trapping	0.2	0.2	0.4
Phosphate assimilation	1.5	1.3	1.3
Nitrate assimilation	1.6	2.5	1.6
Toxicant assimilation	1.3	1.3	1.1
Erosion control	1.5	1.6	1.5
Biodiversity maintenance	1.5	2.9	2.8
Carbon Storage	1	1	0.6
Water Supply	0	0.6	0
Harvestable resources	0	0	0
Cultural value	0	0	0
Cultivated foods	0	0	0
Tourism and recreation	0	0.7	1.8
Education and research	0	0	1.5
SUM	**9.4**	**13.4**	**14.5**
Average score	**0.6**	**0.9**	**1.0**

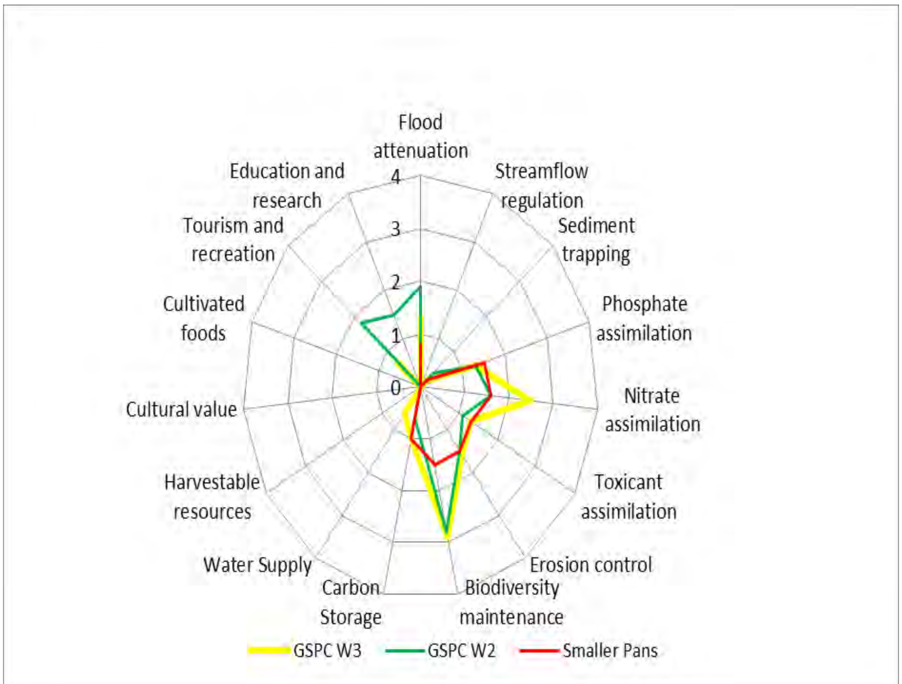


Figure 35: Radar plot of wetland services.

When considering the average scores for the groups it is evident that all depression features within the study area can be considered of moderately low importance in terms of service and function provision. GSPC W2 and GSPC W3 can be considered to be the most important in terms of biodiversity maintenance. Smaller pans were not considered as important in terms of biodiversity maintenance, mainly as result of size that would not retain water as long as GSPC W2 would.

Due to lack of year round surface water, GSPC W2 and smaller pans are not expected to be of any importance in terms of water supply or crop cultivation.

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.

5.4.7 Wet-Health

Due to perceived differences in hydrology and vegetation during the site assessment GSPC W2, GSPC W3 and smaller pans were assessed separately.

The geomorphological module focusses on wetlands that are connected to a drainage network, as a result, present geomorphic state of these features which are regarded as being representative of an endorheic depression, was not assessed.

Table 44: Summary of the overall health of the features based on impact score and change score.

Feature type	Hydrology		Vegetation	
	Impact Score	Change Score	Impact Score	Change Score
GSPC W2	B	↓↓	C	↓↓
GSPC W3	C	↓	A	↓
Smaller Pans	A	→	A	→

Past anthropogenic activity in the vicinity of both GSPC W2 and GSPC W3 resulted in change in the natural hydrological regimes as well as vegetation. Ongoing anthropogenic activity near both features is likely to result in further change of hydrology and vegetation in the next 5 years.

The limited amount of anthropogenic activity noted during the assessment within the immediate vicinity of the smaller pans resulted in the pans still being in a very high PES (unmodified, natural). If mining activity remains outside the allocated buffer zones no change is expected within the next 5 years.

5.4.8 Conclusion

GSPC W2 and GSPC W3 as well as smaller 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. 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.

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.

5.5 Synthesis

Sites selected with the use of desktop methods, were investigated during the field surveys undertaken in July and September 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 Mutamba River and to a lesser degree the Moleletsane Stream. The GSPC W1 wetland on the Black Stone Edge Farm is considered to be a depression feature of high ecological significance while all other depression features in the area are considered to be of lower significance;
- Wet-Health was used to determine the PES of the wetland depressions and pans within the study area. The pans have been impacted by anthropogenic activities, but can still generally be considered to be in good condition and are considered to be important in terms of biodiversity support in the area;

- 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, Mutamba River and the Moleletsane River. The Sand River can be defined as a Class C (moderately modified) system with the upper Mutamba river being less impacted in a Class A and B (natural to largely natural) range and the lower area slightly more modified in the Class C (moderately modified) and mean average scores calculated for the smaller drainage lines, fall within Class B (largely natural) category. The Moleletsane river was classified as a Class C (moderately modified) system

5.6 Ecological Importance and Sensitivity

The Wetland EIS determination method was applied according to the protocol of DWAF (1999). The aim of the application of this method is to clearly define the importance of each system. The wetland EIS was defined for each riverine system as well as the various wetland features identified within the subject property

Table 45: EIS determination for the various river systems on the subject property.

System	Sand River		Mutamba river		Moleletsane river		Smaller drainage lines	
Determinant	**Score**	**Conf**	**Score**	**Conf**	**Score**	**Conf**	**Score**	**Conf**
PRIMARY DETERMINANTS								
1. Rare & Endangered Species	2	2	2	2	1	2	1	2
2. Populations of Unique Species	3	3	2	2	1	3	1	2
3. Species/taxon Richness	2	2	2	2	2	2	2	2
4. Diversity of Habitat Types or Features	2	3	2	3	1	3	1	3
5 Migration route/breeding and feeding site for wetland species	3	3	3	3	2	3	1	3
6. PES as determined by WET-Health assessment*	3	3	3	3	3	3	4	3
7. Importance in terms of function and service provision	3	3	3	3	2	3	2	3
MODIFYING DETERMINANTS								
8. Protected Status according to NFEPA Wetveg	3	4	4	4	4	4	4	3
9. Ecological Integrity	3	3	3	3	2	3	3	2
TOTAL	**24**	**26**	**24**	**25**	**18**	**26**	**19**	**23**
MEDIAN	**2.7**	**2.9**	**2.7**	**2.8**	**2.0**	**2.9**	**2.1**	**2.6**
OVERALL EIS	**B**		**B**		**B/C**		**B**	

***WET IHI used in Place of WET Health**

Based on the findings of the study it is evident that from a wetland point of view, the EIS of the river systems are largely similar. All the systems can be defined as Class B systems indicating a high EIS. The Moleletsane River had the lowest EIS with a borderline (B/C) condition indicating a moderate to high EIS. When the aquatic ecology of the Sand River is considered, from where several assessment points are available it is evident that the aquatic ecology of the system is in a poorer condition than the wetland EIS assessment indicates. Based on the consideration of both the wetland EIS and the aquatic ecostatus indices, the most appropriate EIS for the upper reaches of the Sand River have been defined as a Class B system with the lower areas more likened to a Class D resource.

The wetland features within the subject property showed a more significant variation in the EIS. The GSPC W1 (Wetland on the Black Stone Edge Farm) had the highest EIS being defined as a Class A system, indicating a very high EIS.

The GSPC W2 and GSPC W3 wetlands had lower values (Class C) and can be defined as having a moderate EIS. The smaller natural depression wetlands were considered to have a high (Class B) EIS. The artificial wetlands formed through the construction of small earth dams were defined as having a borderline Class C/D EIS indicating a moderate to low EIS.

Table 46: EIS determination for the various wetland systems on the subject property.

System	GSPC W1		GSPC W2		GSPC W3		Smaller pans		Artificial impoundments	
Determinant	**Score**	**Conf**	**Score**	**Conf**	**Score**	**Conf**	**Score**	**Conf**		
PRIMARY DETERMINANTS										
1. Rare & Endangered Species	4	3	1	2	1	2	1	3	0	3
2. Populations of Unique Species	2	1	1	1	1	1	0	2	0	3
3. Species/taxon Richness	3	3	1	2	1	2	1	2	0	2
4. Diversity of Habitat Types or Features	3	3	2	3	1	3	2	3	2	3
5 Migration route/breeding and feeding site for wetland species	3	2	1	1	1	1	2	1	1	2
6. PES as determined by WET-Health assessment	3	2	2	2	2	2	4	2	3*	2
7. Importance in terms of function and service provision	3	3	2	3	2	3	2	3	2	1
MODIFYING DETERMINANTS										
8. Protected Status according to NFEPA Wetveg	4	4	4	4	4	4	4	3	4	3
9. Ecological Integrity	3	2	2	2	2	2	4	2	3*	2
TOTAL	28	23	16	20	15	20	20	21	9	21
MEDIAN	3.1	2.6	1.8	2.2	1.7	2.2	2.2	2.3	1.0	2.3
OVERALL EIS	**A**		**C**		**C**		**B**		**C/D**	

*** Estimated. No WET Health Applied**

5.7 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.

5.8 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 36: Terrain unit used as primary indicator and vegetation as the secondary indicator

Figure 37: Gleying evident within the soil profile of the smaller drainage lines with riparian zones (left); gleyed soils within the permanent zone of pans (right).

- 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 seasonal zones.

- 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.

- The field assessment was undertaken during the middle of winter, as a result no surface water was present in most systems except for the Sand River, Mutamba River and some of the artificial impoundments.

5.8.1 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, Matumbe River and Moleletsane 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 License 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 License will be required.

GSPC W1, GSPC W2 and GSPC W3 as well as smaller pans are considered wetland habitat, therefore a Water Use License 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.

5.8.2 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 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 to in terms of General Notice no. 1199.

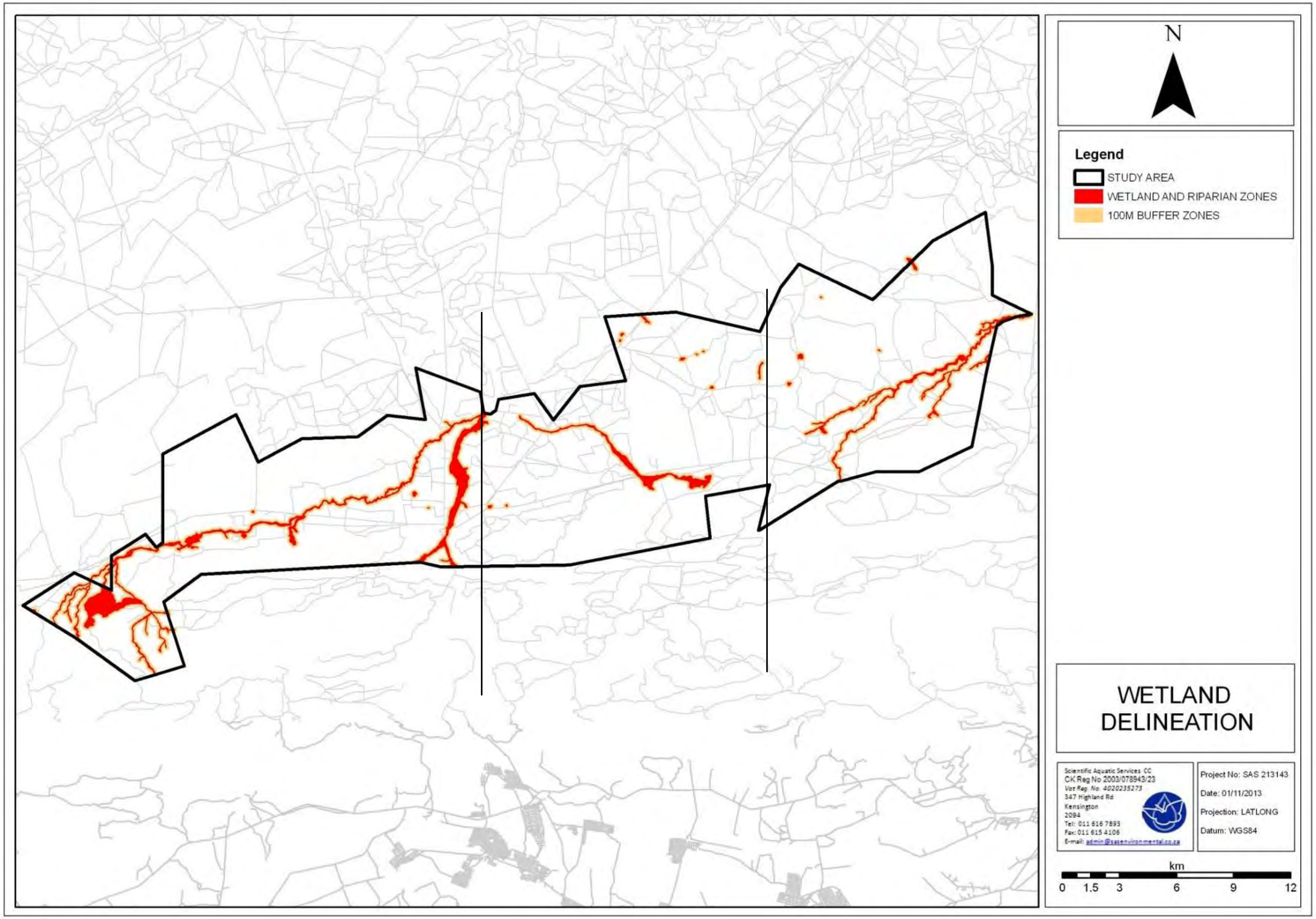


Figure 38: Allocated 100m buffer zones in relation to the study area.

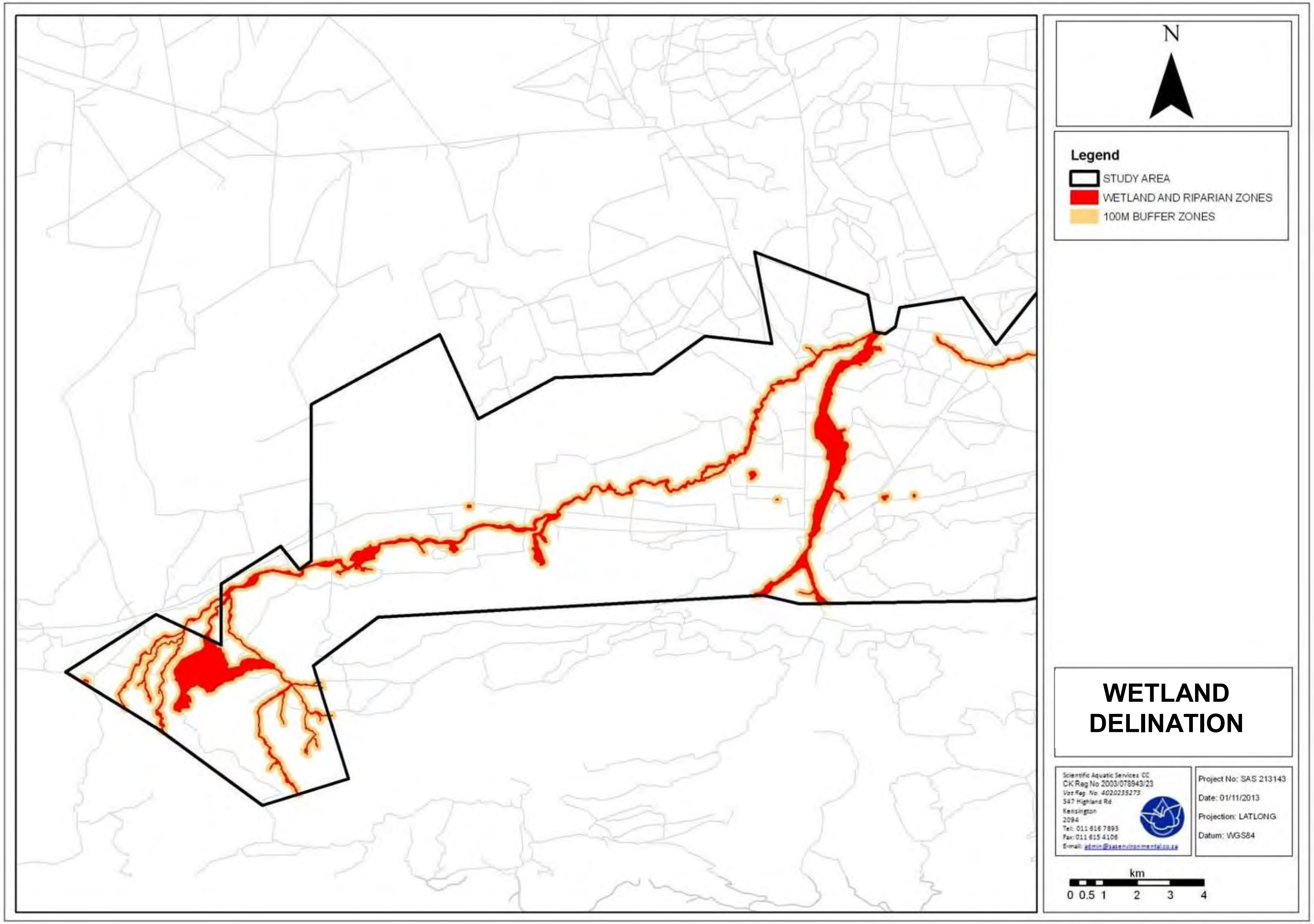


Figure 39: Allocated 100m buffer zones in relation to the Chapudi West section

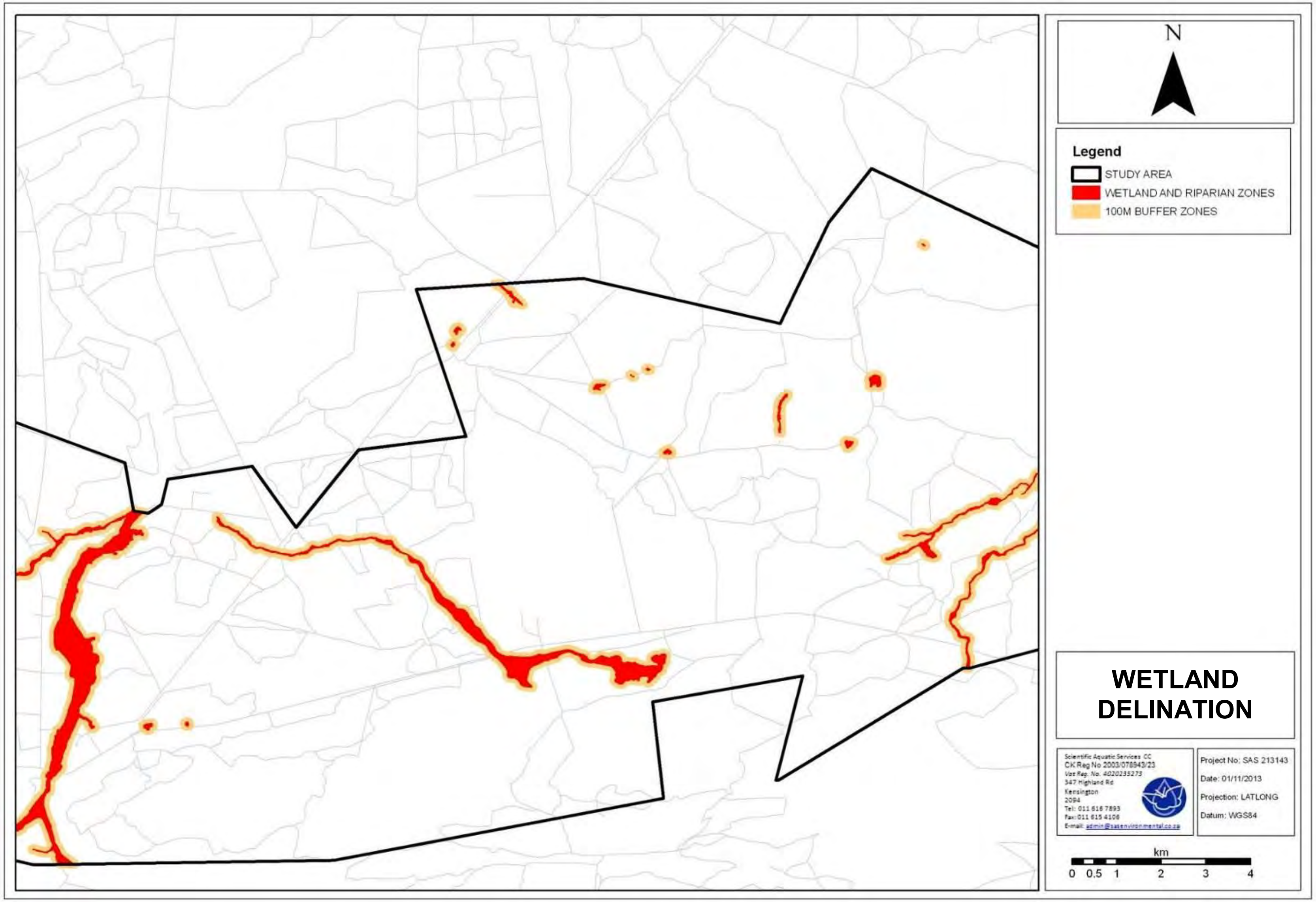


Figure 40: **Allocated 100m buffer zones in relation to the Chapudi Main section.**

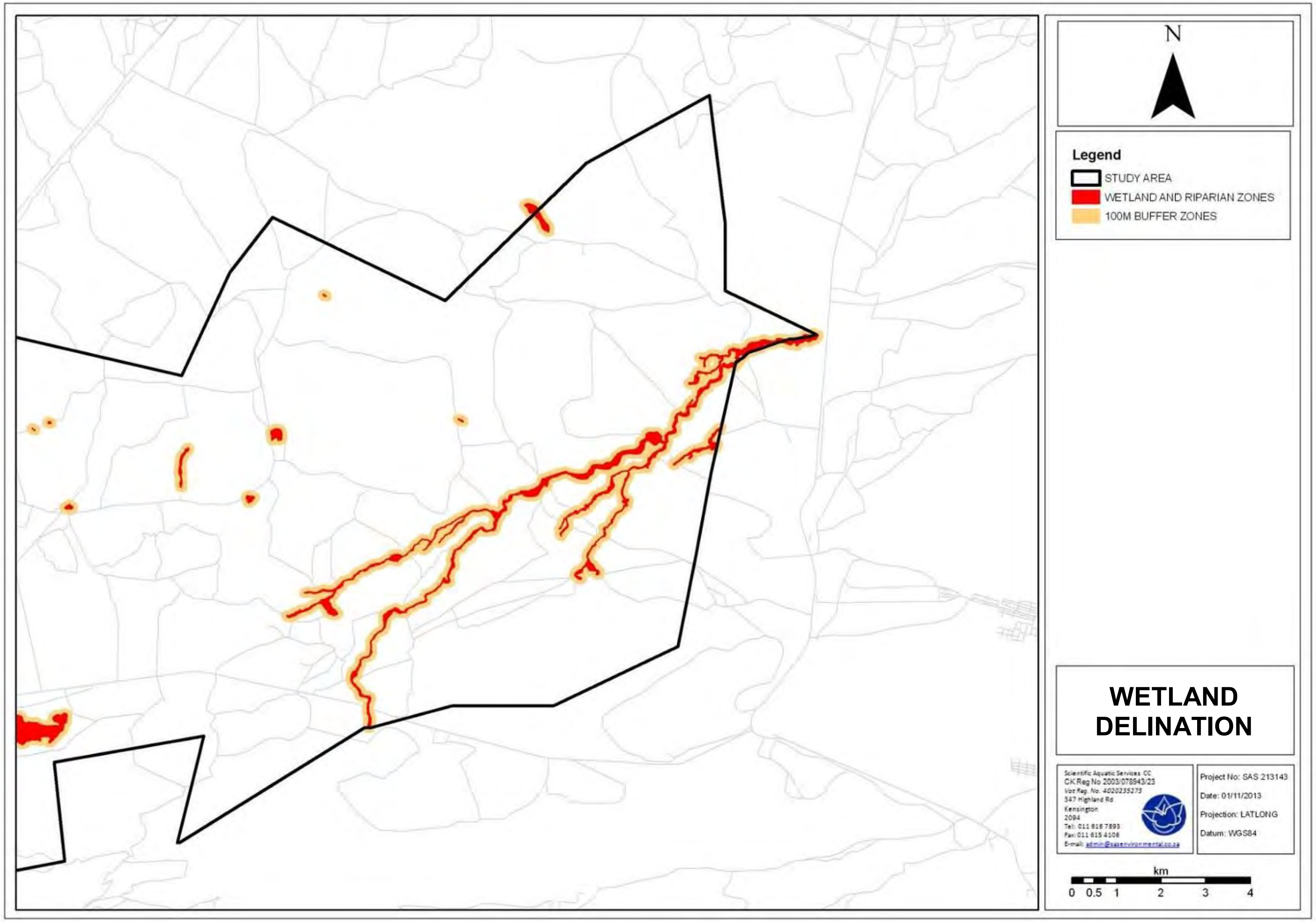


Figure 41: Allocated 100m buffer zones in relation to the Chapudi Wildebeest section.

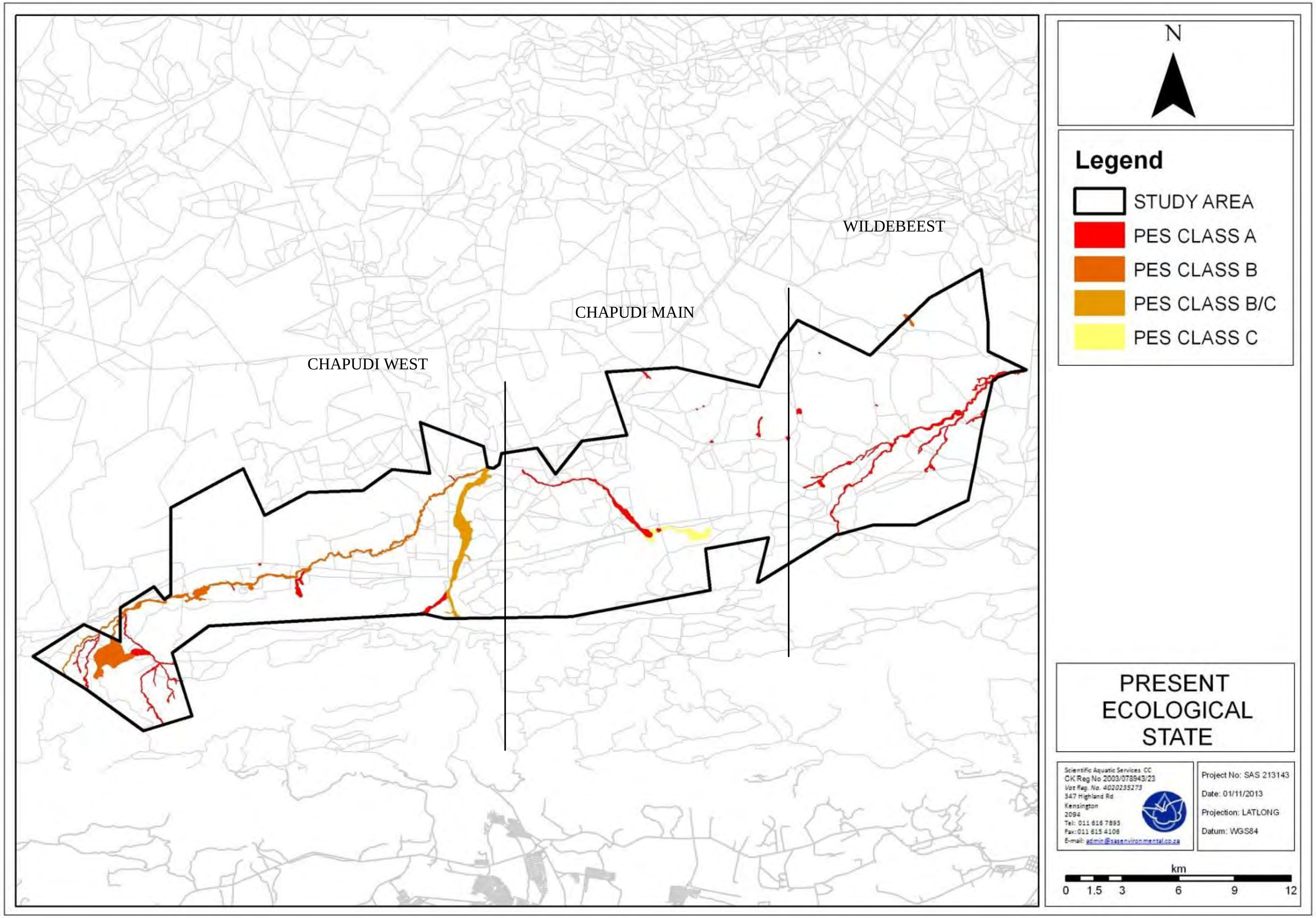


Figure 42: PES maps based on the same principle as above (divided into Chapudi west, Chapudi main and Wildebeest sections).

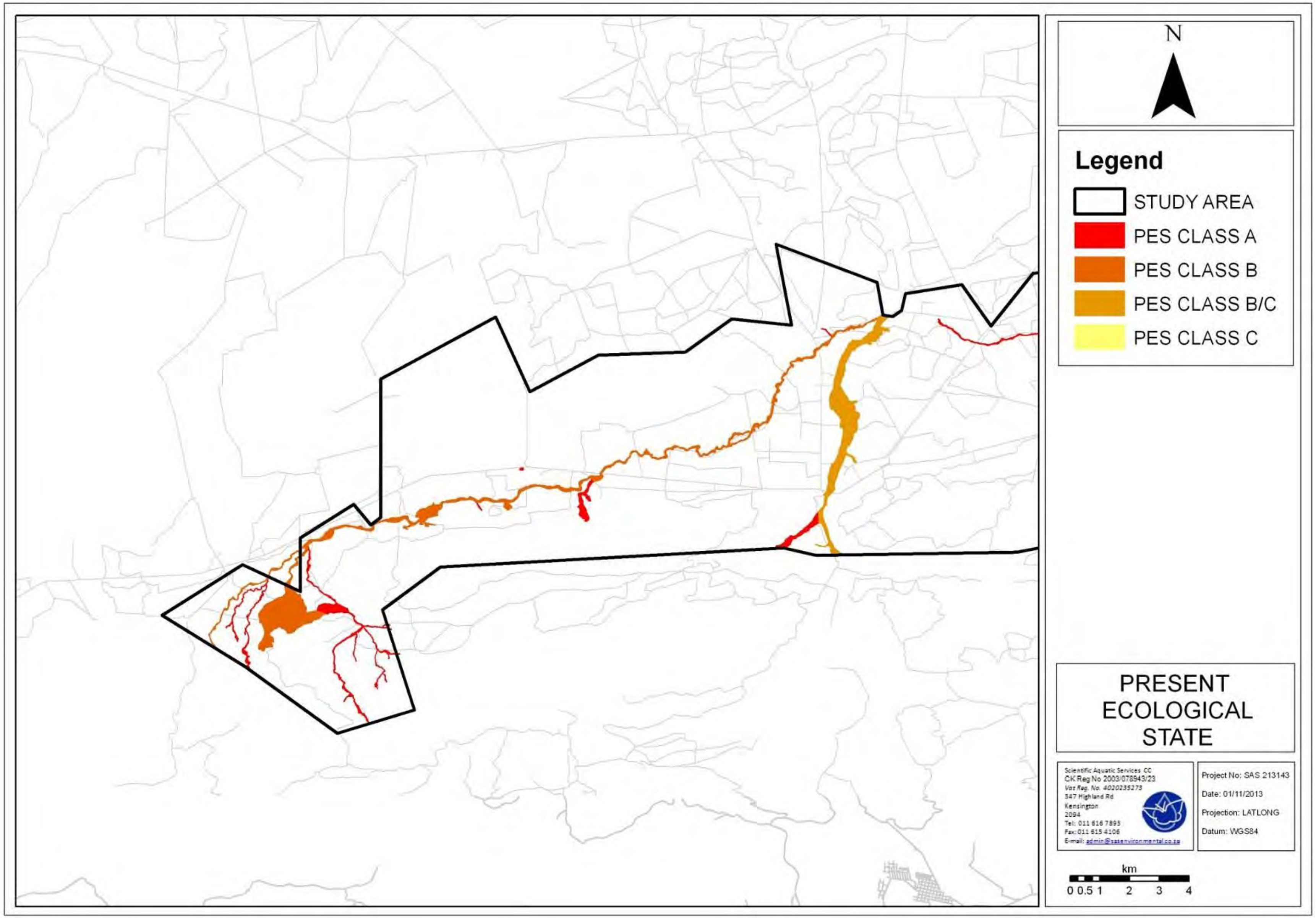


Figure 43: Wetland PES map of the Chapudi West section.

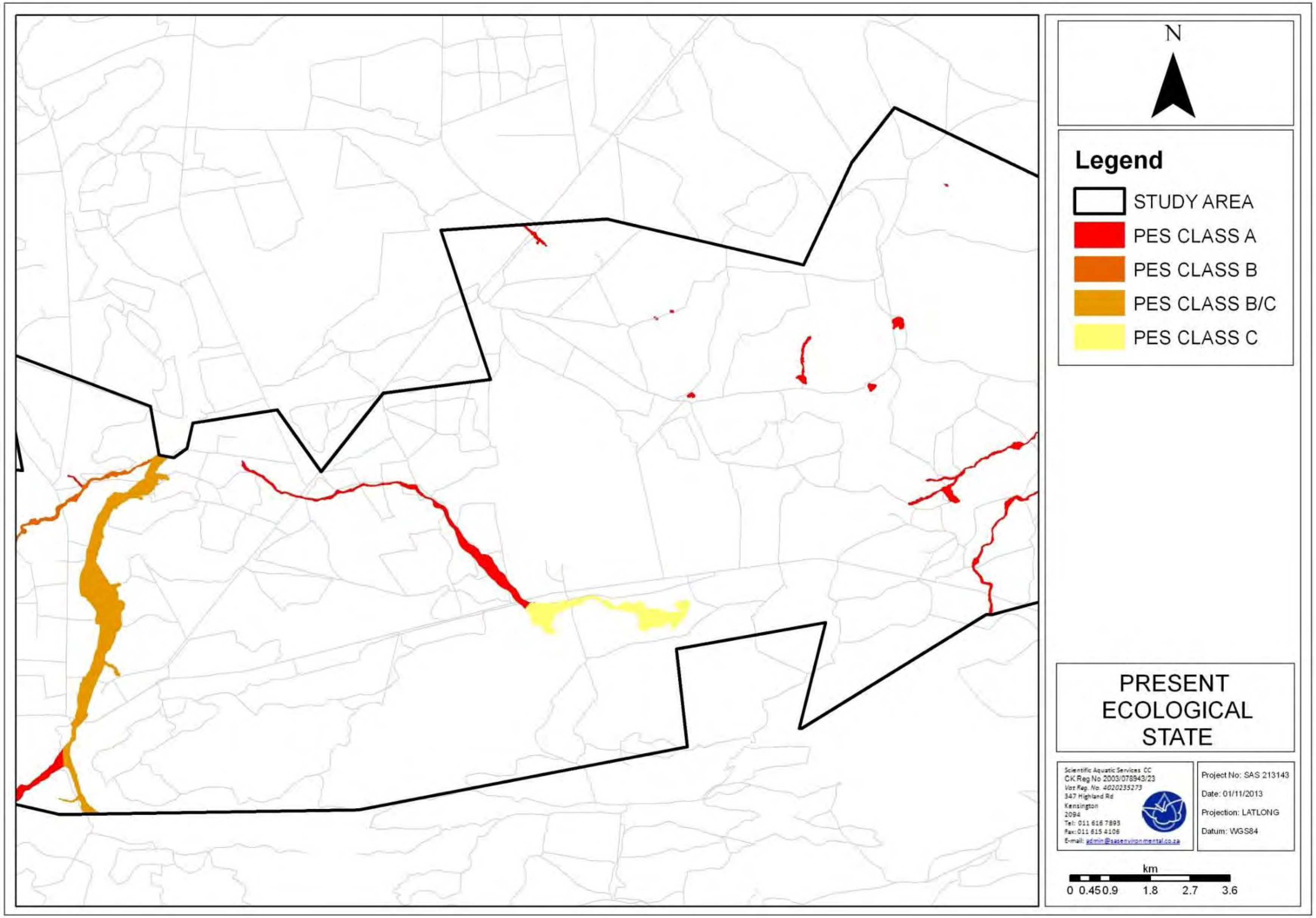


Figure 44: **Wetland PES map of the Main section.**

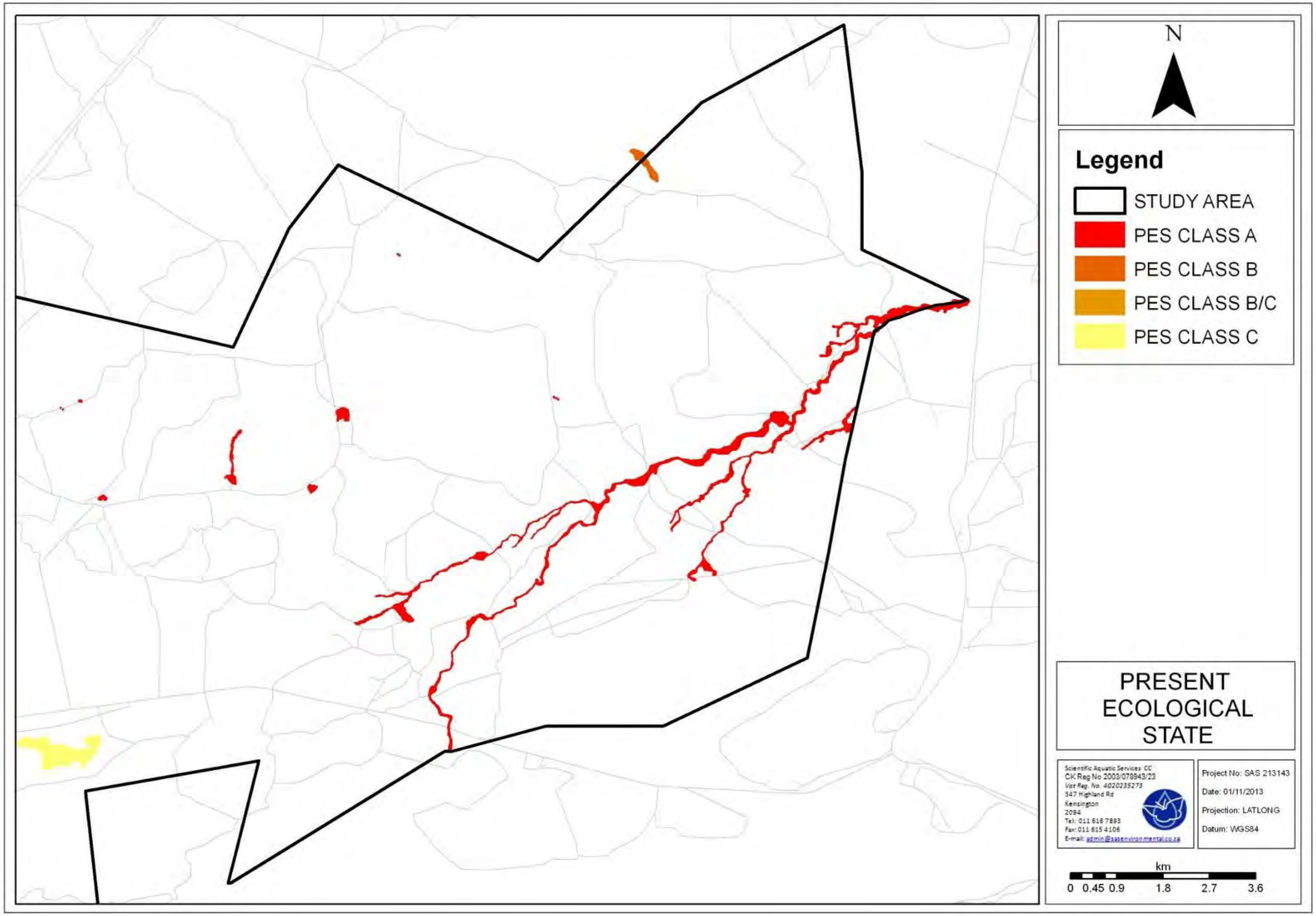


Figure 45: Wetland PES map of the West section.

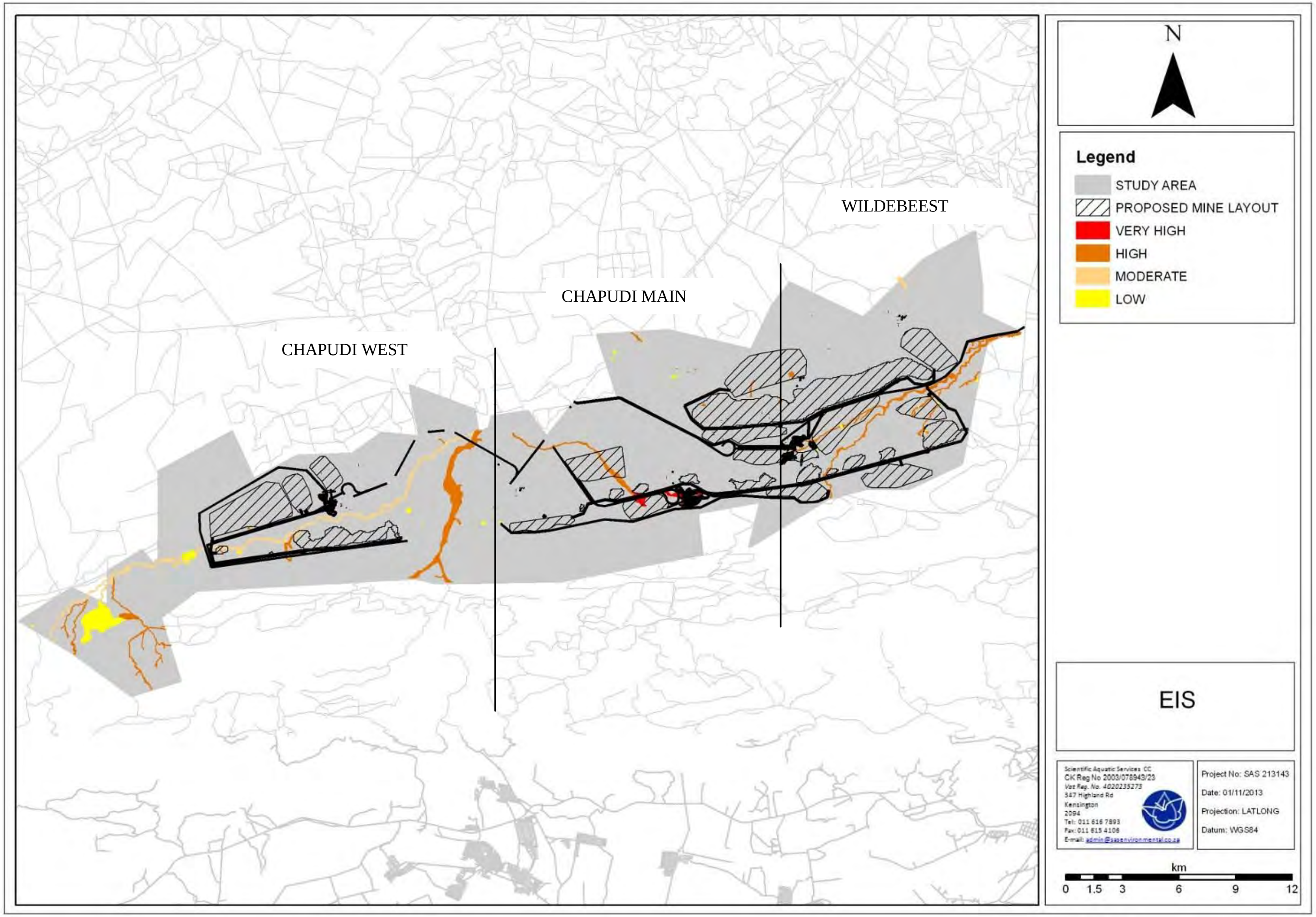


Figure 46: EIS Maps based on the same principle as above (divided into Chapudi west, Chapudi main and Wildebeest sections)

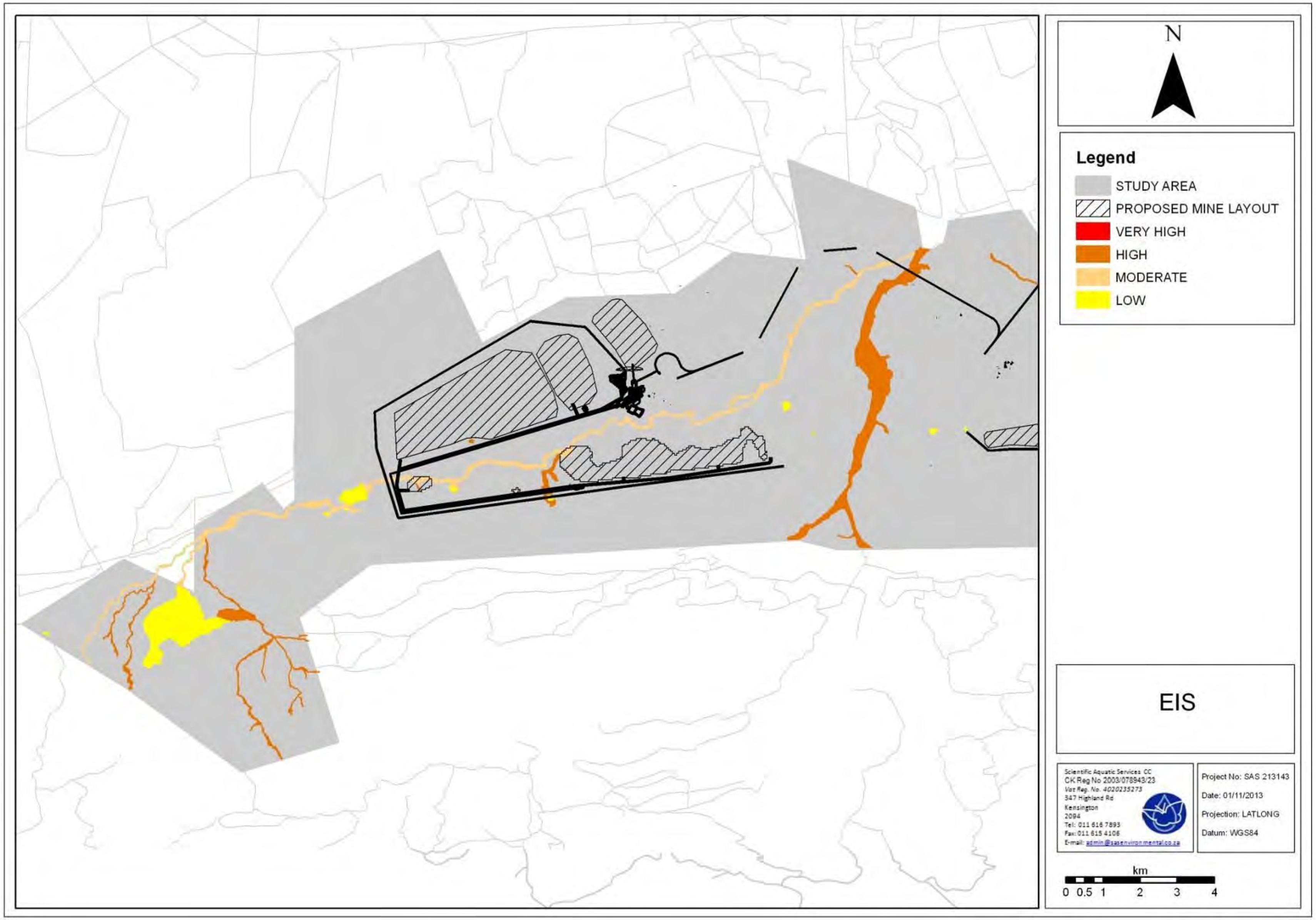


Figure 47: EIS Map (Chapudi west section)

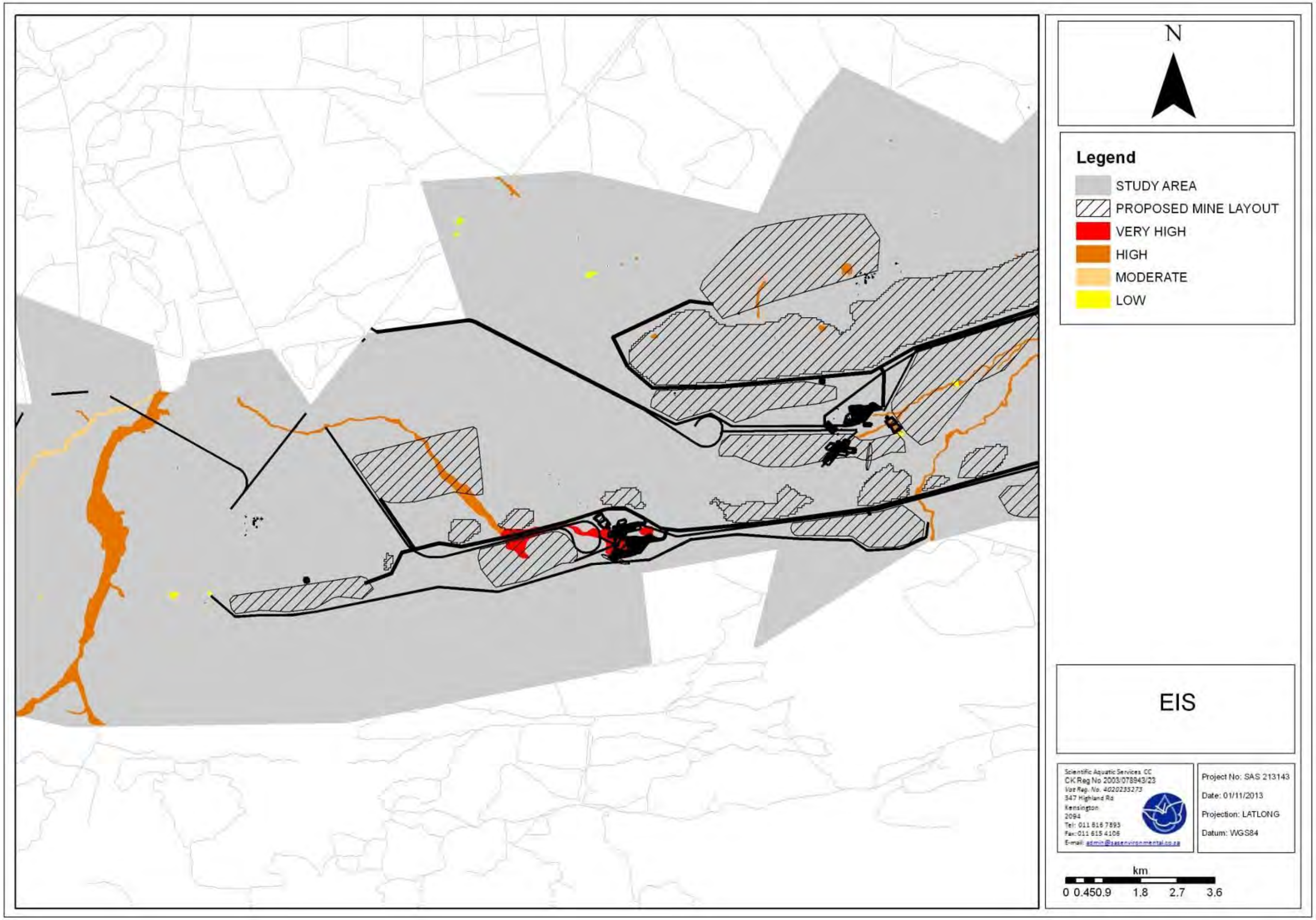


Figure 48: EIS Map (Chapudi main section)

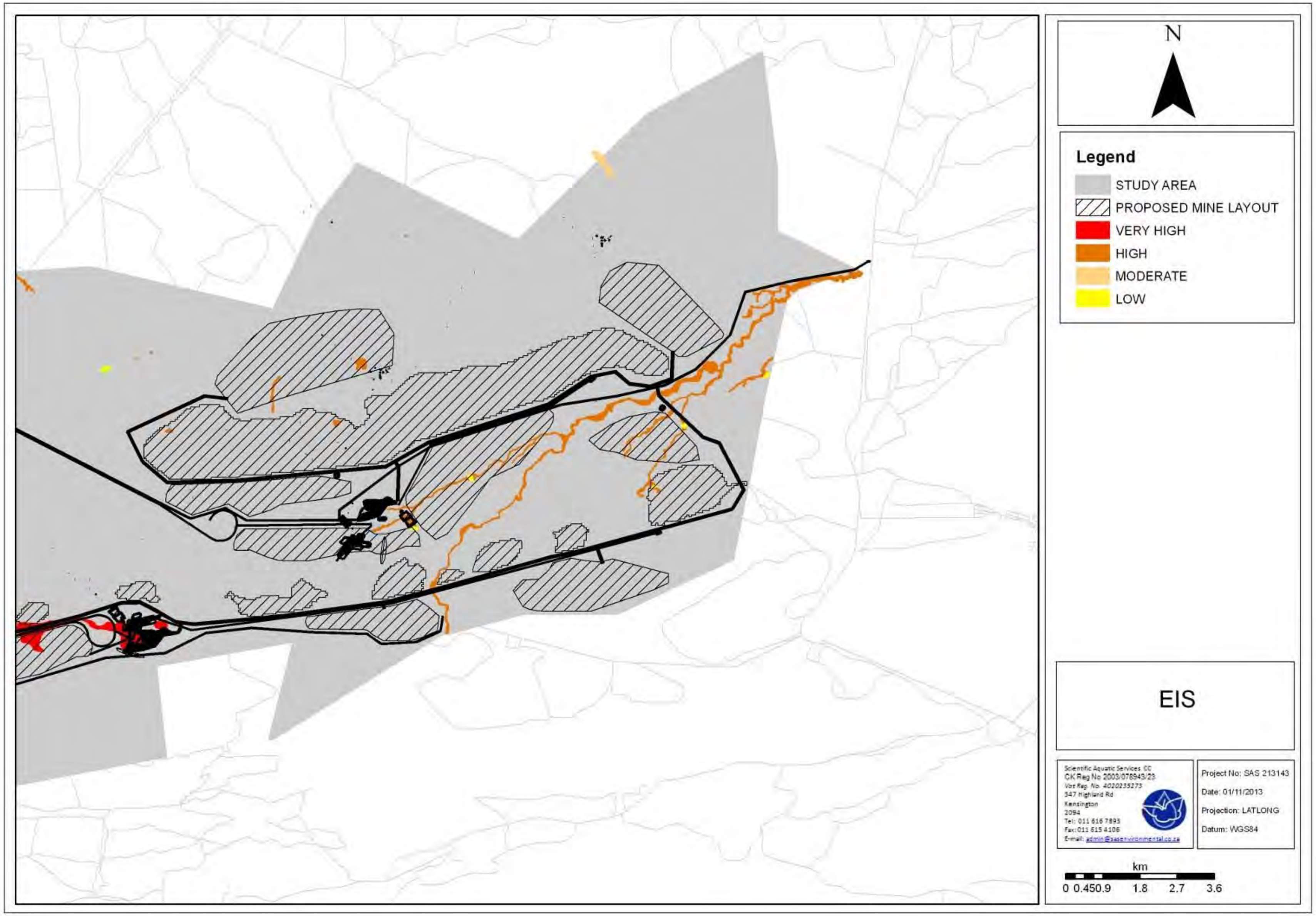


Figure 49: EIS Map (Wildebeest section)

5.9 Recommended Ecological Class

According to the resource directed measures for protection of water resources[13] 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 relatively low levels of transformation on all levels of ecology. It is therefore recommended that the features be assigned the same REC as the PES Class calculated. The EIS and REC values are presented in the table below:

Table 47: Assigned REC Classes.

Feature	VEGRAI Ecostatus	Wetland PES Classes	EIS Class	REC Class
Sand River (upper)	C	B/C	C	C
Mutamba River	B	A/B	B	B
Moleletsane Stream	C	B	B/C	B/C
Smaller drainage lines	B	A	B	B
GSPC W1	*	C	A	A
GSPC W2	*	B	C	C
GSPC W3	*	C	C	C
Smaller pans	*	A	B	B

*** = not applicable**

6 AQUATIC ECOLOGICAL ASSESSMENT RESULTS

6.1 THE SAND RIVER

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.

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

6.1.1 Visual Assessment

<table>
<tr>
<td>
Figure 50: Upstream view of the GSP3 site on the Sand River showing the very limited flow at the time of assessment.</td>
<td>
Figure 51: Downstream view of the GSP3 site showing the sandy substrates present.</td>
</tr>
<tr>
<td>
Figure 52: Upstream view of the GSP2 site on the Sand River.</td>
<td>
Figure 53: Downstream view of the GSP2 site showing the dry river bed</td>
</tr>
</table>

Figure 54: Upstream view of the GSP1 site on the Sand River showing the lack of surface flow upstream of the point.

Figure 55: Downstream view of the GSP1 site showing the deep pool at this point.

Figure 56: Upstream view of the GSP6 site on the Sand River showing the good aquatic and bankside vegetation cover at this point.

Figure 57: Downstream view of the GSP6 site on the Sand River showing the limited flow at the point.

Figure 58: Upstream view of the GSP4 site on the Sand River showing the absence of water at this point.

Figure 59: Downstream view of the GSP4 site on the Sand River showing the sandy substrate and presence of reeds along the stream banks.

Table 48: 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.
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 dominated by reeds and sedges. The riparian zone at this point is being affected by water abstraction, alien vegetation encroachment and removal.

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

6.1.2 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 49: 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 50: 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.

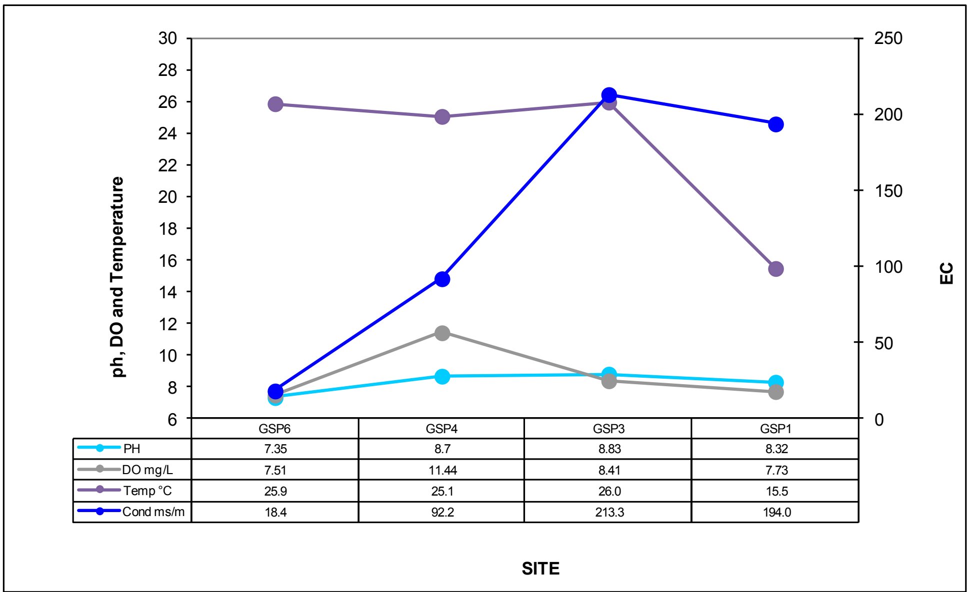


Figure 60: Physicochemical water quality showing spatial trends

6.1.3 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).

6.1.4 Invertebrate Habitat Assessment System (IHAS)

Table 51 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 51: 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.

6.1.5 Aquatic Macro-Invertebrates:

6.1.5.1 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 52 indicates the results obtained at each site, per biotope sampled. SASS5 and ASPT scores (Dickens and Graham, 2001) are presented in Appendix 3.

Table 52: 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 53: 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.

6.1.5.2 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.

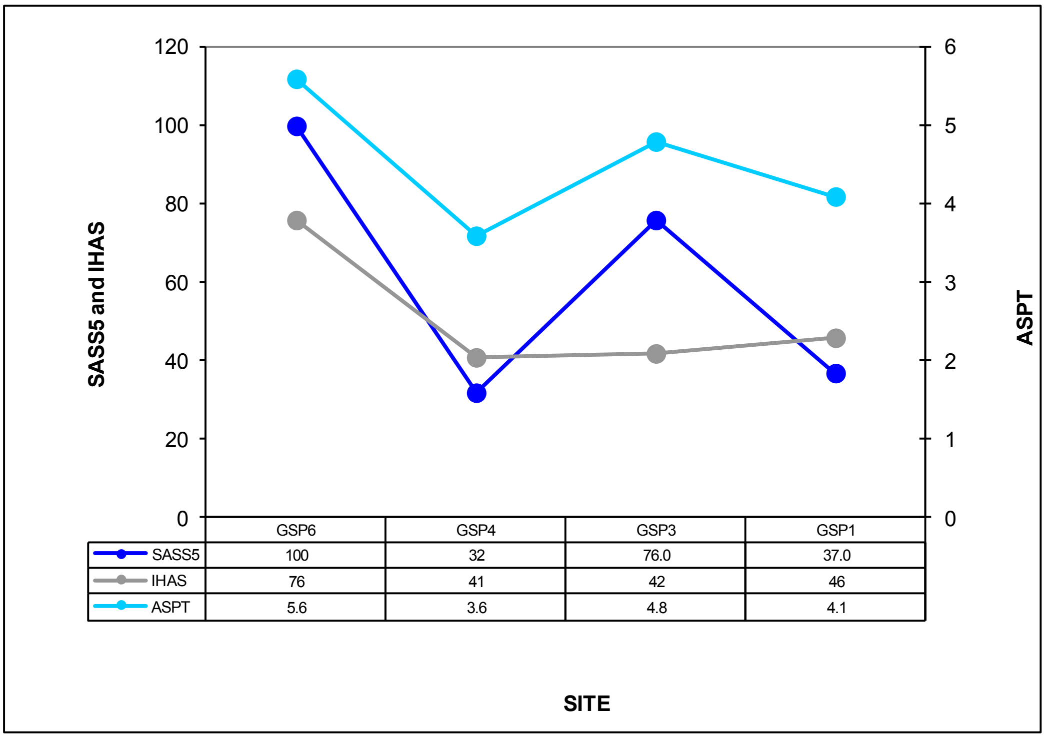
Table 54: Summary of the results (ecological categories) obtained from the application of the MIRAI to the four assessment sites, compared to classes awarded using SASS5.

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.

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.

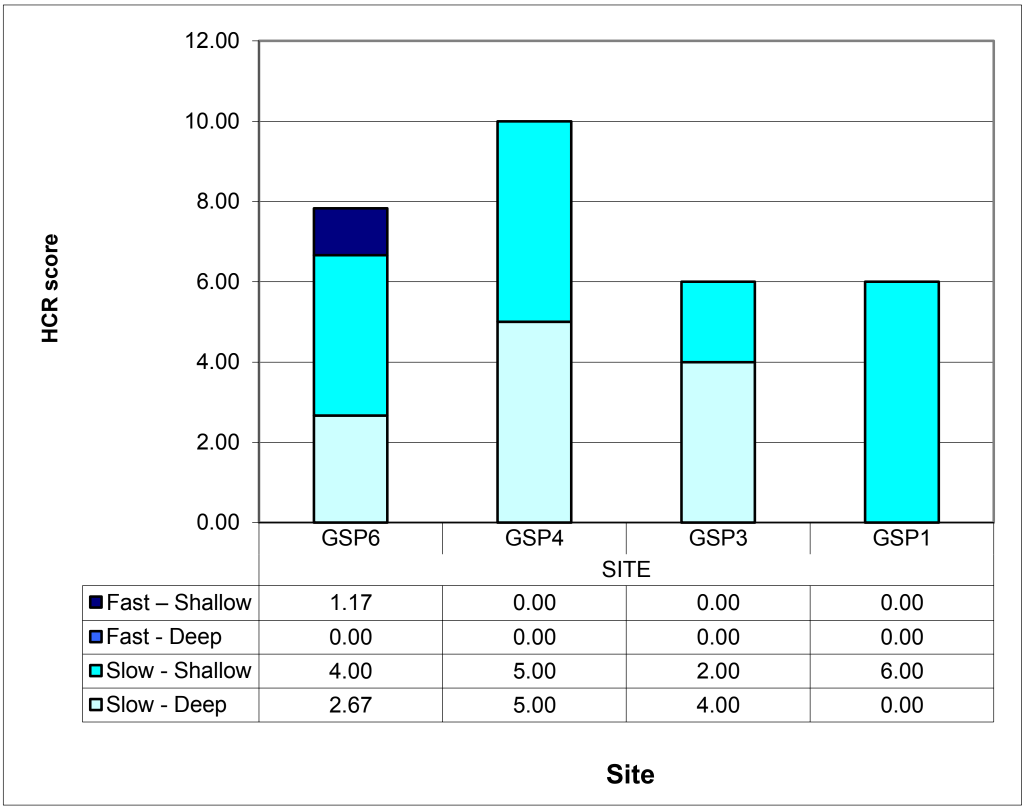


	GSP6	GSP4	GSP3	GSP1
SASS5	100	32	76.0	37.0
IHAS	76	41	42	46
ASPT	5.6	3.6	4.8	4.1

Figure 61: IHAS, SASS5 and ASPT scores showing spatial trends

6.1.6 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 62: HCR scores for the four sites assessed

Table 55: 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 56: 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.

6.2 THE MUTAMBA RIVER

6.2.1 Visual Assessment

Figure 63: Upstream view of the GSP9 site on the Mutamba River showing the very limited flow at the time of assessment.

Figure 64: Downstream view of the GSP9 site showing the excellent rocky substrate present.

Figure 65: A general view of the middle section of the Mutamba River (GSP10) showing the dry conditions at the time of assessment.

Figure 66: A general view of the middle section of the Mutamba River (GSP10) showing the well-developed riparian zone of the system.

Figure 67: Upstream view of the GSP13 site on the Mutamba River showing the dense reed growth.

Figure 68: Downstream view of the GSP13 site showing the small pool below the bridge.

Table 57: Visual description of the sites selected on the Mutamba River

ASPECT	GSP9	GSP10	GSP13
Significance of the point	This site serves as a future spatial reference point for all sites further downstream in the catchment. The point also serves to indicate the condition of the Mutamba River prior to any effects as a result of the activities of the proposed Chapudi and Generaal mining projects.	Photographs are representative of the middle reaches of the system and can be considered representative of the GSP 11 and GSP 12 points too.	The site is situated on the lower reaches of the Mutamba River near to the confluence with the Nzalhele River. Future data for this point can be spatially compared to the results obtained at site GSP9 in order to identify any impacts on the aquatic ecology of the system occurring between the two points.
Surrounding features	This section of the river is located in an area dominated by game farming and winter vegetable production. The surrounding landscape is largely intact as the river flows through a remote gorge where little human activity occurs.	This section of the river is located in an area dominated by game farming The surrounding landscape limited levels of transformation although some impact from water abstraction may occur.	This section of the river is located in an area dominated by game farming upstream of the point and citrus production. The surrounding landscape shows varying degrees of transformation based on the intensity an extent of agricultural activities on each farm portion.
Riparian zone characteristics	The riparian zone along the length of this section of the Mutamba River is steep and narrow due to topography of the area. Some vegetation removal has occurred in the vicinity of the bridge. The riparian zone at this point may be affected by alien vegetation encroachment to a small degree.	The riparian zone along the length of this section of the Mutamba River is relatively broad with a well-developed riparian zone with trees associated with water courses dominating the riparian zone.	The riparian zone along the length of this section of the Mutamba River is relatively broad due to the wide floodplain of the system. The riparian vegetation is dense and consists mostly of *phragmites mauritianum.*
Depth and flow characteristics	The Mutamba River was flowing at this point and displayed some slow flowing sections. No fast flowing water was present. The river consisted mostly of shallow freestone runs and isolated deep sections in the larger pools.	The Mutamba River was dry along most of its course with only subterranean flow through the alluvium present along extensive lengths of the system.	The Mutamba River was dry along most of its course with only subterranean flow present along extensive lengths of the system. At the GSP13 point the site consisted of a pool among the dense vegetation.
Water clarity	Water was very clear.	River segment was dry at the time of assessment	Water was clear although biological activity leads to some increase in turbidity.
Impacts and signs of pollution	At the time of assessment no significant impacts on the instream ecology were visually evident.	At the time of assessment no significant impacts on the instream ecology were visually evident although some impact from water abstraction may occur	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 pools is considered highly likely to be occurring. Some impact on water quality was also deemed possible.

6.2.2 Physico-Chemical Water Quality

Water quality variables were measured at two points on the Mutamba River where surface water was present. GSP9 represents the upstream point on the system on the upper boundary of the project area and GSP 13 represents a downstream point on the system at a point just before the confluence of the Mutamba River with the Nzhelele River.

Table 58: Biota specific water quality data for the assessed river assessment sites

Site	Description	pH (pH units)	Conductivity (mS/m)	DO (mg/L)	Temp (ºC)
GSP9	Mutamba River – Spatial reference point	7.35	18.4	7.51	25.9
GSP13	Mutamba River – Point to assess potential impact	6.32	116.4	5.60	22.8

The following key points on the water quality of the Mutamba River system both upstream and in the vicinity of the proposed Chapudi project 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 an increase in conductivity in a downstream direction, with EC being 6.3 times higher at site GSP13 compared to GSP9;
- 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 GSP9 as reference site, the spatial change downstream thus exceeds the above recommendation although it must be noted that natural salinization of the system is deemed likely in the local area;
- From a temporal perspective, EC increased by 38.3% at site GSP9 from 2009 to 2013. Once again this change exceeds the recommendation;
- Comparing current GSP9 readings to that obtained at an upstream site (GSP8 historically called M0) in 2009, EC was 89.5% higher at GSP9;
- Comparing current GSP9 readings to that obtained at a downstream site (historically called M2) in 2009, EC was 21.6% higher at GSP9;
- The temporal changes in EC at site GSP9 thus falls outside the DWA (2007) guideline recommendation. The Mutamba River is likely to display a naturally high level of variability in dissolved salt concentration linked to seasonality of flow. Close monitoring of these trends will be required in future;
- Spatially there was a 14.0% decrease in pH value in a downstream direction between sites GSP9 and GSP12;
- 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 GSP9 pH value is considered a reference value for the downstream site GSP13, the observed changes in pH value exceed the recommended percentage change range from a spatial perspective;
- From a temporal perspective pH value decreased by 1.1% at GSP9 from 2009 to 2013. This change falls well within the recommended guideline and the observed variations can be attributed to natural temporal variation;
- Comparing the historical M0 (GSP8) and M2 to GSP9 (also from a temporal perspective), the percentage decrease in pH value of 0.7% and 3.5% respectively also falls within the recommended guideline;
- Dissolved oxygen (DO) concentration decreased by 25.4% in a downstream direction between sites GSP9 and GSP13;

- 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 59: 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
GSP9	7.51	25.9	8.09	92.83%
GSP13	5.60	22.8	8.56	65.42%

- Dissolved oxygen concentration at upstream site GSP9 falls well within the recommended range, whilst that at the downstream site (GSP13) falls below the recommended range;
- When comparing current results to historical (2009) data, oxygen concentration increased by 4.5% (from 7.19 to 7.51 mg/mL) at site GSP9;
- Furthermore, from a temporal perspective, when considering the historical data, oxygen concentration at sites M0 (GSP8) and M2 (2009) were 25.4% and 9.6% respectively higher at GSP9 (2013);
- 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 again 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.

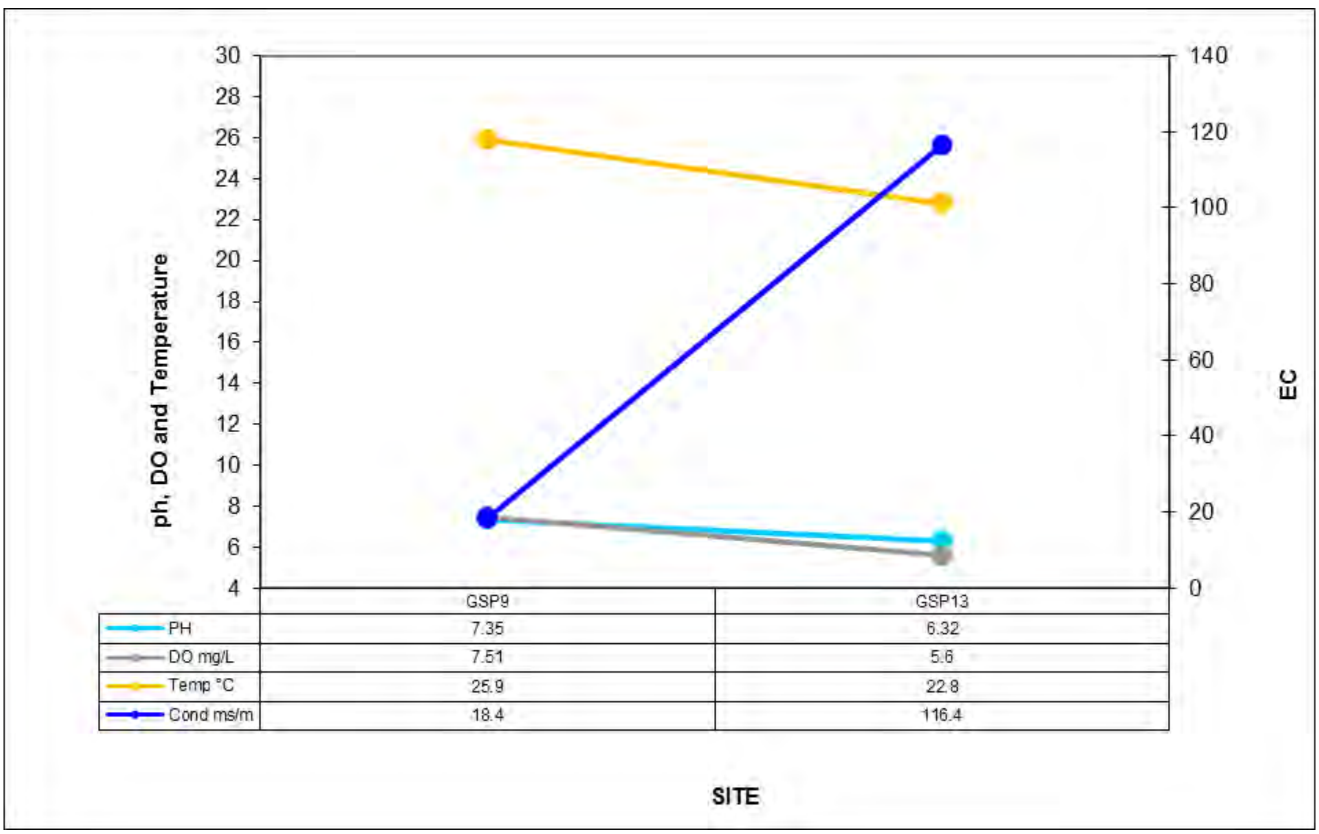


Figure 69: Physico-chemical water quality showing spatial trends

6.2.3 Invertebrate Habitat Integrity Assessment (IHIA)

Assessment site GSP9 was on the Mutamba River and is considered the most suitable reference site for the Chapudi project (most upstream site during current assessment).

For site GSP9, only small and moderate impacts were recorded for both instream and riparian zones habitat. The former relates to bed modification, channel modification, water quality and solid waste disposal, of which only channel modification was moderately impacted. Site GSP9 obtained an “A” (“Unmodified / Natural”) classification with regard to instream habitat integrity.

The most significant riparian zone impacts at site GSP9 were alien encroachment and bank erosion (both moderately impacted). Site GSP9 obtained an “A” (“Unmodified / Natural”) classification with regard to riparian habitat integrity.

An overall score of 86.7% (GSP9) was calculated, placing site GSP9 in class A (unmodified/natural).

6.2.4 Invertebrate Habitat Assessment System (IHAS)

Table 60 is a summary of the results obtained from the application of the Invertebrate Habitat Integrity Assessment (IHAS) Index to one river assessment site on the Mutamba River (GSP9). 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.

- The GSP9 site on the Mutamba River were dominated by pools and runs;
- Water was clear at the time of assessment;
- Water flow was mixed but generally slow;
- Fringing vegetation was absent but rocks provided very good bank cover. Bank/riparian vegetation (mix of reeds and shrubs) were present;
- Suitable rocky substrate was present at the GSP9 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;
- Habitat diversity and structure was considered highly suitable for supporting a diverse and sensitive aquatic macro-invertebrate community.

Table 60: A summary of the results obtained from the application of and IHAS indices to the assessment site on the Mutamba River

SITE	GSP9
IHAS score	73
IHAS Adjustment score (illustrative purposes only)	+22
McMillan, 1998 IHAS description	Habitat diversity and structure is highly suited 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.
Vegetation habitat characteristics	Bank/riparian vegetation (mix of reeds and shrubs) was present. No fringing vegetation were, however, present or sampled. Aquatic vegetation was also absent.
Other habitat characteristics	Sand (under rocks) and gravel habitats available. No mud or bedrock substrate present. No algae present.
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.

6.2.5 Aquatic Macro-Invertebrates:

6.2.5.1 SASS5

Table 61 indicates the results obtained per biotope sampled whilst SASS5 scores are tabulated in Table 62 SASS5 and ASPT scores (Dickens and Graham, 2001) are presented in Appendix 3.

Table 61: 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	GSP9	76	0	22	79
Number of taxa		12	0	5	13
ASPT		6.3	0	4	6.1

Table 62: Summary of the results obtained from the application of the SASS5 index to the four assessment sites

Type of Result	GSP9
Biotopes sampled	Sand, gravel, stones in current, stones out of current.
Sensitive taxa present	*Atyidae; Caenidae; Leptophlebiidae; Chlorocyphidae; Gomphidae*
Sensitive taxa absent	*Philopotamidae; Hydracarina; Corduliidae*
SASS5 score	79
Adjusted SASS5 score	101
SASS5 % of theoretical reference score*	54.5
ASPT % of theoretical reference score**	101.7
Dickens & Graham, 2001 SASS5 classification	Class C
Dallas 2007 Classification	Class A

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

- SASS5 results are relatively comparable to that obtained at site GSP6 which is the reference point on the Sand River;
- Habitat limitations are likely to limit the diversity, abundance and sensitivity of the aquatic community to some degree;
- As for the Sand River reference site GSP6, suitable habitat in the form of ample rocky substrate indicates suitable macro-invertebrate habitat conditions at this point. The absence of vegetation biotopes, however, is the most likely reason for the lower SASS score obtained as GSP9 compared to GSP6;
- Taxa dependent on faster flow conditions are also likely to be largely absent;
- Water quality is likely to be an additional limiting factor shaping the aquatic community in the lower reaches of the system. As more data on the system is collected, better inferences on the ecological condition of the community will be possible;

- At site GSP9, the stream may be considered to be in a class C (moderately impaired) condition according the Dickens & Graham (2001) classification system. According to the Dallas (2007) classification system, the site can be classified as class A (Natural);
- This apparent discrepancy can be explained by the high ASPT score that exceeded 6, resulting in a much higher classification on the reference graph compiled by Dallas (2007);
- The Dallas (2007 classification is considered to be a more accurate representation of the conditions at this point;
- As for the Sand River, the system is expected to exhibit 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 in conjunction with application of the IHIA and IHAS indices. Close monitoring of such 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 Mutamba River.

6.2.5.2 Aquatic Macro-Invertebrates: MIRAI

Table 63: Summary of the results (ecological categories) obtained from the application of the MIRAI to the GSP9 assessment site on the Mutamba River, compared to classes awarded using SASS5.

Variable / Index	GSP9
Ecological category (MIRAI)	C
Dickens and Graham (SASS5)	C
Dallas (SASS5)	A

The MIRAI ecological category classification for GSP9 is comparable to that obtained for GSP6.

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 between six sites. For five of these sites classifications varied between D and E with only one site achieving a C ecological classification. For site GSP9 (M1 historically) specifically, an ecological classification of D was achieved (compared to C obtained in the current assessment).

6.2.6 Fish Community Assessment

The HCR (Habitat Cover Rating) results for the GSP9 site assessed on the Mutamba River are provided in Figure 70. With regard to application of the FRAI, fish collected and scores employed are provided in Table 64.

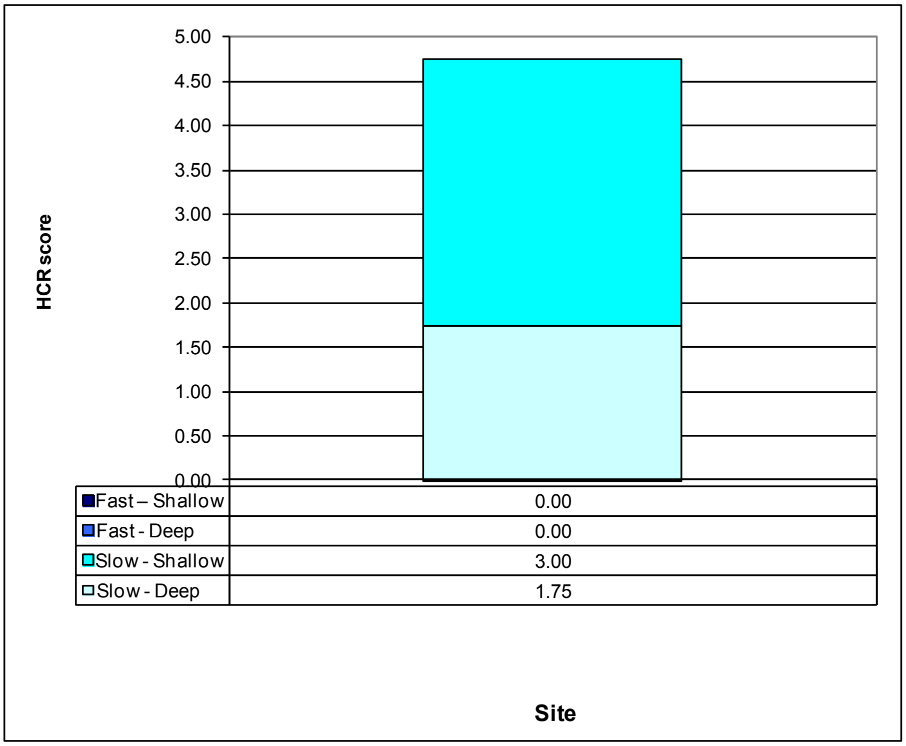


Figure 70: HCR scores for the GSP9 site assessed on the Mutamba River

Table 64: Intolerance ratings for naturally occurring indigenous fish species with natural ranges included in the Mutamba River [4] (Limpopo River system) of the study area (Skelton, 2001; Kleynhans, 2003; Kleynhans, Louw and Moolman, 2007).

SPECIES NAME	COMMON NAME	INTOLERANCE RATING [3]	COMMENTS
Amphilius uranoscopus [2]	Stargazer (mountain catfish)	4.8	Okovango and Zambezi systems, east coast rivers south to Mkuze in northern Kwa-Zulu Natal
Barbus eutaenia [2]	Orangefin barb	4.3	Cunene, Okovango and Zambezi, east coast systems south to the Phongolo
Barbus paludinosis [1]	Straightfin barb	1.8	Widespread
Barbus trimaculatus [2]	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 viviparous [1]	Bowstripe barb	2.4	East coastal rivers from the Ruvuma south to Vungu in KwaZulu-Natal.
Chiloglanis pretoriae [1]	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.
Gambusia affinis	Mosquito fish	2.0	Widespread
Labeo cylindricus [1]	Redeye labeo	3.1	Widespread East-African rivers down to Phongolo system in KwaZulu-Natal
Labeo molybdinus [1]	Leaden labeo	3.2	Middle and lower Zambezi down to Tugela system in KwaZulu-Natal

SPECIES NAME	COMMON NAME	INTOLERANCE RATING [3]	COMMENTS
Labeo rosae [1]	Rednose labeo	2.4	Lowveld region of the Limpopo, Incomati and Phongolo systems
Mesobola brevianelis [1]	River sardine	2.3	East coastal rivers from Limpopo to Umfolozi in KwaZulu-Natal
Micralestes acutidens [1]	Silver robbers	2.3	Cunene, Okavango, Zambezi and east coast rivers south to Phongolo.
Oreochromis mossambicus [1]	Blue Kurper	1.3	Widespread
Pseudocrenilabrus philander [1]	Southern mouthbrooder	1.3	Widespread
Tilapia sparrmanii [1]	Banded Tilapia	1.3	Widespread
Tilapia rendalli [1]	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

[4] Note: The Mutamba River is a main tributary of the Nzhelelele River. No FROC data are available for the Mutamba River so available data for the Nzhelelele River was used instead as described below:
[1] Fish species previously encountered below the Nzhelelele Dam (catchment A80G) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007).
[2] Fish species previously encountered above the Nzhelelele Dam (catchment A80B) for which FROC (reference frequency of occurrence) values are listed (Kleynhans *et al.* 2007). Given the position of the assessment sites these species are unlikely to occur. However, as they do occur in the same river system, they have been included in the list. 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. [3] Average overall intolerance rating as per Kleynhans (1999).

Table 65: 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 Mutamba River (Limpopo River system) of the study area (Skelton, 2001; Kleynhans, 2003; Kleynhans, Louw and Moolman, 2007).

SPECIES NAME	Number of fish collected at site GSP7	Abundance score (AS)	FROC[1] score (below Nzhelele Dam)
Barbus trimaculatus	18	**3**	**1** [2]
Barbus paludinosis	24	**3**	**1**
Barbus unitaeniatus	11	**2**	**1**
Barbus viviparous	2	**1**	**1**
Labeo cylindricus	1	**1**	**1**
Pseudocrenilabrus philander	2	**1**	**1**
Tilapia sparrmanii	4	**1**	**1**

[1] Fish species previously encountered below the Nzhelele Dam (catchment A80G) 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 Mutamba River.
[2] FROC score from above Nzhelele Dam catchment A80B (fish species FROC score not listed below dam in catchment A80G).
[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 MIRAI have again been included.

Table 66: Summary of the results (ecological categories) obtained from the application of the FRAI to the four assessment sites on the Sand River and one site on the Mutamba River, compared to that obtained using MIRAI.

River assessed	Mutamba	Sand				
Variable / Index	**GSP9**	**GSP6**	**GSP4**	**GSP3**	**GSP1**	**System**
Automated FRAI (%)	35.3	59.9	29.9	30.9	47.8	14.5
Automated EC (FRAI)	E	C/D	E	E	D	F
Refined EC (FRAI)	D/E	D/E	D/E	D/E	D/E	D/E
Ecological category (EC) (MIRAI)	C	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. Because the habitat (and hence potential drivers) was fairly homogenous between the sites, the refined EC was 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 variation in results may be attributed to the low flows at the time of assessment and potential migratory movement of fish in the system.

The EC values calculated during the current assessment are, however, incongruence with results obtained using macro-invertebrate indices (MIRAI and SASS5).

When the results of the aquatic assessment are compared to the results of the wetland assessment it is evident that the wetland/riparian zone integrity of the Matumba River is slightly higher than that of the aquatic macro-invertebrate community and significantly higher than the ecostatus of the fish community. The results therefore elude to the fact that instream impacts on the Matumba River are more significant than the impacts on the riparian zone, largely as a result of the water stressed nature of the system.

When the results of the aquatic assessment are compared to the results of the wetland assessment it is evident that the wetland/riparian zone integrity of the Sand River and the aquatic macro-invertebrate community are the same while it is significantly higher than the ecostatus of the fish community. The results therefore elude to the fact that instream impacts on the Sand River are more significant than the impacts on the riparian zone, largely as a result of the water stressed nature of the system and impacts on instream flow and the availability of refugia in the system along with impacts form migratory barriers in the system.

6.3 SYNTHESIS

Based on the findings of the aquatic study the Sand River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. The Sand River can be considered to be a system of high aquatic Ecological Importance and Sensitivity due to the provision of refugia and in the local area and the support it provides to the aquatic ecology of the area. The system is also deemed important in terms of the provision of services to the terrestrial fauna, such as the provision of drinking water of the area as well as a high significance from a socio-cultural point of view, with special mention of water provision for agriculture. It is deemed essential that all effort is made to ensure that impacts on the Sand River as a result of the proposed Chapudi Project are minimised.

Based on the findings of the aquatic study the Mutamba River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. Some recovery of the system does however occur in the lower reaches but impacts on the aquatic ecology of the lower reaches of the system are still considered to be likely. The Mutamba River can be considered to be a system of reduced Ecological Importance and Sensitivity in relation to the Sand River due to the limited provision of refugia and in the local area and the limited support it provides to the aquatic ecology of the area. The system is however deemed important in terms of the provision of services to the terrestrial fauna of the area as well as fair significance form a socio-cultural point of view. It is deemed essential that all effort is made to ensure that impacts on the Mutamba River as a result of the proposed Chapudi Project are minimised.

7 IMPACT ASSESSMENT

The proposed Chapudi 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 Chapudi West Section; and
- Impact assessment for the Chapudi main and Wildebeest sections.

The tables in the subsections below serve to summarise the activities which will lead to impacts on the aquatic ecology of the Sand and Mutamba River systems 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, Mutamba River, and to a lesser degree the other systems in the vicinity of the Proposed Chapudi 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 and Mutamba Rivers being dry along most of their 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 and Mutamba 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 and Mutamba Rivers are the most significant and require the most attention when considering impacts on reduced instream flow and aquatic refugia and the loss of flow dependent taxa.

The remainder of the project area is very dry and no other systems were identified in which aquatic biota occurred. The perennial pools within the Black Stone Edge wetland GSPC W1 support low abundances of tolerant aquatic taxa and wetland vegetation. In addition many of the drainage lines in the area have well established riparian zones. In particular mention is made of the Moleletsane River as well as some smaller systems.

According to Jacana cc (2013) Mean annual runoff (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;
- Runoff from stockpiles. Rain falling directly onto the „dirty" stockpiles will either seep into the stockpile or runoff the sides of the stockpile. Any runoff 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 runoff is intercepted by canals. The canal system will intercept runoff 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 river system 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 runoff following storms and consequently higher peak flow rates.
- Capture of runoff and capture of rainfall in the „dirty" area would lower instream flow in the receiving environment.
- Canalisation of runoff. Intercepting runoff from the hillslopes 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 base flow due to the formation of a cone of dewatering in the aquifer 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 and Mutamba River	The drying out of aquatic refugia in the Sand and Mutamba River	The drying out of aquatic refugia in the Sand and Mutamba 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
Chapudi Main and Wildebeest Sections	5	4	5	5	5	9	15	135 (Very high)
Chapudi West Section	3	3	3	4	4	6	11	66 (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 GSPC W1 wetland located on the Black Stone Edge farm 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 and Mutamba Rivers and the on the GSPC W1 wetland located on the Black Stone Edge farm;
- Very strict control of water consumption must take place and detailed monitoring must take place. All water usage must continuously be optimised;
- 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

- Infrastructure near to the Sand and Mutamba Rivers must be kept to an absolute minimum and must be placed as far from these water courses as possible
- 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
Chapudi Main	4	4	3	5	4	8	12	96

and Wildebeest Sections								(Medium high)
Chapudi West Section	2	3	3	3	4	5	10	50 (Low)

Probable latent impacts
- Reduced recharge of the Sand, Mutamba and Moleletsane Rivers and other riparian systems affected by upstream and adjacent mining;
- Reduced availability of refugia for aquatic biota on the Sand and Mutamba Rivers;
- Altered riparian vegetation structures and increased moisture stress on riparian vegetation communities.

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 Chapudi 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 (Jacana cc 2013)

7.2.2 Increased sediment load in Sand River

In the natural state of the project site, vegetation cover causes friction to rainfall runoff, 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 runoff 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 runoff volumes, including roads, buildings and paved areas;
- Canalisation of runoff, particularly if canals do not discharge directly into the Sand River; and
- Construction activities that loosen the ground surface.

Furthermore, if runoff from the stockpiles is uncontrolled, such runoff 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 runoff 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 runoff from stockpiles

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

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 runoff 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 and/or wetlands 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 with special mention of changes to sediment balances	Impact on riparian vegetation structures due to impaired water quality with special mention of changes to pH and increased salt loading	Impact on riparian vegetation structures due to impaired water quality with special mention of changes to pH and increased salt loading
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
Chapudi Main and Wildebeest Sections	5	3	4	5	5	8	14	112 (High)
Chapudi West 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 GSPC W1 wetland located on the Black Stone Edge farm 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
- Infrastructure near to the Sand and Mutamba Rivers must be kept to an absolute minimum and must be placed as far from these water courses as possible;
- No infrastructure or open pits should encroach into any major drainage lines and associated riparian zones.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Chapudi Main and Wildebeest Sections	3	3	3	4	4	6	11	66 (Medium low)
Chapudi West 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 Chapudi project has significant potential to lead to habitat loss and/or alteration of the aquatic and riparian resources on 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 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
Chapudi Main and Wildebeest Sections	4	4	4	4	4	8	11	88 (Medium-high)
Chapudi West 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 GSPC W1 wetland located on the Black Stone Edge farm 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 and Mutamba 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 ecological monitoring must take place on a 6 monthly basis by an SA RHP Accredited assessor;

Recommended mitigation measures

- Infrastructure near to the Sand and Mutamba Rivers must be kept to an absolute minimum and must be placed as far from these water courses as possible;
- 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, Ficus, sp.* and *Xanthocercis zambesiaca*;

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Chapudi Main and Wildebeest Sections	3	4	3	4	4	8	11	88 (Medium-high)
Chapudi West 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 potentially 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	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
Chapudi Main and Wildebeest Sections	4	4	4	5	5	8	14	112 (High)
Chapudi West 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 this regard specific mention is made of the GSPC W1 wetland on the Black Stone Edge farm;
- 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 and especially in the vicinity of the Mutamba and Sand River systems;

- 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 and Mutamba River systems;
- 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 runoff 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;
- Toxicological monitoring of the receiving and process water systems on a quarterly basis.

Recommended mitigation measures

- Infrastructure near to the Sand and Mutamba Rivers must be kept to an absolute minimum and must be placed as far from these water courses as possible;
- 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
Chapudi Main and Wildebeest Sections	4	4	4	5	4	8	13	104 (High)
Chapudi West 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 in the Sand and Mutamba Rivers 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) and fig species were restricted to river systems such as the Mutamba River. None the less, the smaller drainage lines 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 concentrated on the Sand and Mutamba rivers. The permanently inundated wetland depressions in the GSPC W1 wetland on the Black stone edge farm however also retains water for longer periods increasing these features importance in terms of niche habitat as well as drinking water for wildlife and habitat for waterfowl. Some of the more ephemeral pans in the area are also likely to be of some importance in surface water provision to the faunal communities of the area

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 runoff and erosion and altered runoff patterns	Vehicles may impact upon sensitive riparian and wetland areas resulting in a loss of habitat
	Earthworks within and in the vicinity of wetland areas may lead to increased runoff and erosion and altered runoff patterns	Topsoil stockpiling adjacent to wetlands and runoff 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	

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	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

Construction	Operational	Decommissioning & 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
Chapudi Main and Wildebeest Sections	5	4	5	4	4	9	13	117 (High)
Chapudi West 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 GSPC W1 wetland located on the Black Stone Edge farm 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 and to minimise impacts on catchment yield;
- 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 curtains 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 and Mutamba 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

- Infrastructure near to the Sand and Mutamba Rivers must be kept to an absolute minimum and must be placed as far from these water courses as possible;
- No infrastructure or open pits, except for bridge crossings should encroach into any major drainage lines and the associated riparian zones; 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) as well as fig species.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Chapudi Main and Wildebeest Sections	4	4	3	4	4	8	11	88 (Medium-high)
Chapudi West 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 Socio-cultural Service Provision

To determine feature specific importance in terms of function and service provision, the Sand River, Mutamba River, Moleletsane Stream, 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 which affects the baseflows in the aquifers of the Sand and Mutamba river systems.

Activities potentially 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 loss of base flow in the riverine resources in the area	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
Chapudi Main and Wildebeest Sections	9	4	4	4	5	8	13	117 (High)
Chapudi West 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 GSPC W1 wetland located on the Black Stone Edge farm 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 curtains 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 and Mutamba Rivers 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 in the vicinity of the Sand And Mutamba Rivers 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* as well as fig species.

With Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Chapudi Main and Wildebeest Sections	4	4	3	4	4	8	11	88 (Medium high)
Chapudi West 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 67 indicates the impact summary for the Chapudi Main and Wildebeest sections and Table 68 the impact summery for the Chapudi West 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 67: A summary of the results obtained from the assessment of aquatic ecological impacts for the Chapudi Main and Wildebeest sections

Impact level	Prior to mitigation	Post mitigation
IMPACT 1:Loss of instream flow, aquatic refugia and flow dependent taxa	Very high	Medium high
IMPACT 2: Impacts on water quality affecting aquatic ecology	High	Medium low
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**	**Medium 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 Chapudi main and Wildebeest section of the Chapudi Project is considered to be 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 medium high level impact.

Table 68: A summary of the results obtained from the assessment of aquatic ecological impacts for the Chapudi West section

Impact level	Prior to mitigation	Post mitigation
IMPACT 1:Loss of instream flow, aquatic refugia and flow dependent taxa	Medium low	Low
IMPACT 2: Impacts on water quality affecting aquatic ecology	Medium low	Medium low
IMPACT 3: Loss of Aquatic habitat	Medium low	Medium low
IMPACT 4: Loss of Aquatic Biodiversity and sensitive taxa	Medium 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 Chapudi West section of the project while the impact on the loss of wetland ecoservices is considered to be low. Overall the impact of the proposed Chapudi West section of the Chapudi Project is considered to be moderately low prior to mitigation. If mitigation takes place all impacts except impacts due to impaired water quality and loss of aquatic habitats considered to be low while latter impacts can be considered moderately low. With mitigation the overall impact is considered to be a medium low to low level impact.

The most significant impacts that need to be avoided include:

1. Infrastructure proposed within the GSPC w1 wetland on the Black Stone edge farm need to be avoided completely by moving the infrastructure in this area to an alternate location.
2. All infrastructure planned in the vicinity of the Matumba and Sand Rivers should remain as far as possible form these systems as possible in order to reduce the impact on the systems
3. Any activities which lead to loss of instream flow need to be managed according to the mitigation hierarchy (DMR 2013) as follows:
    a. Avoid
    b. Minimize
    c. Rehabilitate
    d. Offset

7.7.2 Cumulative impacts

The Sand River and to a lesser degree the Mutamba are extremely important systems with these systems 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 both these systems 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. According to DWA (2004), the Nzhelele River is a water stressed region and therefore, the implementation of the ecological Reserve may require compulsory licensing to deal with the over-allocation to the irrigation sector.

The Sand River 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 in the Sand and Mutamba River systems.

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 Chapudi and Generaal projects are likely to contribute to the cumulative impact on the Mutamba River as well as the cumulative impact on the Nzhelele River although some very small impacts on the Limpopo River system may occur.

There will also 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 three projects, should they proceed, in order to ensure that the impact on the Sand River system as well as the Nzhelele River system with special mention of the Mutamba River 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 and ensure the implementation of the ecological reserve. In each phase of the GSP projects 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 Chapudi project, located approximately 30km to the south of Musina within the Limpopo Province.

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 Chapudi project, located approximately 30km to the south of Musina within the Limpopo Province hereafter referred to as the „study area".

<u>The following general conclusions were drawn upon completion of the literature review:</u>

The Chapudi Project Area falls within the Limpopo Plain Ecoregion and is located within the A71J and A80F quaternary catchments and negligibly in the A71H quaternary catchment. The most important systems in the A71 quaternary catchment is the Sand River and the most significant riverine resource within the Chapudi Project area within the A80F quaternary catchment is the Mutamba River, a major tributary of the Nzhelele River. The RSA Wetland Types (2010) and National Freshwater Ecosystem Priority Areas (NFEPA) (2011) databases were consulted to define the ecology of the wetland or river systems within the Chapudi Project Area that may be of ecological importance. Aspects applicable to the Chapudi Project Area and surroundings are discussed below:

- The subWMA is not listed as a fish Freshwater Ecosystem Priority Area (FEPA).
- The portions of the rivers which flow through the Chapudi Project Area are indicated as Upstream Management Areas.
- The Sand River is a perennial system and the Moleletsane River is an ephemeral system. Both rivers are classified as Class B (largely natural) rivers and are not indicated as free flowing or flagship rivers.
- 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 Mutamba River is a perennial system classified as a Class D (largely modified) river
- The Mutamba is not indicated as a free flowing, flagship or FEPA river.
- Several wetland features are located within the Chapudi Project Area. Three different wetland types, valley floor, bench and slope wetlands, occur within the Chapudi Project Area.
- Three wetland features within the Chapudi Project Area (in the western project area) which are indicated as wetland FEPAs. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.
- Two wetland clusters are indicated within the Chapudi Project Area. Wetland clusters are groups of wetlands embedded in a relatively natural landscape. This allows for important ecological processes such as migration of frogs and insects between wetlands.
- No RAMSAR wetlands are located within or close to the Chapudi Project Area.

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

- 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). Three main feature groups are present within the study area, namely depressions (GSPC W1, GSPC W2, GSPC W3 and smaller pans), rivers (Sand River, Mutamba River and Moleletsane Stream) and smaller drainage lines. Within the area several artificial earth dams were also observed, some of which are perennial with others that only seasonally or ephemerally hold surface water and support vegetation adapted to life in saturated soils. The results of the classification of the systems are illustrated in the tables below;
- The riverine resources are of significant importance in terms of wetland function and service provision with special mention of biodiversity as well as water provision to farmers within a water stressed region. Game farming is also the present land use of the majority of the farms investigated with limited areas utilised for crop cultivation, consequently the river systems have remained largely undisturbed and are therefore important in terms of biodiversity value. The Sand River and the Nzhelele River, of which the

Mutamba River is a major tributary, have 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 and Mutamba Rivers 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 significantly impact on the Moleletsane River, Sand River and Mutamba River. 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 Mutamba River. 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 in the aquifers associated with these water courses, 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 adverse impacts on the ecology of the area.
- The Sand and Mutamba rivers are also considered to be of increased significance with regards to biodiversity maintenance due to the presence of fish that would be restricted to river corridors and refugia 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, as a result of the project 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 on the Sand River and a moderate to high risk on the Mutamba River.
- 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 agriculturally 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 limited levels of present impact, which can be considered important in terms of biodiversity conservation;
- GSPC W2 and GSPC W3 as well as smaller 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. 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;
- The results obtained from the assessment of wetland ecoservices 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 Mutamba River and to a lesser degree the Moleletsane Stream. The GSPC W1 wetland on the Black Stone Edge Farm is considered to be a depression feature of high ecological significance while all other depression features in the area are considered to be of lower significance;
- Wet-Health was used to determine the PES of the wetland depressions and pans within the study area. The pans have been impacted by anthropogenic activities, but can still generally be considered to be in good condition and are considered to be important in terms of biodiversity support in the area;
- The VEGRAI ecostatus was used to assess the response of riparian vegetation to impacts within rivers as well as smaller drainage lines. The mean scores calculated for the Sand River, Mutamba River and the Moleletsane River. The Sand River can be defined as a Class C (moderately modified) system with the upper Mutamba river being less impacted in a Class A and B (natural to largely natural) range and the lower area slightly more modified in the Class C (moderately modified) and mean scores calculated for the smaller drainage lines, fall within Class B (largely natural) category. The Moleletsane river was classified as a Class C (moderately modified) system;
- Based on the findings of the study it is evident that from a wetland point of view, the EIS of the river systems are largely similar. All the systems can be defined as Class B systems indicating a high EIS. The Moleletsane River had the lowest EIS with a borderline (B/C) condition indicating a moderate to high EIS. When the aquatic ecology of the Sand River is considered, from where several assessment points are available it is evident that the aquatic ecology of the system is in a poorer condition than the wetland EIS assessment indicates. Based on the consideration of both the wetland EIS and the aquatic

ecostatus indices, the most appropriate EIS for the upper reaches of the Sand River have been defined as a Class B system with the lower areas more likened to a Class D resource.

- The wetland features within the subject property showed a more significant variation in the EIS. The GSPC W1 (Wetland on the Black Stone Edge Farm) had the highest EIS being defined as a Class A system, indicating a very high EIS.
- The GSPC W2 and GSPC W3 wetlands had lower values (Class C) and can be defined as having a moderate EIS. The smaller natural depression wetlands were considered to have a high (Class B) EIS. The artificial wetlands formed through the construction of small earth dams were defined as having a borderline Class C/D EIS indicating a moderate to low EIS.
- 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 License 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;
- The bulk of the mining support structure such as the plant ROM facilities and the associated pollution control facilities are planned in this area on the Black Stone Edge Farm. These activities in the area are likely to severely impact on the GSPC W1 wetland leading to the permanent destruction of the wetland features. Since the infrastructure in this area is not resource dependent, the infrastructure could be moved to an alternative location without compromising on the mining resource. Due to the unique nature of this feature and the biodiversity it supports, with special mention of the known presence of protected species and the high probability of occurrence of other species of conservation concern, it is strongly recommended that the infrastructure be moved from this area to an area which where these activities will have a significantly lower impact on wetland resources;

<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 both the Sand and Mutamba Rivers or 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.
- An overall IHIA score of 86.7% was obtained for the upstream site on the Mutamba River (GSP9) was calculated, defining the system class A (unmodified/natural). Some reductions in integrity are however evident in a downstream direction on the system;
- Habitat diversity and structure was considered highly suitable for supporting a diverse and sensitive aquatic macro-invertebrate community
- 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 between six sites. For five of these sites classifications varied between D and E with only one site achieving a C ecological classification. For site GSP9 (M1 historically) specifically, an ecological classification of D was achieved (compared to C obtained in the current assessment).
- From the fish community assessments it is clear that the EC calculated for the FRAI largely corresponds to that obtained for the MIRAI. Because the habitat (and hence potential drivers) was fairly homogenous between the sites, the refined EC was 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 variation in results may be attributed to the low flows at the time of assessment and potential migratory movement of fish in the system.
- The Sand River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. The Sand River can be considered to be a system of high aquatic Ecological Importance and Sensitivity due to the provision of refugia and in the local area and the support it provides to the aquatic ecology of the area. The system is also deemed important in terms of the provision of services to the terrestrial fauna, such as the provision of drinking water of the area as well as a high significance from a socio-cultural point of view, with special mention of water provision for agriculture. It is deemed essential that all effort is made to ensure that impacts on the Sand River as a result of the proposed Chapudi Project are minimised.
- Based on the findings of the aquatic study the Mutamba River is seen to be a water stressed system with the degree of water stress increasing in a downstream direction. Some recovery of the system does however occur in the lower reaches but impacts on the aquatic ecology of the lower reaches of the system are still considered to be likely. The Mutamba River can be considered to be a system of reduced Ecological Importance and Sensitivity in relation to the Sand River due to the limited provision of refugia and in the local area and the limited support it provides to the aquatic ecology of the area. The system is however deemed important in terms of riparian vegetation habitat and the provision of services to the terrestrial fauna of the area as well as fair significance form a socio-cultural point of view. It is deemed essential that all effort is made to ensure that impacts on the Mutamba River as a result of the proposed Chapudi Project are minimised.

The proposed Chapudi 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 addressing the Chapudi West Section and the Chapudi Main and Wildebeest sections:

- From the results of the impact assessment 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 Chapudi main and Wildebeest section of the Chapudi Project is considered to be 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 medium high level impact.

- From the impact assessment it is evident that prior to mitigation all impacts are moderately low level impacts in the Chapudi West section of the project while the impact on the loss of wetland ecoservices is considered to be low. Overall the impact of the proposed Chapudi West section of the Chapudi Project is considered to be moderately low prior to mitigation. If mitigation takes place all impacts except impacts due to impaired water quality and loss of aquatic habitats considered to be low while latter impacts can be considered moderately low. With mitigation the overall impact is considered to be a medium low to low level impact.
- The Sand River and to a lesser degree the Mutamba are extremely important systems with these systems 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 both these systems 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. According to DWA (2004), the Nzhelele River is a water stressed region and therefore, the implementation of the ecological Reserve may require compulsory licensing to deal with the over-allocation to the irrigation sector.
- The Sand River 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 in the Sand system.
- 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 Chapudi and Generaal projects are likely to contribute to the cumulative impact on the Mutamba River as well as the cumulative impact on the Nzhelele River although some very small impacts on the Limpopo River system may occur.
- There will also 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 three projects, should they proceed, in order to ensure that the impact on the Sand River system as well as the Nzhelele River system with special mention of the Mutamba River 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 and ensure the implementation of the ecological reserve.

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Appendix 1: IHIA data

Sand River

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		
GSP6	July 2013	16	16	12	8	14	3	3	2	7	39.7	D: Largely modified
GSP4	July 2013	16	14	9	7	4	9	2	6	1	48.6	D: Largely modified
GSP3	July 2013	21	12	4	4	12	0	0	0	1	48.0	D: Largely modified
GSP1	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		
GSP6	July 2013	14	13	12	11	9	9	3	2	47.3	D: Largely modified
GSP4	July 2013	13	11	8	7	9	7	1	8	60.0	C: Moderately modified
GSP3	July 2013	12	11	12	19	9	7	19	0	27.1	E: Extensive loss
GSP1	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

Mutamba River

Instream Zone Habitat Integrity

	Weights	14	13	13	13	14	10	9	8	6		
Reach	ASSESSMENT DATE	Water abstraction	Flow modification	Bed modification	Channel modification	Water quality	Inundation	Exotic macrophytes	Exotic fauna	Solid waste disposal	Total Score (%)	Classification
GSP 9	September 2013	0	0	4	6	2	0	0	0	3	93.0	A: Unmodified

None *Small* *Moderate* *Large* *Serious* *Critical*

Riparian Zone Habitat Integrity

	Weights	13	12	14	12	13	11	12	13		
Reach	ASSESSMENT DATE	Vegetation removal	Alien encroachment	Bank erosion	Water abstraction	Flow modification	Channel modification	Water quality	Inundation	Total Score (%)	Classification
GSP 9	September 2013	3	7	7	2	2	2	0	0	80.4	A: Unmodified

None *Small* *Moderate* *Large* *Serious* *Critical*

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
GSP9	September 2013	93.0	80.4	86.7	A: Unmodified

Appendix 2: IHAS Score sheets July 2013 (Mopane section) / September 2013 (Chapudi section)

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)***	>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):				**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 45):					**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 45): 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 45): 35

TOTAL IHAS SCORE (%): 76

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: MATUMBA RIVER
Site Name: GSP9
Date: SEPTEMBER 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): **19**						
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): **0**						
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	**>1**	
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): **14**						
HABITAT TOTAL (MAX 55): **33**						
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): **40**						
TOTAL IHAS SCORE (%): **73**						

Appendix 3: SASS5 Score sheets July 2013 (Mopane section) / September 2013 (Chapudi section)

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**					
MVEG IC: DOM SP:	Baetidae 1sp	4			1		Hydropsychidae 1sp	4					Ancylidae	6				
MVEG 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 (101.7%)	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					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: September 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	Blepharoceridae	15				
SITE CODE: GSP8	**ANNELIDA:**						Gerridae*	5	A			A	Ceratopogonidae	5				
RIVER: MATUMBA RIVER	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A		A	B
SITE DESCRIPTION: UPSTREAM PROJECT	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: WARM DRY/LOW FL	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 25.9 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.35	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 7.51 mg/l	Atyidae	8	A			A	Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 18.4 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: 5 TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC: 5	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: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4	1			1	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	B			B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL: 2	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND: 3	Caenidae	6	A		A	B	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				
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	0	22	79
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		12	0	5	13
	Chlorocyphidae	10	A			A	Petrothrincidae SWC	11					**ASPT:**		6.3	0.0	4	6.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		73%			
	Coenagrionidae	4					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	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					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					