ECOLOGICAL ASSESSMENT AND REHABILITATION PLAN FOR THE PROPOSED UPGRADE OF BRIDGE STRUCTURES TRAVERSING THE SKOENMAKERS RIVER NEAR SOMERSET EAST IN THE EASTERN CAPE

Prepared for

SRK Consulting

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Prepared by:	**Scientific Aquatic Services**
Report authors:	**L. Zdanow (BSC Hons)**
	M. Hanekom
	D. Crafford (Pr. Sci. Nat)
Report Reviewer	**S. van Staden (Pr. Sci. Nat.)**
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Scientific Aquatic Services CC
CK RegNo 2003/078943/23
Vat Reg. No. 4020235273
91 Geldenhuis Road
Malvern East Ext 1
2007
Tel: 011 616 7893
Fax: 011 615 6240/086 724 3132
E-mail: admin@sasenvironmental.co.za

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a wetland and aquatic assessment and to develop a Riparian and Wetland Rehabilitation Plan for the upgrade and construction of bridge structures crossing the Skoenmakers River near Somerset East in the Eastern Cape Province. The portion of the river to be assessed is located to the east of the R400 and to the west of the R335 and will hereafter be referred to as the "study area".

OBJECTIVES:

The following objectives have been set in order to achieve the required ecological management goals and to ensure sustainability of the natural resources associated with the study area:

- To provide guidelines to prevent and manage certain environmental impacts, such as sedimentation, loss of topsoil and erosion of watercourse and wetland resources during the remainder of the construction phase of the development;
- To provide rehabilitation measures to be implemented immediately after construction of the river crossings, including required bank stabilisation and reprofiling, reinstatement of topographical sequences and levelling and reinstatement/protection of indigenous vegetation;
- To provide management measures to be implemented during the post-rehabilitation/operational phases of the development to ensure that no ongoing impacts, such as incision and erosion take place as a result of construction activities in the vicinity of the Skoenmakers River;
- To provide measures to control alien vegetation and maintain soil integrity;
- To ensure adequate riparian vegetation cover within the watercourse and to allow for Albany Broken Thicket and suitable vegetation to be reinstated within riparian and terrestrial areas adjacent to the river crossing affected by the development activities;
- To ensure the ongoing functioning and ecological service provision of the watercourse in the vicinity of the development;
- To ensure that functionality and hydrological characteristics, such as water flow within the watercourse are maintained through provision of measures to ensure that soil wetting conditions upstream and downstream of the river crossing are maintained; and
- To provide suitable monitoring guidelines to ensure the long term sustainability and determine the overall rehabilitation success of the rehabilitation works.

LITERATURE REVIEW

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

- The study area falls within the Great Karoo and Drought Corridor Aquatic Ecoregions and the Fish to Tsitsikama Water Management Area (WMA). The study area is located within the N23A quaternary catchment with an EIS classification of "Moderate", DEMC classification of C (moderately sensitive) and a PEMC classification of E or F (not acceptable).
- The PES/EIS database, as developed by the Department of Water Sanitation (DWS) and Resource Quality Services (RQS) department, was utilised to obtain additional background information on the project area:
  - The system has low to moderate levels of aquatic biodiversity;
  - Habitat flow sensitivity is considered high with mean low-flow width about 4 m. The Skoenmakers River can thus be classified as a narrow-sized river (2.5 to 5.0 m);
- The National Freshwater Ecosystem Priority Areas (NFEPA) database was consulted to define the aquatic ecology of the wetland systems close to or within the study area that may be of ecological importance.
  - Five channelled valley bottom wetlands are associated with the River;
  - Channelled valley bottom wetlands are indicated to be in AB (good or natural) and C (moderately modified) conditions (Figure 4) and three of the features associated with the western portion of the study area are indicated as FEPA wetlands. However, no bridge structures will traverse these wetland areas.

- The BSP of the study area has indicated that:
  - The majority of the study area is located within a Critical Biodiversity Area (CBA) which is associated with the Skoenmakers River; and
  - CBAs are terrestrial and aquatic areas which must be safeguarded in their natural or near-natural state as they are critical for conserving biodiversity and maintaining ecosystem functioning.

WETLAND ASSESSMENT

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

- Although the majority of the Skoenmakers River is classified as a riparian system, small, isolated wetland areas are associated with the system. These wetland areas include seep wetlands, channelled valley bottom features and artificial depressions;
- The function and service provision was calculated for wetland features associated with the study area. Wetland features are considered to provide an intermediate level of ecological function and service provision;
- The PES of wetland features was determined using the Index of Habitat Integrity (IHI) methodology. Wetland features associated with the study area are considered to be in a Category D condition (Largely modified, a large loss of natural habitat, biota and basic ecosystem functions has occurred);
- The EI was calculated for wetland features. Wetland features associated with the Skoenmakers River have an EIS falling within Category B (High - features that are considered to be ecologically important and sensitive);
- Should the proposed bridge upgrades prove feasible an appropriate and achievable REC for the portions of the Skoenmakers River to be affected is deemed to be Category C (moderately modified);

AQUATIC ASSESSMENT

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

Physico-chemical water quality data

- EC concentrations recorded correspond with historical data.
- Spatially, the EC level decreases by 23.6% between Sites SM1 and SM2 in a downstream direction. This is considered a positive change toward more natural conditions and may indicate that, within the system assessed, agricultural impact diminishes in a downstream direction.
- However, current sampling efforts cannot substantiate such a general statement and such a trend would need to be confirmed and monitored employing additional assessments in future.
- The pH levels at both sites were very similar, increasing by 3.7% in a downstream direction. The change is in compliance with guidelines.
- Temperatures can be regarded as normal for the time of year and time of day when assessment took place. The slight variation between the sites can be ascribed to natural diurnal variation between sampling times.

Intermediate Habitat Integrity Assessment

The general habitat integrity of the system as a whole can be considered “largely modified” (Class D). The system achieved 51.2% for instream integrity, 47.8% for riparian zone integrity and an overall IHIA rating of 49.5%. Instream impacts included small impacts on channel modifications and moderate impacts on water abstraction, water quality and exotic fauna. Large impacts on bed modification and inundation were evident with flow modification regarded a serious impact. Small impacts on the riparian environment included water abstraction and water quality, whilst moderate impacts included vegetation removal, alien vegetation encroachment and inundation. Flow and channel modifications were considered large impacts whilst bank erosion was considered a serious impact. The majority of large and serious impacts (such as flow modification and inundation) pertains to, or are the result of (for example erosion), the inter-basin water transfer scheme operation. Overall the habitat integrity was classified as Class D indicating largely modified conditions.

Invertebrate Habitat Assessment System (IHAS)

- Overall habitat conditions at both sites can be considered inadequate to support a diverse and sensitive macro-invertebrate community at the time of assessment. Thus, an aquatic macro-invertebrate community of limited diversity and sensitivity can be expected at these points during the current assessment.
- Some variation in habitat suitability for aquatic macro-invertebrates is evident between sites in terms of substrate types available. This is likely to influence the macro-invertebrate community structure to some degree during the current assessment. These observations will aid in the interpretation of the SASS data variation between the sites.

South African Scoring System 5 (SASS5)

- The SASS5 data at Sites SM1 and SM2 indicates that the aquatic macro-invertebrate community has suffered a significant loss in integrity throughout the area when compared to the reference score derived from taxa expected in the system;
- The aquatic macro-invertebrate community integrity at both Sites SM1 and SM2 may presently be classified as being in a severely impaired condition (Class E) according to the Dickens & Graham (2001) classification system;
- Spatially, the SASS5 score decreases by 25.7% between Sites SM1 and SM2, and the ASPT score increases by 18.2%. This indicates that no negative impact on the diversity or sensitivity of the macro-invertebrate community is likely to be occurring in a downstream direction;
- Instream and riparian habitat limitations and lack of diversity are also likely to have contributed to the low scores at both sites. The lack of aquatic vegetation available for sampling as well as steep banks with limited cover in the form of fringing vegetation within the system are very likely to result in limited colonisation by suitably-adapted macro-invertebrates;
- The lower IHAS score recorded from SM2 when compared to SM1 correlates with a lower SASS5 score at the former site;
- According to the MIRAI, both sites SM1 and SM2 are in a D (Largely impaired) state.

Fish biota and habitat for fish

- Both slow-shallow and fast-deep conditions dominate the system.
- As variation in both depth (shallow and deep conditions) and flow speed (slow and fast conditions) is evident, a diverse fish community may be expected at sites SM1 and SM2.
- However, fish that require fast-flowing rapid or riffle habitat (fast-shallow conditions) and hence demonstrate a high intolerance for deep or slow conditions, are expected to be less abundant.
- The EC calculated for the FRAI (D/E) corresponds well to that obtained for the MIRAI (D).
- Based on these observations it is evident that this segment of the Skoenmakers River is of limited ecological importance to fish as it is mostly characterised by "naturalised endemic" fish species transferred from the Orange River system by the IBT.

Aquatic EIS determination

Based on the findings of the assessment it is evident that aquatic features associated with the Skoenmakers River have an EIS falling within Category C. This is described as: "Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged".

Aquatic assessment synopsis

The following summary table provides an overview of aquatic assessment results:

Site	IHIA	IHAS	SASS5	MIRAI	FRAI	VEGRAI*	IHIA	EIS
SM1	C	Inadequate	E	D	D/E	D	D	C
SM2	C	Inadequate	E	D	D/E			

REHABILITATION

A Riparian and Wetland Rehabilitation Plan including management measures was developed to effectively manage, maintain and improve the ecological characteristics of the study area. Key management factors identified in the rehabilitation plan were the:

- Minimisation of impacts from the proposed construction activities;
- Reshaping and levelling of rehabilitated areas to resemble pre-construction environments as far as possible;
- Reconstruction of river banks to tie in with existing river banks;
- Re-vegetation of disturbed areas;
- Measures to prevent erosion and sedimentation of aquatic resources;
- Alien plant species control within the construction footprint and surrounding areas;
- Removal of all construction material within the riparian and wetland areas upon decommissioning; and
- Re-profiling and sloping of areas at risk of erosion and incision as a result of construction activities in order to maintain the ecological functionality.

The measures as set out in the Riparian and Wetland Rehabilitation Plan are deemed sufficient for the conservation of ecological processes and provide a tool for managing and improving the current ecological state of the area in the vicinity of the river crossings. If the measures as set out in the rehabilitation plan are adhered to, ecological processes within the area will not only re-establish, but also allow for the continued improvement of the functionality of the wetland and watercourse system. If these measures are implemented along with measures to minimise implementation/construction and post-rehabilitation/operational footprint areas within the watercourse and wetland areas, impacts on the system can be adequately minimised.

IMPACT ASSESSMENT

There are three major impacts that have an impact on the overall riparian and wetland ecology of the study area and five major impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed bridge crossings. The tables below summarise the findings indicating the significance of the impacts before mitigation takes place as well as the significance of the impacts if appropriate management and mitigation takes place.

Table A: Summary of impact significance of the bridge upgrade project on the Skoenmakers River from an aquatic assessment perspective.

No.	Impact	Design Phase		Implementation/ Construction		Post Rehabilitation/ Operational	
		Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation
1	Impact on riparian and wetland habitat and ecological structure	LM (-)	L (-)	LM (-)	LM (+)	H (-)	L (-)
2	Impact on riparian and wetland function and socio-cultural service provision	LM (-)	L (-)	LM (-)	LM (+)	H (-)	L (-)
3	Impact on riparian and wetland hydrological function and sediment balance	LM (-)	L (-)	LM (-)	LM (+)	MH (-)	VL (-)

VL = Very low; L = Low; LM = Low-medium; MH = Medium-high; H = High

Table B: Summary of impact significance of the bridge upgrade project on the Skoenmakers River from an aquatic assessment perspective.

No.	Impact	Design Phase		Implementation/ Construction		Post Rehabilitation/ Operational	
		Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation
1	Impact on in-stream flow and hydrological function	LM	L	MH	L	H	L
2	Changes to in-stream habitat and loss of aquatic habitat	MH	L	LM	L	MH	L
3	Impacts on in-stream biota and loss of aquatic biodiversity and sensitive taxa	LM	VL	LM	VL	LM	L
4	Impacts on stream connectivity and migratory taxa	LM	L	LM	L	MH	L
5	Impacts on water quality affecting aquatic ecology	LM	VL	LM	VL	LM	VL

VL = Very low; L = Low; LM = Low-medium; MH = Medium-high; H = High

The design phase has bearing on both the implementation/construction and post-rehabilitation/operational phases, as recommendations drafted during the former needs to be applied in the implementation/construction phase, with largely permanent implications in the post-rehabilitation/operational phase.
As a result mitigatory measures highlighted during the design phase should also be consulted during the other phases. Envisioned impacts during the design phase are largely low-medium to medium-high before mitigation but very low to low after mitigation.

Impacts encountered during the implementation/construction phase are often more significant or severe, but shorter in duration, than those generally encountered in the post-rehabilitation/operational phase of any proposed development. However, in the case of in-stream alterations the impacts during the post-rehabilitation/operational phase are often scored as permanent and this translates into a higher impact score.

Envisioned aquatic impacts during the implementation/construction phase are largely low-medium to medium-high before mitigation but very low to low after mitigation. Envisioned riparian and wetland impacts during the construction phase are largely low-medium before mitigation. However, rehabilitation measures implemented during the implementation/construction phase are likely to result in an increase in the PES of River crossing areas and impacts are therefore considered to be low-medium positive after mitigation.

Envisioned impacts during the operational phase are largely low-medium to high before mitigation but very low to low after mitigation. As mentioned the high impact score pertains to the fact that any impacts resulting from structural sources will be permanent.

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1 INTRODUCTION

Scientific Aquatic Services (SAS) was appointed to conduct a wetland and aquatic assessment and to develop a Riparian and Wetland Rehabilitation Plan for the upgrade and construction of bridge structures crossing the Skoenmakers River near Somerset East in the Eastern Cape Province. The portion of the river to be assessed is located to the east of the R400 and to the west of the R335 and will hereafter be referred to as the "study area".

The study area is considered to be environmentally sensitive due to the presence of the Skoenmakers River and associated riparian and wetland areas and therefore due care needs to be taken during the construction of the river crossing and in rehabilitation of the area.

Throughout the design, implementation/construction and post-rehabilitation/operational phases of the river crossing development, the watercourse present in the vicinity thereof needs to be managed in such a way as to ensure that the functionality of the system, with special mention of the need to ensure that hydrological, ecological and geomorphological functioning is maintained or reinstated at a suitable level in order to prevent permanent degradation of the environment both within the study area and in areas further downstream in the catchment.

This report presents the delineation of the riparian and wetland resources in the study area and provides a summary of the Present Ecological State (PES), the Ecological Importance and Sensitivity (EIS), and the function and service provision associated with the Skoenmakers River and associated riparian and wetland areas. In addition, a long term rehabilitation programme, covering all development phases has been developed in order to restore the Skoenmakers River watercourse to environmentally acceptable conditions and includes the rehabilitation of disturbed and degraded riparian areas associated with bridge structures to restore and upgrade the riparian habitat integrity from its present state to sustain a biodiverse riparian and aquatic ecosystem.

Furthermore, the purpose of this report, after consideration of the structure, function, integrity and service provision of the watercourse in its current state, is to guide the relevant authorities, management and bodies associated with the river crossing development as to the management of the ecological attributes of the watercourse and surrounding natural terrestrial areas.

Impacts on the riparian area will be defined, as well as measures and expected timeframes to rehabilitate the impacts to levels suitable to ensure the ongoing and improved functioning of the riparian resources at the desired REC.

As a result, the following objectives have been set in order to achieve the required ecological management goals and to ensure sustainability of the natural resources associated with the study area:

- To provide guidelines to prevent and manage certain environmental impacts, such as sedimentation, loss of topsoil and erosion of watercourse and wetland resources during the remainder of the construction phase of the development;
- To provide rehabilitation measures to be implemented immediately after construction of the river crossings, including required bank stabilisation and reprofiling, reinstatement of topographical sequences and levelling and reinstatement/ protection of indigenous vegetation;
- To provide management measures to be implemented during the post-rehabilitation/operational phases of the development to ensure that no ongoing impacts, such as incision and erosion take place as a result of construction activities in the vicinity of the Skoenmakers River;
- To provide measures to control alien vegetation and maintain soil integrity;
- To ensure adequate riparian vegetation cover within the watercourse and to allow for Albany Broken Thicket and suitable vegetation to be reinstated within riparian and terrestrial areas adjacent to the river crossing affected by the development activities;
- To ensure the ongoing functioning and ecological service provision of the watercourse in the vicinity of the development;
- To ensure that functionality and hydrological characteristics, such as water flow within the watercourse are maintained through provision of measures to ensure that soil wetting conditions upstream and downstream of the river crossing are maintained; and
- To provide suitable monitoring guidelines to ensure the long term sustainability and determine the overall rehabilitation success of the rehabilitation works.

The Riparian and Wetland Rehabilitation Plan is discussed as three separate sections. The Design Phase Rehabilitation Plan contains measures which are to be implemented as part of the design phase of the development.

The Implementation/Construction Phase Rehabilitation Plan contains measures which are to be implemented immediately and as part of the construction phase of the development. Lastly the Post-rehabilitation/Operational Phase Plan is to be implemented upon completion of construction and rehabilitation works.

The measures as set out in this report are deemed sufficient to manage and improve the ecological resources of the system to a point where the resource can be sustainably utilised, and funds must be set aside to cover costs of these rehabilitation actions.

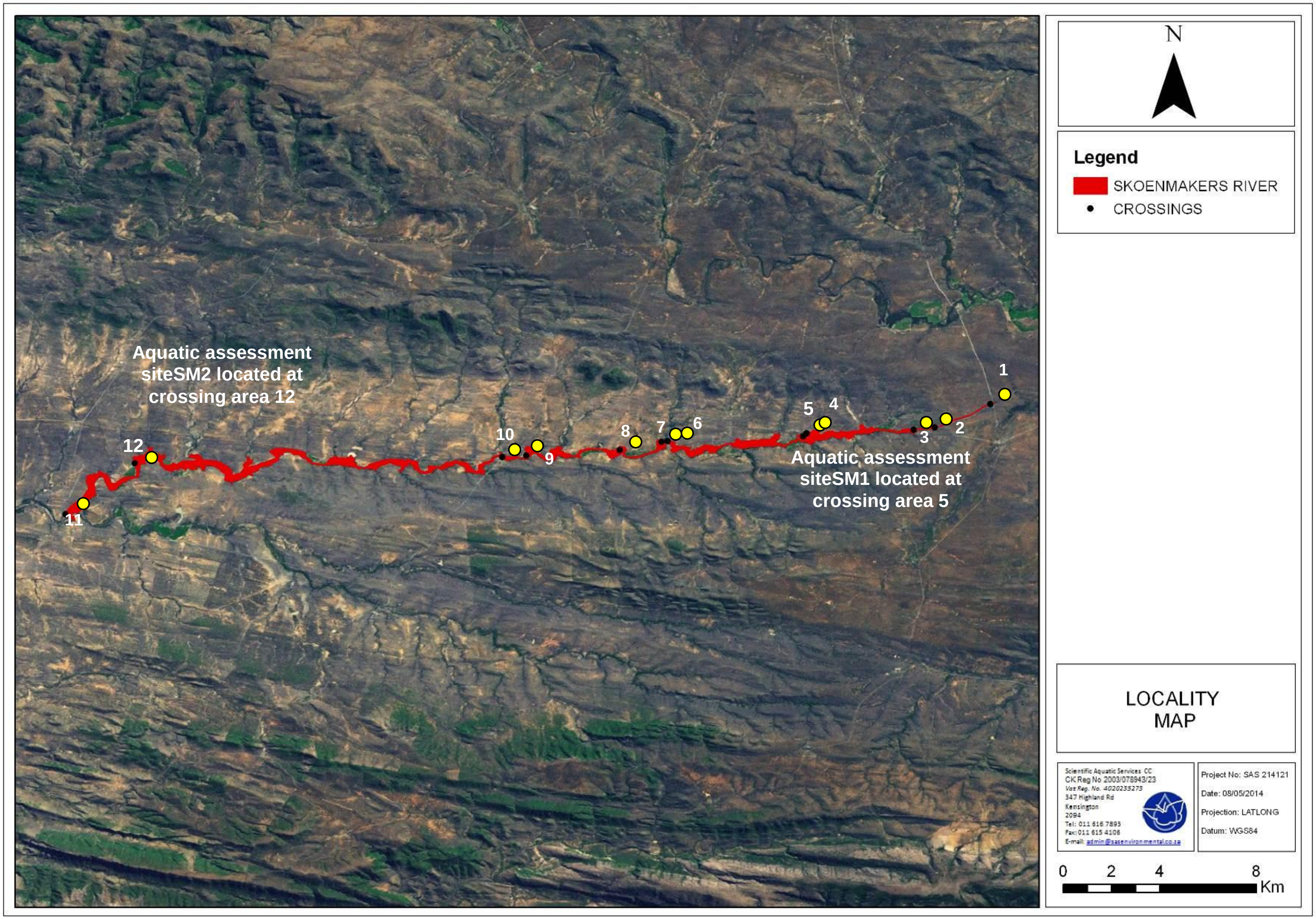

Figure 1: Digital satellite image depicting the location of the Skoenmakers River with associated crossing areas (1 to 12) and aquatic assessment sites SM1 and SM2(crossing areas 5 and 12 respectively).

1.1 Scope

Specific outcomes in terms of this report are as follows:

<u>Wetland Assessment</u>

- Classify freshwater features according the Classification System for Wetlands and other Aquatic Ecosystems in South Africa as defined by Ollis *et al*., 2013;
- Define the function and services provided by the resources on the study area according to the Method of Kotze *et al* (2008);
- Determine the Present Ecological State (PES) according to the the Index of Habitat Integrity (IHI) for South African floodplain, channelled and channelled valley bottom wetland types (DWAF Resource Quality Services, 2007);
- Delineate the riparian zone according to "DWA (Department of Water Affairs), 2005: A practical Guideline Procedure for the Identification and Delineation of Wetlands and Riparian Zones";
- Determine the EIS according to the method as adapted from Harding (2013);
- Advocate a Recommended Ecological Category (REC) for the river feature based on the findings of the EIS assessment;
- Identify wetland features located further from the proposed footprint that will still fall within the 500 m boundary of applicability of General Notice no. 1199 as it relates to the National Water Act (NWA, Act 36 of 1998).

<u>Aquatic Assessment</u>

- The aquatic assessment will include a survey of general habitat integrity, habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity as well as fish community integrity;
- The protocols of applying the indices will be strictly adhered to and all work will be done by a South African River Health Program (SA RHP) accredited assessor;
- Representative aquatic ecological assessment points will be identified which will be used to define the PES of the riverine features in the vicinity of the bridge options and proposed infrastructure; and
- The aquatic assessment section of this report will serve to document the condition at the time of sampling to indicate the state of the riverine ecological integrity.

1.2 Assumptions and limitations

The following assumptions and limitations are applicable to this report:

- The assessment is confined to the study area as per Figure 1 and does not include the neighbouring and adjacent properties, these were however considered as part of the desktop assessment;
- Due to the extent of the study area, use was made of aerial photographs, digital satellite imagery as well as provincial and national wetland databases to delineate riparian zones and wetland features. However, the boundaries of the riparian and wetland areas associated with bridge crossing areas were verified during the site assessment;
- Temporal variability: The data presented in this report are based on a single site visit, undertaken in May 2014. The effects of natural seasonal and long-term variation in the ecological conditions are therefore unknown, however the results obtained are deemed sufficient to provide an accurate indication of the EIS of the wetland features;
- Global Positioning System (GPS) technology is inherently inaccurate and some inaccuracies due to the use of handheld GPS instrumentation may occur. If more accurate assessments are required the wetland will need to be surveyed and pegged according to surveying principles;
- 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 boundary may occur however if the DWA 2005 method is followed, all assessors should get largely similar results; and
- With wetland ecology being dynamic and complex, some aspects (some of which may be important) may have been overlooked.

1.3 Indemnity and Terms of Use of this Report

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

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1.4 Legislative requirements

National Environmental Management Act (NEMA, Act 107 of 1998)

- The National Environmental Management Act (NEMA, 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 DWA; and
- Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from DWA in terms of Section 21.

General Notice 1199 as published in the Government Gazette 32805 of 2009 as it relates to the NWA (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 or estuary.

2 METHOD OF ASSESSMENT

The scope of work included a literature review, followed by a site assessment undertaken in May 2014. Delineation of the riparian and wetland boundary took place according to “DWAF, 2005: A practical Guideline Procedure for the Identification and Delineation of Wetlands and Riparian Zones”. Aspects such as topography, vegetation and alluvial soils were used to delineate the riparian and wetland areas according to the guidelines. The buffer zone was then delineated around the riparian and wetland zones. The riparian and wetland classification assessment was undertaken according the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems (Ollis *et al*., 2013). In addition the IHI for South African floodplain, channeled and unchannelled valley bottom wetland types was used to determine the PES of the system (DWAF Resource Quality Services, 2007). Ecological and socio-economic service provision (Kotze *et al.* 2008) and the EIS of wetland features were also determined. Please refer to Appendix A for an explanation of the wetland method of assessment used.

During the assessment, note was made of current impacting activities which affect the riparian and wetland areas, as well as historical impacts and impacts that may potentially further affect the riparian and wetland areas as a result of the river crossing construction activities. Special attention was paid to the re-vegetation of areas within the watercourse and wetland boundary which have been affected by the river crossing development, reinstatement of streambanks and the re-profiling of the soil profiles in the vicinity of the stream diversion and downstream areas which are at risk from erosion and incision as a result of the development activities, with the aim of restoring the functionality and habitat integrity of the watercourse and wetland system.

Two aquatic assessment sites, upstream site SM1 located at bridge crossing 5, as well as downstream site SM2 located at bridge crossing 12, were selected which are considered representative of the segment of the river under investigation. Factors considered during the aquatic assessment were visual assessment of condition, *in situ* biota specific water quality at all three sites, habitat integrity and suitability for aquatic macro-invertebrates, macro-invertebrate and fish community integrity at both up and downstream sites. Details on the various indices employed are also provided in Appendix A.

3 RESULTS

3.1 Literature Review

3.1.1 Ecoregions

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

The study area falls within the Great Karoo and Drought Corridor Aquatic Ecoregions and the Fish to Tsitsikama Water Management Area (WMA). This database was used as reference for the catchment of concern in order to define the EIS, PEMC and DEMC. Figure 2 below indicate the aquatic ecoregion and quaternary catchments of the study area:

The study area is located within the N23A quaternary catchment. The results of the assessment are summarised in the table below.

Table 1: Summary of the ecological status of quaternary catchment N23A based on Kleynhans 1999.

Name	Rivers	EIS	DEMC	PEMC
N23A	Main Sundays (dam)	Moderate	C: Moderately Sensitive Systems	CLASS E or F: not acceptable

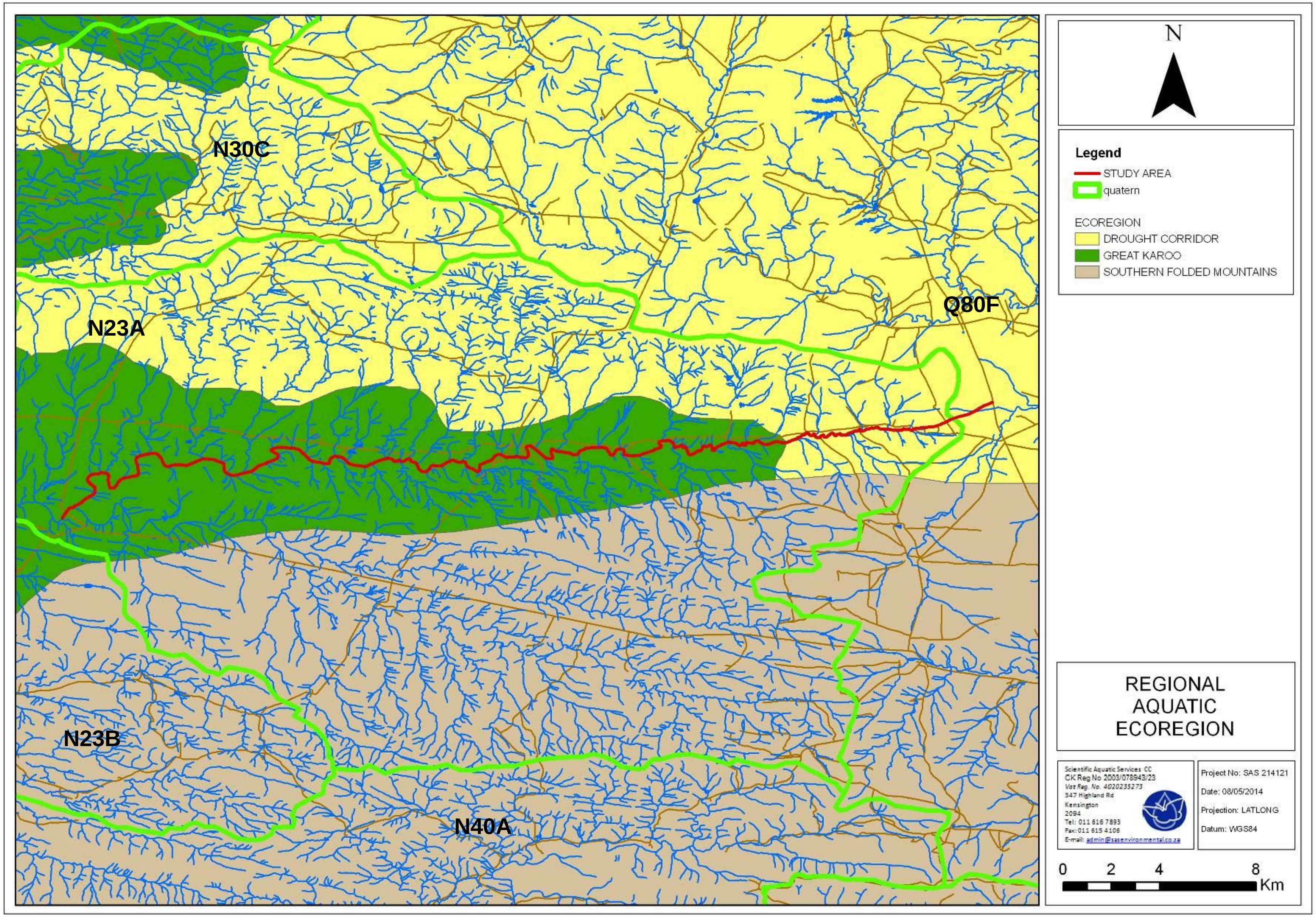

Figure 2: Ecoregion and quaternary catchment associated with the Study area.

3.1.2 Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database

The PES/EIS database, as developed by the DWS RQS department, was utilised to obtain additional background information on the project area. The PES/EIS database has been made available to consultants since mid-August 2014. The information from this database is based on information at a sub-quaternary catchment reach (subquat reach) level with the descriptions of the aquatic ecology based on the information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, EWR sites and Hydro WMS sites. In this regard information for sub-quaternary catchment reach (SQR) N23A-08164 (Skoenmakers) is applicable. Key information on background conditions within the study area, as contained in this database and pertaining to the Present Ecological State (PES), ecological importance and ecological sensitivity for the Skoenmakers River, is tabulated in Table 2. From the assessment of the PES/EIS data, the following points are highlighted which summarise the data:

The system has low to moderate levels of aquatic biodiversity. The following macro-invertebrate families have been recorded from this point

- Coelenterata;
- Oligochaeta;
- Baetidae (1 sp);
- Libellulidae;
- Cramnidae (Pyrilidae);
- Corixidae.
- Naucoridae;
- Notonectidae;
- Pleidae;
- Veliidae/Mesoveliidae;
- Dytiscidae;
- Gyrinidae.
- Hydroptilidae;
- Ceratopogonidae;
- Chironomidae;
- Culicidae;
- Simuliidae and
- Tabanidae.

Table 2: Summary of the ecological status of the sub-quaternary catchment (SQ) reach N23A-08164 (Skoenmakers) based on the DWS RQS PES/EIS database

Synopsis (SQ reach N23A-08164 Skoenmakers)					
PES[1] category median	**Mean EI[2] class**	**Mean ES[3] class**	**Length**	**Stream order**	**Default EC[4]**
C	High	Moderate	40.7 km	1.0	B
PES details					
Instream habitat continuity MOD		Large	**Riparian/wetland zone MOD**		Small
RIP/wetland zone continuity MOD		Small	**Potential flow MOD activities**		Large
Potential instream habitat MOD activities		Moderate	**Potential physico-chemical MOD activities**		Small
EI details					
Invertebrate taxa/SQ		18.00	**Invertebrate average confidence**		1.33
Invertebrate representivity per secondary class		High	**Invertebrate rarity per secondary class**		High
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		Low	**Habitat diversity class**		Low
Habitat size (length) class		Very high	**Instream migration link class**		Moderate
Riparian-wetland zone migration link		Very high	**Riparian-wetland zone habitat integrity class**		Very high
Instream habitat integrity class		High	**Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m**		Very high
Riparian-wetland natural vegetation rating based on expert rating					Low
ES details					
Invertebrates physical-chemical sensitivity description		Very high	**Invertebrates velocity sensitivity**		Very high
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description					Low
Stream size sensitivity to modified flow/water level changes description					High
Riparian-wetland vegetation intolerance to water level changes description					Low

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.

In terms of PES, the SQR can be considered a small, non-perennial upper catchment reach characterised by numerous in-channel dams and weirs. The SQR experiences little cultivation with largely natural riparian/wetland zones and continuity between these zones. However, some sheet erosion is evident and physico-chemical impacts are expected due to flow modifications.

With reference to habitat conditions, the SQR is typically characterised by a moderate gradient river with cobble/bedrock pools as well as rapids/riffles. Habitat flow sensitivity is considered high with mean low-flow width about 4 m. The Skoenmakers River can thus be classified as a narrow-sized river (2.5 to 5.0 m). Whilst width-flow sensitivity is considered high, length-flow sensitivity is considered low, translating in an overall medium size/habitat flow sensitivity rating. Whilst instream vertebrates (excluding fish) are either highly mobile or not solely dependent on water, plant species are mostly tolerant and adapted to both no/low flow conditions and flooding events.

For FRAI assessments information on expected fish fauna were gleaned from fish community data available for the Skoenmakers SQR, as well as an MSc dissertation (Traas 2009) entitled "The conservation and management of the fresh water fishes in the greater Addo Elephant National park". A list of expected fish species is provided in Appendix A.

3.1.3 National Freshwater Ecosystem Priority Areas (NFEPAs; 2011)

The National Freshwater Ecosystem Priority Areas (NFEPA) database was consulted to define the aquatic ecology of the wetland systems close to or within the study area that may be of ecological importance.

Aspects applicable to the study area are discussed below:

- The study area falls within the Fish to Tsitsikama Water Management Area (WMA). 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 study area is the Sundays subWMA;
- The subWMA is not regarded as important with regards to fish migrational corridors, fish translocation or fish rehabilitation;
- The Skoenmakers River is a perennial river that is classified as a system in a Category E-F condition (Not acceptable). The river is not a flagship river, is not free flowing and is not indicated as a Freshwater Ecosystem Priority Area (FEPA) River;
- The wetland vegetation group indicated for the stretch of river is the Lower Nama Karoo vegetation group which is classified as a critically endangered;
- Five channelled valley bottom wetlands are associated with the River;
- Channelled valley bottom wetlands are indicated to be in AB (good or natural) and C (moderately modified) conditions (Figure 3) and three of the features associated with the western portion of the study area are indicated as FEPA wetlands (Figure 4). However, no bridge structures will traverse these wetland areas.

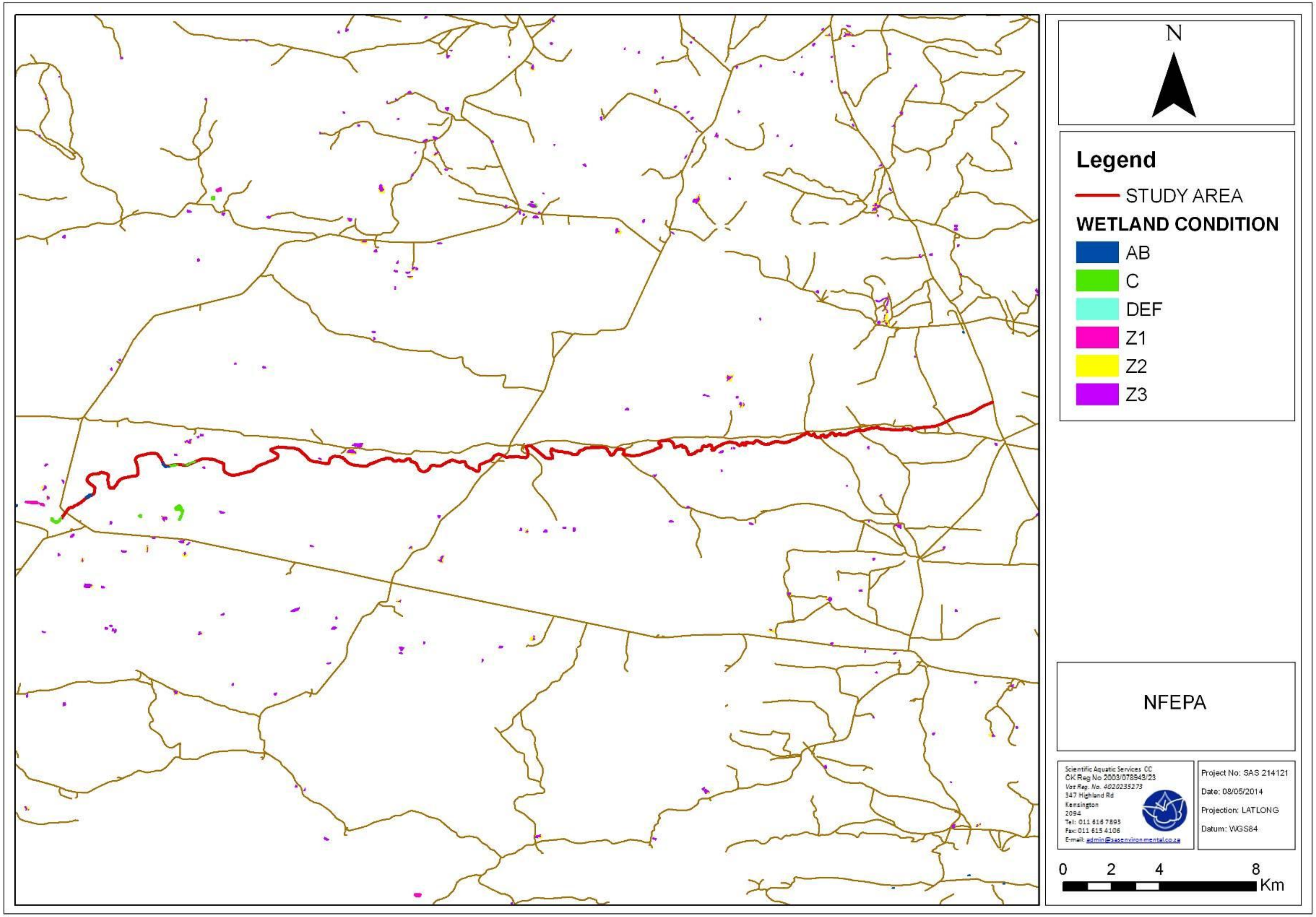

Figure 3: Wetland condition indicated by the NFEPA database.

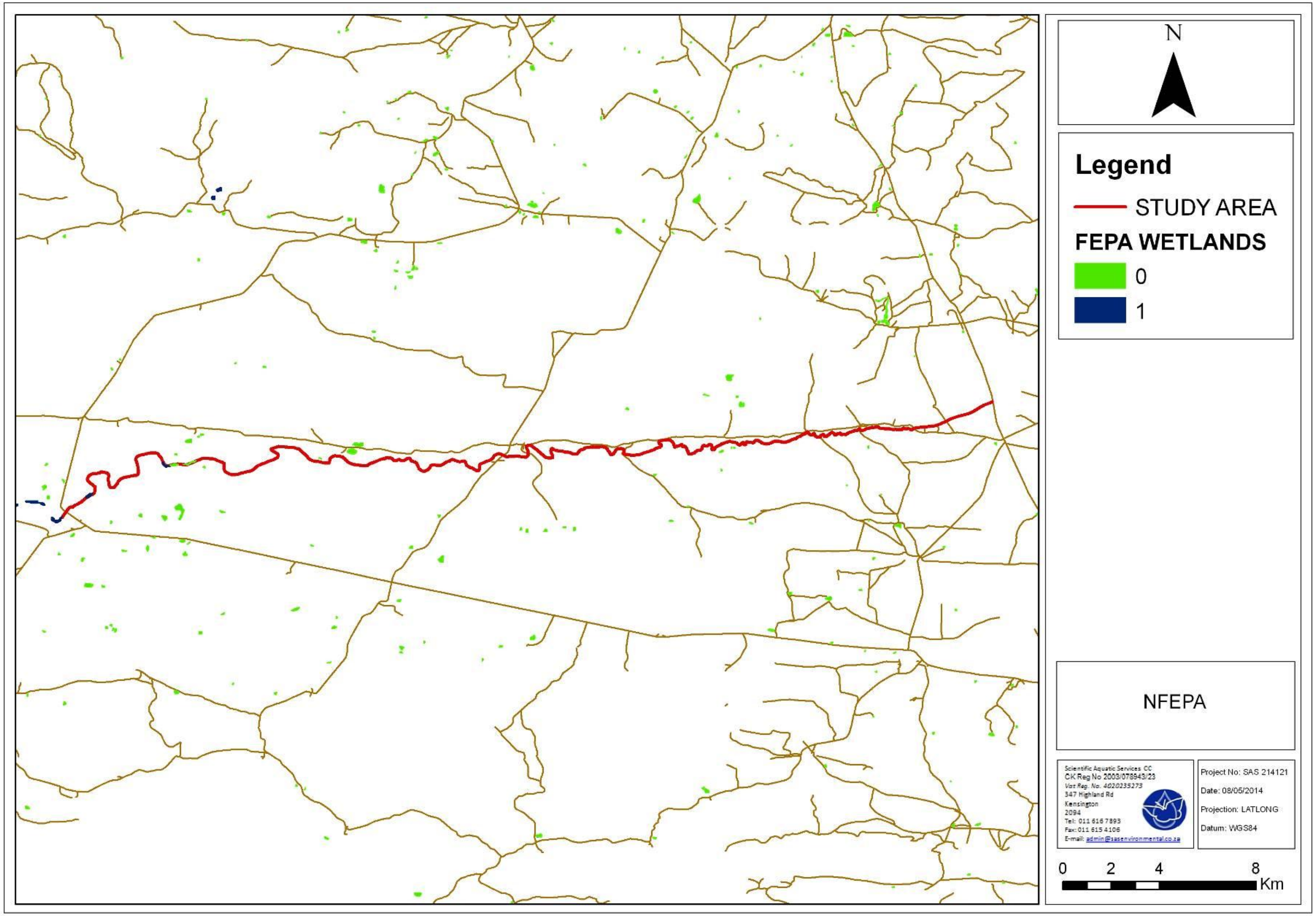

Figure 4: FEPA wetlands (1= FEPA wetland, 2= non-FEPA wetland).

3.1.4 Importance According to the Addo Biodiversity Sector Plan (ABSP; 2012)

The Addo Biodiversity Sector Plan (BSP) is intended to guide land-use planning, environmental assessments and land-use authorisations, as well as natural resource management, in order to promote the sustainable development agenda. The BSPs have been developed to further the awareness of the areas unique biodiversity, the value this biodiversity represents to people and to promote management mechanisms that can ensure the protection and sustainable utilization of the regions biodiversity.

The BSP of the study area has indicated that:

- The majority of the study area is located within a Critical Biodiversity Area (CBA) which is associated with the Skoenmakers River (Figure 5);
- CBAs are terrestrial and aquatic areas which must be safeguarded in their natural or near-natural state as they are critical for conserving biodiversity and maintaining ecosystem functioning;
- The western portion of the study area is located on the border of the Addo Elephant National Park which is a national protected area (Figure 5).

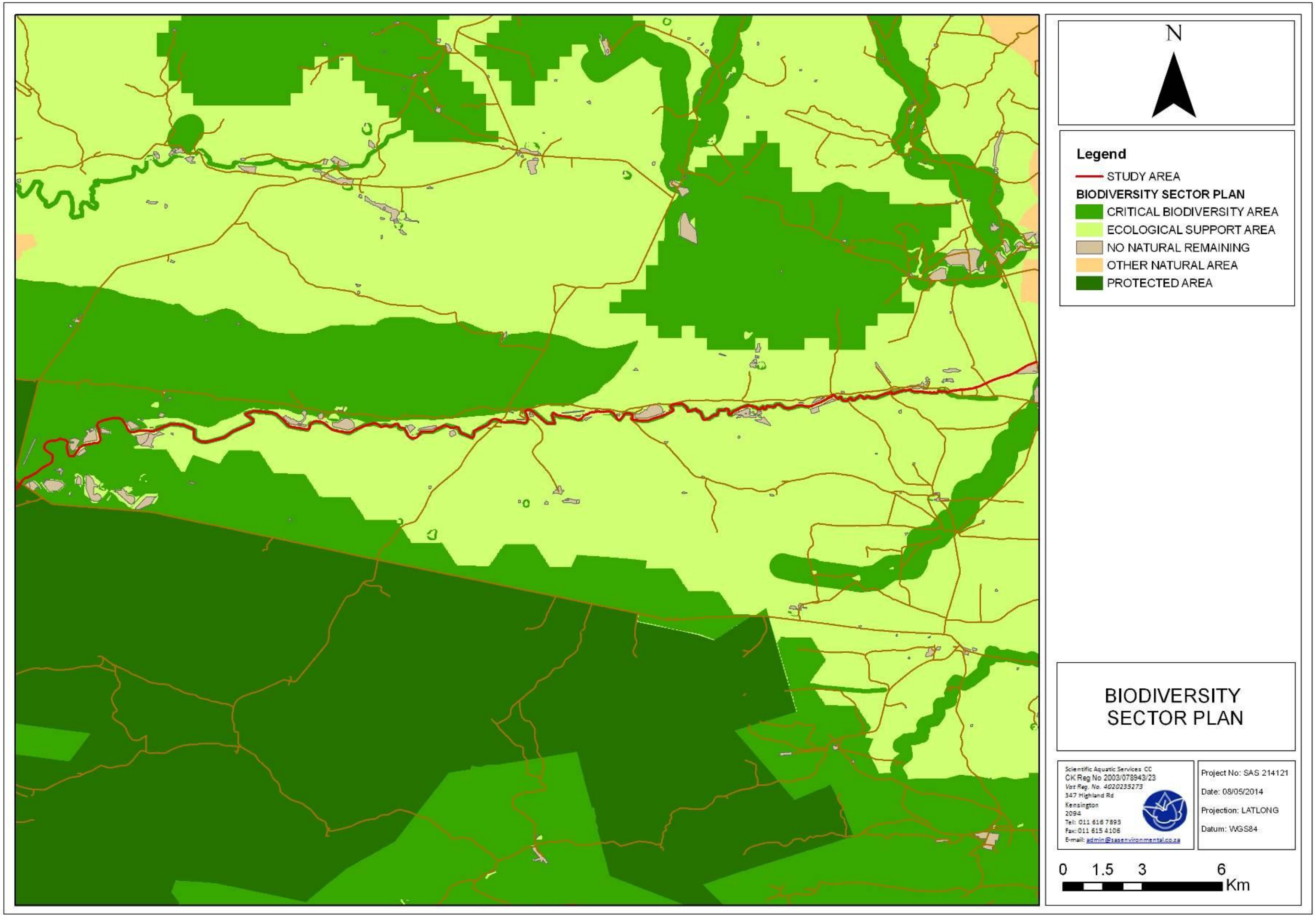

Figure 5: Critical Biodiversity Areas and Ecological Support Areas associated with the study area.

3.2 Characterisation of Wetland Features

The wetlands within the study area were categorised with the use of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis *et al,* 2013). Wetland features associated with the study area are indicated in Figures 6, 7 and 8 below.

Table 3: SANBI 2013 Classification of the Skoenmakers River.

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 subject property falls within the Great Karoo and Drought Corridor Ecoregion and the Lower Nama Karoo wetland vegetation group (NFEPA WetVeg).	Plain: An extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land.	River: a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.	Lowland river with distinct active channel present.

Table 4: SANBI 2013 Classification of seep wetlands.

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 subject property falls within the Great Karoo and Drought Corridor Ecoregion and the Lower Nama Karoo wetland vegetation group (NFEPA WetVeg).	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.	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	With channelled outflow

Table 5: SANBI 2013 Classification of channeled valley bottom wetlands

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 Great Karoo and Drought Corridor Ecoregion and the Lower Nama Karoo wetland vegetation group (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 – A valley bottom wetland with a river channel running through it.	N/A

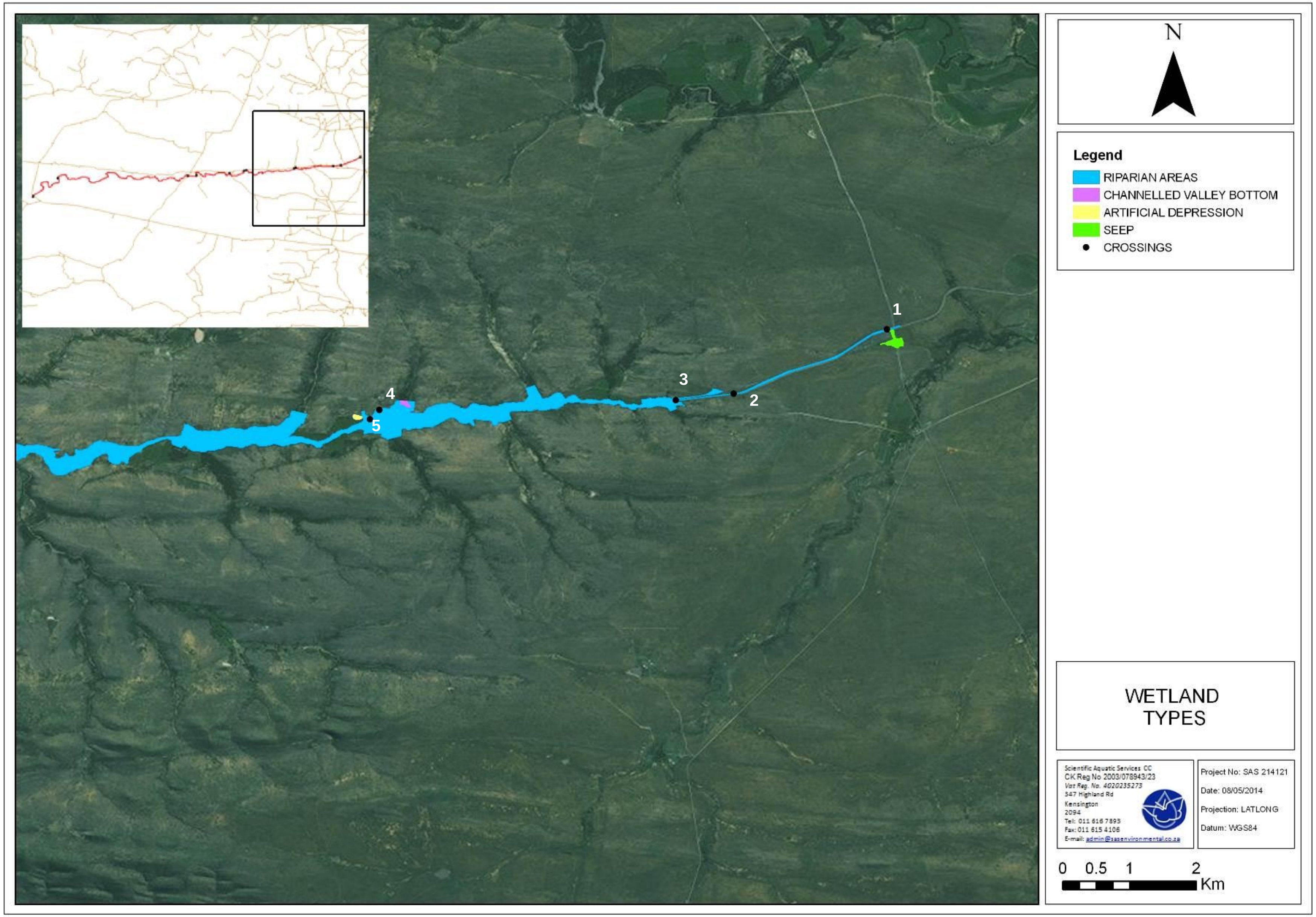

Figure 6: Riparian areas and wetland types associated with each of the proposed crossing areas (eastern portion of study area).

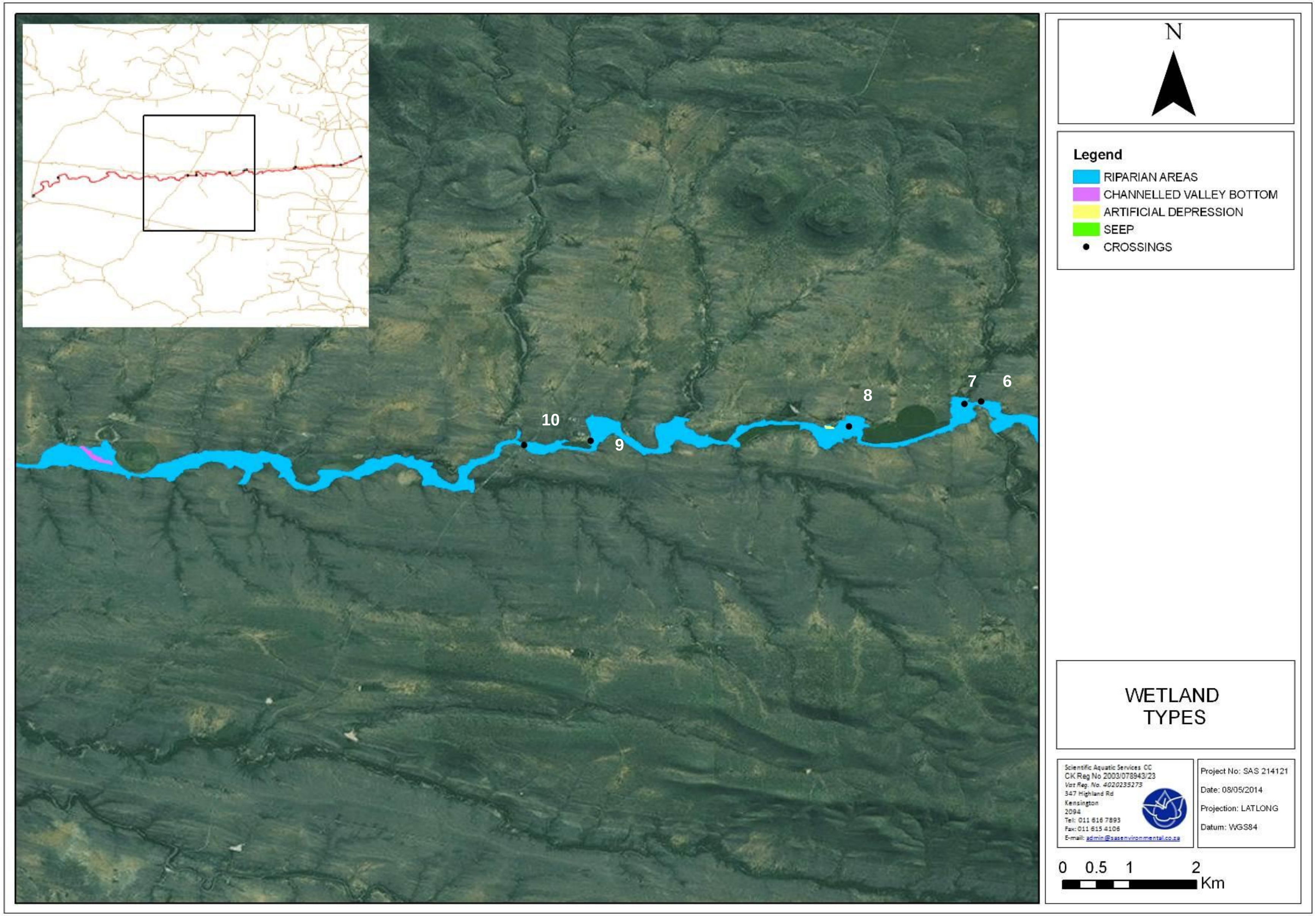

Figure 7: Riparian areas and wetland types associated with each of the proposed crossing areas (central portion of study area).

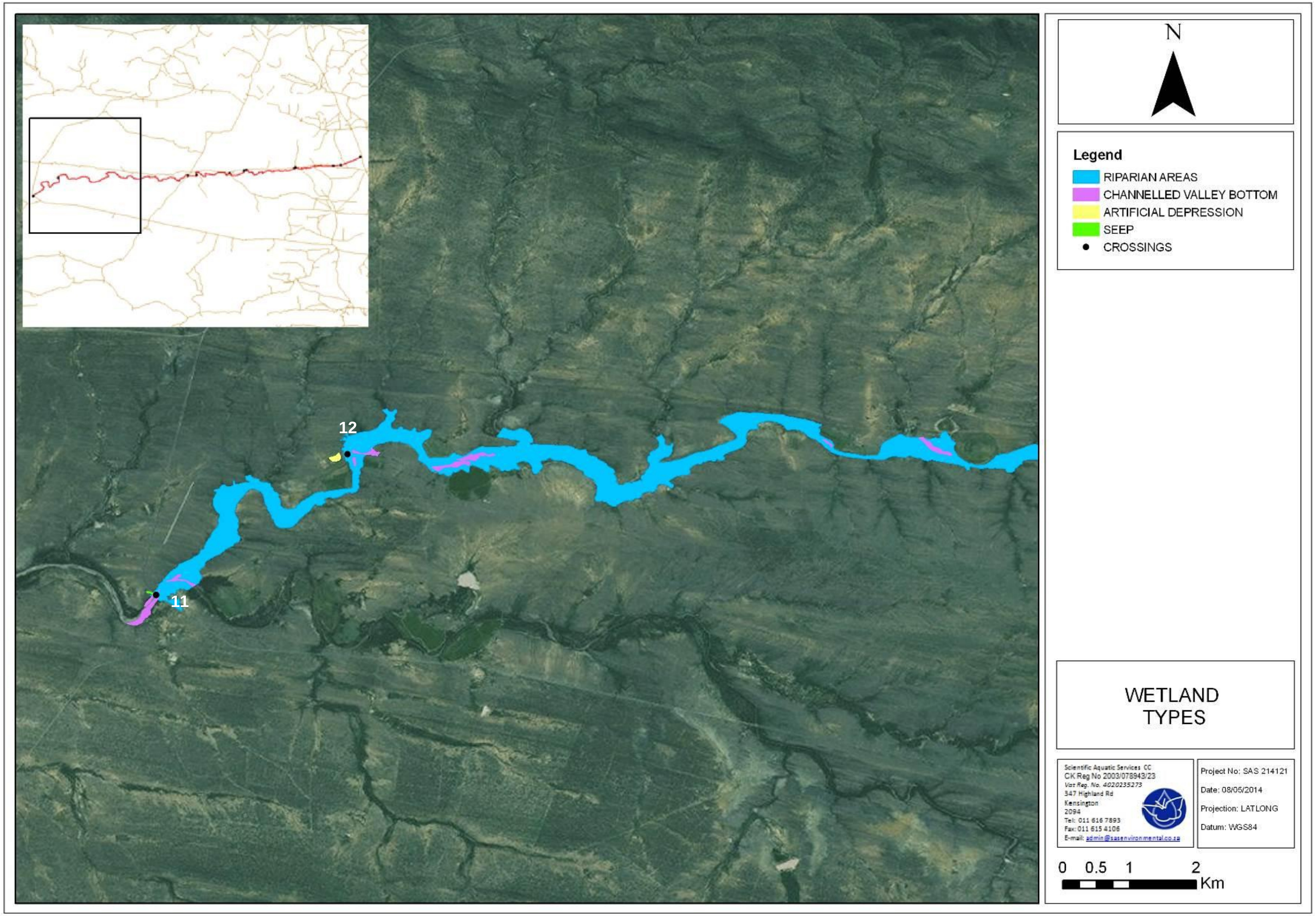

Figure 8: Riparian areas and wetland types associated with each of the proposed crossing areas (western portion of study area).

3.3 General River and Wetland Assessment Results

According to the NWA, 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 majority of the Skoenmakers River can be defined as a riparian system due to the presence of alluvial, soil as well as the presence of vegetation with a composition and physical structure distinct from adjacent areas. A distinctive change in vegetation abundance as well as diversity was noted in the lower and upper zones of the riparian habitat compared to the surrounding terrestrial zones. The woody vegetation component increased significantly within these areas when compared to surrounding terrestrial areas. The riparian habitat of the river is characterised by the dominance of tree and shrub species including *Acacia karroo, Lycium spp, Searsia lancea, Searsia longispina* and *Azima tetracantha*. The obligate wetland/riparian species *Phragmites australis, Typha capensis, Juncus* sp*., Cyperus textilis*, *Cyperus esculentus, Cyperus dives* and *Cyperus rotundus* were also encountered in more sheltered areas within the active channel of the river.

Figure 9: Riparian areas associated with the Skoenmakers River

Although the majority of the Skoenmakers River is classified as a riparian system, small, isolated wetland areas are associated with the system. These wetland areas include seep wetlands, channelled valley bottom features and artificial depressions and are characterised by the presence of obligate wetland species such as *Typha capensis*, *Phragmites australis* and *Cyperus rotundus* (refer to Figures 6, 7 and 8 for an indication of the localities of wetland areas).

The majority of the wetland features are located within the riparian habitat, however, two seep wetlands, an artificial seep located to the south of site 1 and a natural seep located to the north west of site 11, are located outside of the riparian habitat.

Figure 10: Wetlands associated with the Skoenmakers River

The Skoenmakers River is located in a largely natural area with a few isolated areas of cultivated land encountered. However, the hydrology of the system has been significantly altered as a result of a large interbasin transfer scheme which transfers significant volumes of water from the Little Fish River into the upper reaches of the system. The increased volume and velocity of water running through the system has resulted in the significant erosion and incision of the banks of the river.

Where current bridge structures traverse the river an increase in the erosion and incision of the river banks was noted downstream of the bridge structures. This has been caused as a result of the turbulent flow created by the passage of water through pipes and culverts below bridge structures. Disturbance associated with the development of bridge structures has also resulted in the encroachment of alien and invasive floral species such as *Opunti ficus-indica*, *Opuntia aurantiaca*, *Verbesina encelioides*, *Atriplex lindleyii*, *Atriplex semibaccata*, *Atriplex versicaria*, *Pennisetum setaceum* and *Pennisetum clandestinum* into the surrounding area. However these species are largely restricted to areas of disturbance with only a few scattered individuals encountered elsewhere within the study area.

<u>**Site Specific descriptions**</u>

Sites 1, 2 and 3 are located within the interbasin transfer scheme. The interbasin transfer consists of an artificial concrete canal in which water is conveyed. Water does not appear to overtop the banks of this canal and vegetation surrounding the canal has been significantly degraded. A wetland area is however located to the south of site 1.

This wetland appears to have been created as a result of the seepage of water into the area from a leaking artificial canal and was characterised by the dominance of the obligate wetland species *Phragmites australis* and *Typha capensis*.

Site 3 is located just east of the boundary of the natural river system and is characterised by the emergence of riparian vegetation.

Figure 11: Site 1 (a), site 2 (b) and site 3 (c)

Site 4 is located on an existing gravel road which traverses riparian habitat. Disturbance to surrounding riparian habitat as a result of this gravel road appears to be minimal.

Figure 12: Site 4

Site 5 is associated with an existing bridge structure which traverses the Skoenmakers River. The existing bridge structure has resulted in the obstruction of flow through the river and has caused ponding in upstream areas and erosion and incision in downstream areas. Vegetation associated with this crossing has been significantly disturbed and alien and invasive species including *Verbesina encelioides*, *Opuntia ficus-indica* and *Pennisetum clandestinum* have encroached into areas in the immediate vicinity of the bridge. Riparian habitat located to the east of the crossing has also been removed to make way for cultivation activities.

Figure 13: Incision and erosion downstream of the crossing (left) and alien and invasive vegetation encroachment (right).

No bridge structures are currently present at **site 6 or 7**. The active channel of the river portion associated with site 6 has been significantly eroded and is characterised by steeply incised banks to either side of the river. Site 7 is located within the dry, sandy bed of a tributary which enters into the Skoenmakers River. Riparian habitat associated with this crossing point appears to be largely intact with exception of the existing gravel road which traverses the area.

Figure 14: Eroded and incised banks associated with site 6 (left) and dry, sandy tributary associated with site 7 (right).

Site 8 is associated with an existing bridge structure which has been damaged as a result of the force of increased water velocities moving through the system and the southern portion of the bridge has been completely washed away.

The development of the bridge structure has resulted in an increase in the turbulence of water moving through the system which has caused the erosion and incision of downstream areas. Furthermore, areas of sediment accumulation within the active channel downstream of the bridge structure were also noted.

Figure 15: Turbulent flow and incised river banks associated with site 8

Sites 9 and 10 are associated with existing bridge structures. Both bridge structures have resulted in upstream ponding and downstream erosion and incision within the system. Site 9 is located in close proximity to an agricultural small holding and agricultural fields and the associated disturbance has resulted in the encroachment of alien invasive species such as *Tagetes minuta*, *Pennisetum setaceum, Solanum* sp, and *Pennisetum clandestinum*.

Figure 16: Turbulent flow, erosion and incision associated with sites 9 (left) and 10 (right).

Site 11 is associated with an existing bridge structure which was developed as part of the R400 roadway. This site lies adjacent to the boundary of the Addo Elephant National Park. The erosion and incision of the river banks associated with this structure is not as severe as that associated with the other bridge structures assessed.

However, downstream sedimentation within the active channel was noted. An additional seep wetland feature also drains into the river to the north west of the crossing.

Figure 17: Less incised river banks associated with site 11 (left) and seep wetland entering into the riparian area from the north west (right).

Site 12 is associated with an existing bridge structure which has been partially washed away by the river. The concrete pipes beneath the bridge have been completely blocked by debris and sediment which has caused ponding and flooding upstream of the crossing and has resulted in water flowing over the bridge instead of below it. The movement of water over the bridge has resulted in turbulent flow and in significant erosion and incision directly downstream of the bridge.

The riparian area located to the west of the crossing point has been significantly disturbed as a result of anthropogenic and agricultural activities. Furthermore, a leak in an artificial dam located to the west of the riparian area has resulted in the seepage of water through the area. However, the majority of surface water flows along existing gravel roads and other areas of surface water do not appear to have been present for a sufficient period of time to allow for the formation of wetland soils and the creation of wetland conditions.

Figure 18: Degraded, flooded bridge structure associated with site 12 (left) and seepage from dam (right).

3.4 Wetland Function Assessment

The function and service provision provided by all wetland features associated with the Skoenmakers River is likely to be similar and was therefore assessed in a single assessment. It should be noted that wetland characteristics utilised during the calculation of function and service provision varied slightly from feature to feature. However, the use of the average condition is deemed sufficient to determine the overall importance of each of the features and guide decision making on utilisation of the resources in the vicinity of these areas and in order to determine management and mitigation measures to protect these resources. The results are presented in the table and radar plot that follows.

Table 6: Wetland functions and service provision.

Ecosystem service	Wetlands associated with the Skoenmakers River
Flood attenuation	1.7
Streamflow regulation	1.6
Sediment trapping	2.8
Phosphate assimilation	2.8
Nitrate assimilation	2.8
Toxicant assimilation	3
Erosion control	2.4
Biodiversity maintenance	2
Carbon Storage	1.3
Water Supply	2.8
Harvestable resources	0.2
Cultural value	0
Cultivated foods	0
Tourism and recreation	1.5
Education and research	0
SUM	**24.9**
Average score	**1.7**

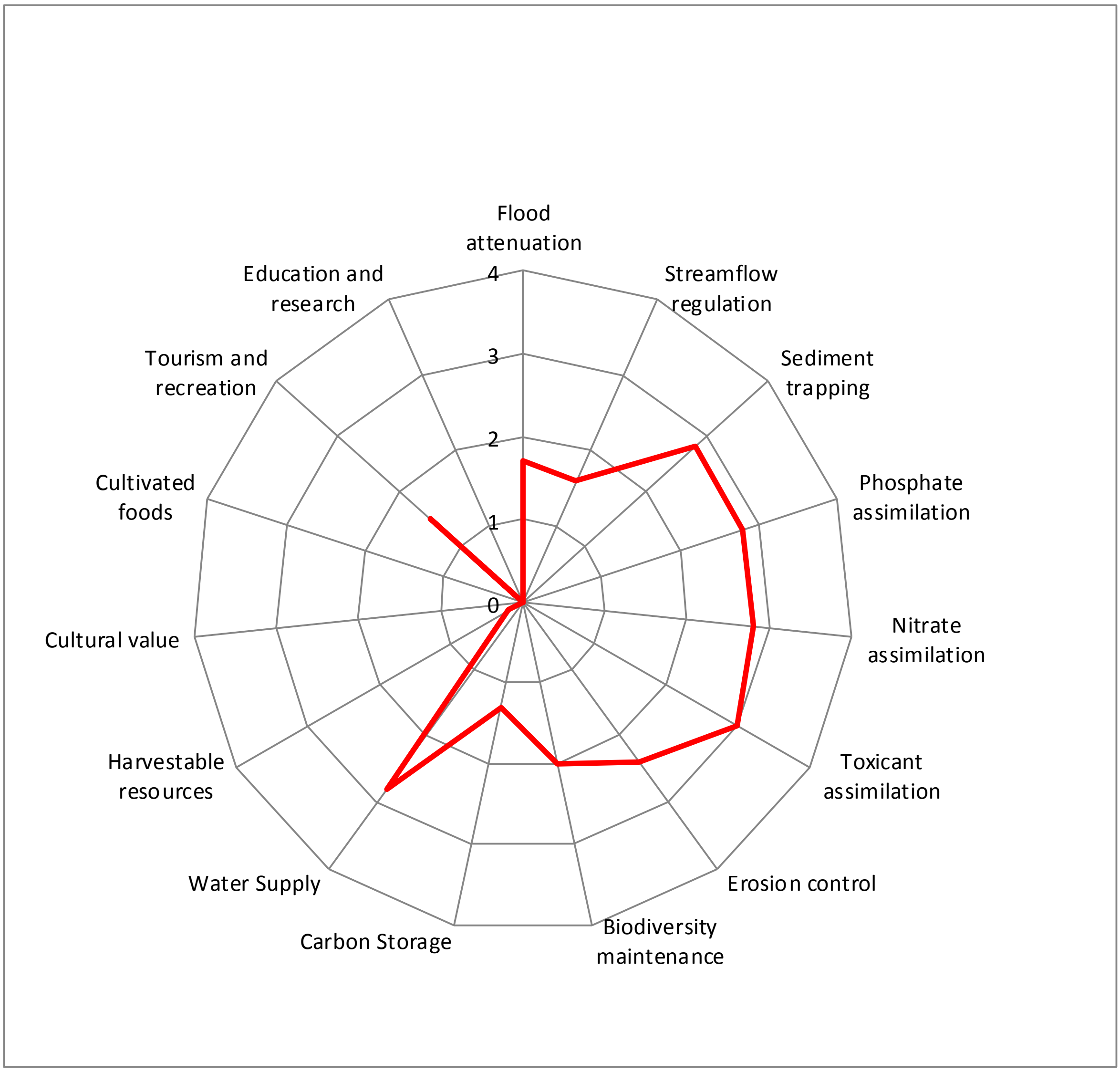

Figure 19: Radar plot of wetland services provided by the Skoenmakers River.

From the results of the assessment it is evident that wetland features associated with the Skoenmakers River can be considered of intermediate importance in terms of function and service provision. Wetland features are likely to play a moderate role in the attenuation of floodwater entering into the system. Flood water moving across the features is likely to be spread out and slowed down, however, the flood attenuating ability of the wetlands is decreased as a result of the small size of the features in relation to the overall size of the river and due to the already increased volumes of water which have been transferred into the system from the Little Fish River.

Sediment trapping and erosion control are also considered important services provided by the wetlands.

The increased velocities and volumes of water entering into the river via the interbasin transfer from the Little Fish River has resulted in the significant erosion of the banks of the

Skoenmakers River and the associated increase in the sedimentation and turbidity of river water.

Wetland features associated with the river are likely to trap sediment carried in stormwater. Furthermore, water which is spread across wetland features is slowed down and the erosive capability is therefore decreased.

Assimilation of nitrates, phosphates and toxicants calculated moderately high scores. The majority of wetland features are located in close proximity to cultivated fields and are therefore likely to play a role in the assimilation of these substances from stormwater before it enters into the river.

Evidence was encountered during the field assessment that the river system associated with the wetland features is used by the local community. Multiple artificial canals have been constructed which divert water from the river into surrounding agricultural areas. This increases the importance of the river and associated wetland features in terms of the supply of water.

3.5 Index of Habitat Integrity (IHI)

The IHI was used to determine the PES of wetland features associated with the Skoenmakers River. It was not possible to determine the PES of the artificial depression wetland features because there is no natural reference state to use as a baseline for such an assessment.

The PES of individual natural wetland features associated with the study area is likely to differ slightly. However, the average conditions associated with wetlands could be utilised to determine the overall PES. The use of the average conditions of wetland features was deemed sufficient to determine the average health of all wetlands associated with the study area.

The overall score calculated falls within Category D (Largely modified: A large loss of natural habitat, biota and basic ecosystem functions has occurred).

Table 7: Wetland IHI

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	**Weighting**	**Score**	***Confidence Rating***	**PES Category**
DRIVING PROCESSES:		**100**	**3.3**		
Hydrology	1	100	4.0	*4.6*	**E/F**
Geomorphology	2	80	3.3	*3.9*	**E**
Water Quality	3	30	0.7	*2.0*	**B**
WETLAND LANDUSE ACTIVITIES:		**80**	**0.8**	***4.0***	
Vegetation Alteration Score	1	100	0.8	*4.0*	**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:			**2.2**	***Confidence Rating***	
	PES %		**56.9**		
	PES Category		**D**	***1.8***	

The hydrology of the system and wetland features is considered to have been significantly altered as a result of a large interbasin transfer scheme which transfers significant volumes of water from the Little Fish River into the upper reaches of the system. The increased volume and velocity of water running through the system has resulted in a change in the floodpeaks, baseflows and seasonality of flows into the wetland features.

The increased volume and velocity of water entering into the system has also resulted in the significant erosion and incision of the banks of the river and has likely resulted in an increase in the sedimentation of wetland areas.

The only alteration of vegetation within wetland areas encountered was removal of vegetation as a result of cultivation activities. No significant excavation or backfilling was noted and alien invasive vegetation proliferation did not appear to be a significant problem in the area.

The main factor which may have impacted on water quality within wetland features is the modified flow conditions within the system. Increased flows have likely resulted in the alteration of the salt and nutrient contents in the system and the erosion created as a result of increased flows has likely resulted in an increase in the turbidity of the features. Furthermore, existing bridge structures have also resulted in an increase in water turbidity, and runoff from agricultural areas is likely to have altered the pH, salt content, nutrient content and turbidity of the system.

Figure 20: Erosion and incision of river banks (left) and bridge structure within the active channel of the river (right).

3.6 Riparian and Wetland Vegetation

The riparian vegetation community dominated by *Acacia karroo, Lycium* spp.*, Searsia lancea, Searsia longispina, Searsia pallens* and *Azima tetracantha* could be clearly distinguished from the terrestrial community which was dominated by low growing shrubs such as *Pentzia incana* and *Felicia muricata* and grasses such as *Chloris virgata, Cynodon dactylon, Panicum* sp and *Eragrostis curvula*.

The wetland habitat unit was characterised by the dominance of obligate wetland species such as *Typha capensis* and *Phragmites australis* as well as the alien and invasive grass species *Pennisetum clandestinum* and *Cynodon dactylon*. Dominant species were characterised as either riparian and wetland or terrestrial species as listed in the table below.

Table 8: Dominant floral species identified during the assessment of the Skoenmakers River.

Riparian and wetland species	Terrestrial species
Acacia karroo	*Boscia oleoides*
Lycium spp.	*Lycium cinereum*
Searsia longispina	*Pappea capensis*
Searsia lancea	*Aloe striata*
Searsia pallens	*Pentzia incana*
Azima tetracantha	*Drosanthemum lique*
Phragmites australis	*Jordaaniella dubia*
Typha capensis	*Felicia muricata*
Juncus sp.	*Felicia filifolia*
Cyperus textilis	*Asparagus sp.*
Cyperus rotundus	*Drimia sp.*
Cynanchum elipticum	*Jamesbrittenia pinnatifida*
Cineraria geifolia	*Gazania* sp

Riparian and wetland species	Terrestrial species
Moraea elliotii	*Stachys aethiopica*
Drimia sp.	*Aizoon rigidum*
Pennisetum setaceum	*Selago sp.*
Pennisetum clandestinum	*Chloris virgata*
Cynodon dactylon	*Eragrostis curvula*
Panicum sp.	*Panicum sp.*
	Cynodon dactlyon

3.7 Riparian Vegetation Response Assessment Index (VEGRAI)

The 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. 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 9: VEGRAI Ecological Category Description Scores for the Kuruman River.

Portion	VEGRAI %	EC	Definition
Skoenmakers River	54.4%	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.

The overall VEGRAI score calculated for the Skoenmakers River falls within the Ecological Category Class D (Largely modified – a large loss of natural habitat, biota and basic ecosystem functions has occurred). Vegetation cover, abundance and species composition within the marginal zone of the river have been significantly impacted as a result of the interbasin transfer which has significantly increased the quantity of water entering into the system. Increase water quantities have resulted in the erosion of the marginal and non-marginal zones and the loss of non-woody and woody vegetation.

3.8 Hydrological Function

Wetland hydrology generally refers to the inflow and outflow of water through a wetland therefore land is characterised as having wetland hydrology when, under normal circumstances, the land surface is either inundated or the upper portion of the soil is saturated at a sufficient frequency and duration to create anaerobic conditions[1].

[1] www.forestandrange.org/new_wetlands

The hydrological function of the Skoenmakers River and associated wetland features has been significantly altered as a result of an interbasin transfer, which transfers large volumes of water from the Little Fish River to the upper reaches of the Skoenmakers River.
This has resulted in a significant increase in the volume and velocity of water moving through the system, an increase in the turbidity of the system and has resulted in the erosion and incision of the banks of the river.

3.9 Wetland EIS Determination

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 IHI as well as function and service provision to enable the assessor to determine the most representative EIS Category for the river or wetland 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 as listed in Table 10 below.

Table 10: Wetland EIS determination

Determinant	**PES**	
	Score	**Confidence**
PRIMARY DETERMINANTS		
1.Rare & Endangered Species	2	4
2.Populations of Unique Species	3	4
3.Species/taxon Richness	3	3
4.Diversity of Habitat Types or Features	3	3
5.Migration route/breeding and feeding site for wetland species	4	3
6.PES as determined by IHI assessment	1	4
7.Importance in terms of function and service provision	2	4
MODIFYING DETERMINANTS		
8.Protected Status according to NFEPA Wetveg	4	4
9.Ecological Integrity	3	4
TOTAL	25	
MEDIAN	2.8	
OVERALL EIS Category	**B**	

Based on the findings of the assessment it is evident that wetland features associated with the Skoenmakers River have an EIS falling within Category B (High - features that are considered to be ecologically important and sensitive). Although the hydrology of the features has been significantly altered and the service provision of the features is considered intermediate, the features are considered of increased importance in terms of species richness and the provision of migration routes and breeding and foraging sites for faunal species. Furthermore, the wetland vegetation type is hardly protected in the region which increases the sensitivity of the habitat.

3.10 Recommended Ecological Category

Should the proposed bridge upgrades prove feasible an appropriate and achievable REC for the portions of the Skoenmakers River to be affected is deemed to be Category C (moderately modified). The rehabilitation of riparian areas associated with the bridge crossings is likely to improve their PES slightly. However, impacts created as a result of the interbasin transfer and the associated increase in erosion and incision within the system will remain.

3.11 Riparian and Wetland Zone Delineation

The Skoenmakers riparian zone and associated wetland features were delineated according to the guidelines advocated by DWA (2005). It should be noted that the identification of the outer boundary of the upper riparian zone and the temporary zone of wetland features did prove difficult in some areas as a result of general disturbance and agricultural activities. However, the delineation as presented in this report is regarded as a best estimate of the boundary of the riparian zone and temporary zone of wetlands based on the site conditions present at the time of assessment.

During the assessment, the following indicators were used to determine the boundary of the upper riparian zone:

- Riparian vegetation proved to be the most indicative of the boundary of the riparian zone with a distinctive change in vegetation abundance, as well as diversity noted in the lower and upper zones of the riparian habitat compared to the surrounding terrestrial zones. The woody vegetation component increased significantly within these areas when compared to surrounding terrestrial areas;
- Due to the Skoenmakers River flowing at the bottom of the topographical sequence as well as the incised nature of the river, terrain units were used in support of the vegetation or landscape characteristics;
- The presence of alluvial soils could be used to identify riparian zones;
- Surface water was mainly restricted to the active channel of the river. As a result, surface water and wet soils were of limited use as indicator during the riparian zone delineation.

Figure 21: Dense woody vegetation associated with the Skoenmakers River riparian zone

During the assessment, the following indicators were used to determine the boundary of the wetland temporary zones:

- Wetland vegetation and the presence of obligate and facultative wetland species was used as a primary indicator of the wetland temporary zones; and
- The presence of soils form indicators such as gleyed soils (most of the iron has been leached out of the soil leading to a low chroma greyish/greenish/bluish colour) were used as secondary indicators of the wetland boundary.

Figure 22: Obligate wetland species (left) and gleyed soils (right)

3.12 Buffer Allocation

The National Environmental Management Act (Act 107 of 1998) stipulates that no activity can take place within 32m of a wetland without the relevant authorisation. In addition, the National Water Act (Act 36 of 1998) states that no diversion, alteration of bed and banks or impeding of flow in watercourses (which includes wetlands) may occur without obtaining a Water Use Licence authorising the proponent to do so. This prescribed 32m buffer zone is deemed sufficient to maintain and improve the PES and limit any further impact of the proposed development on the local wetland resources.

The Skoenmakers riparian zone/wetland areas and their associated 32 m buffer areas are presented in the figures to follow. Any activities occurring within the riparian zone/wetland areas or within a 32m buffer of the riparian zone/wetland areas must be authorised by the DWA in terms of Section 21 (c) & (i) of the NWA (Act 36 of 1998).

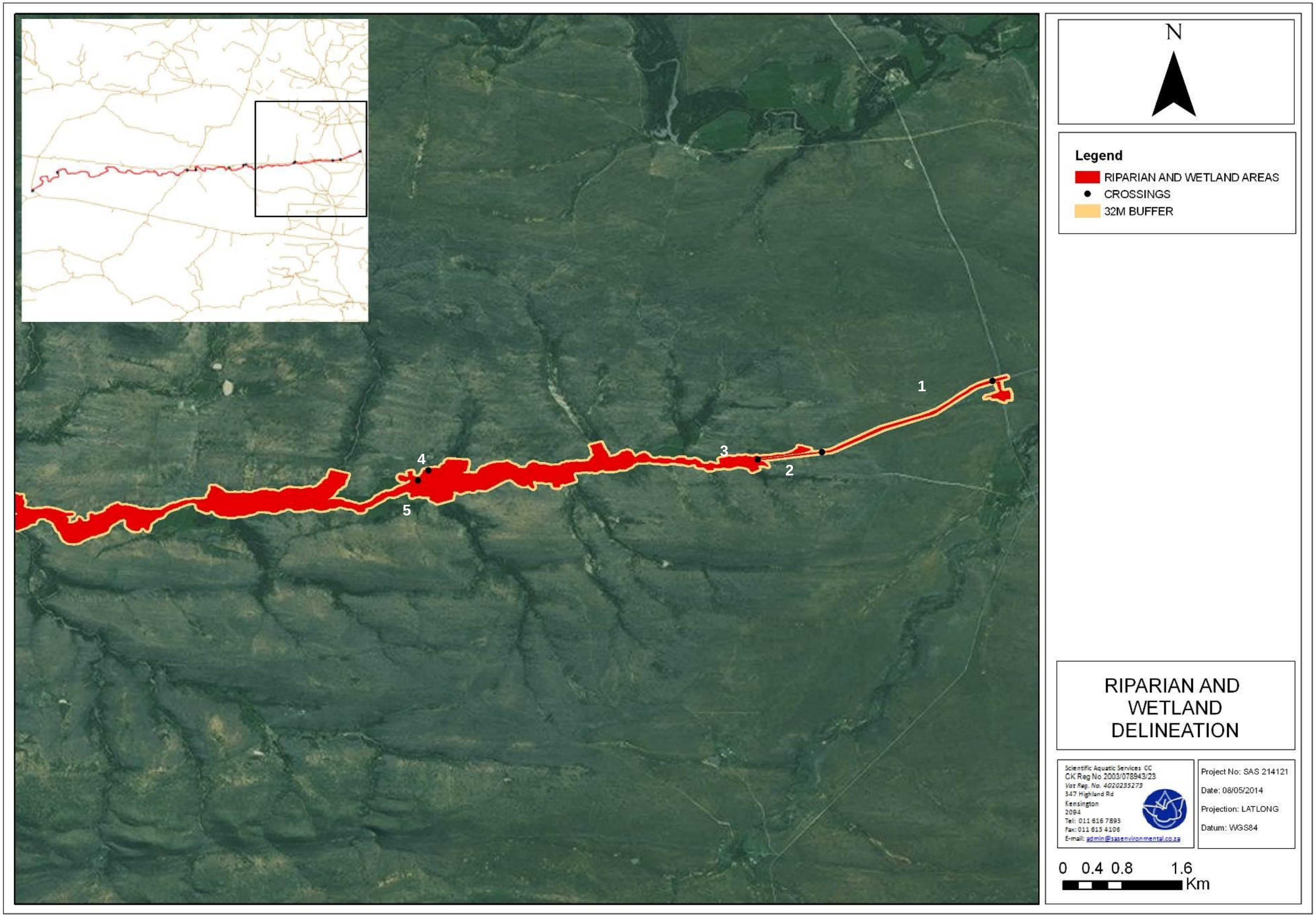

Figure 23: Skoenmakers riparian and wetland delineation indicating 32m buffer (east).

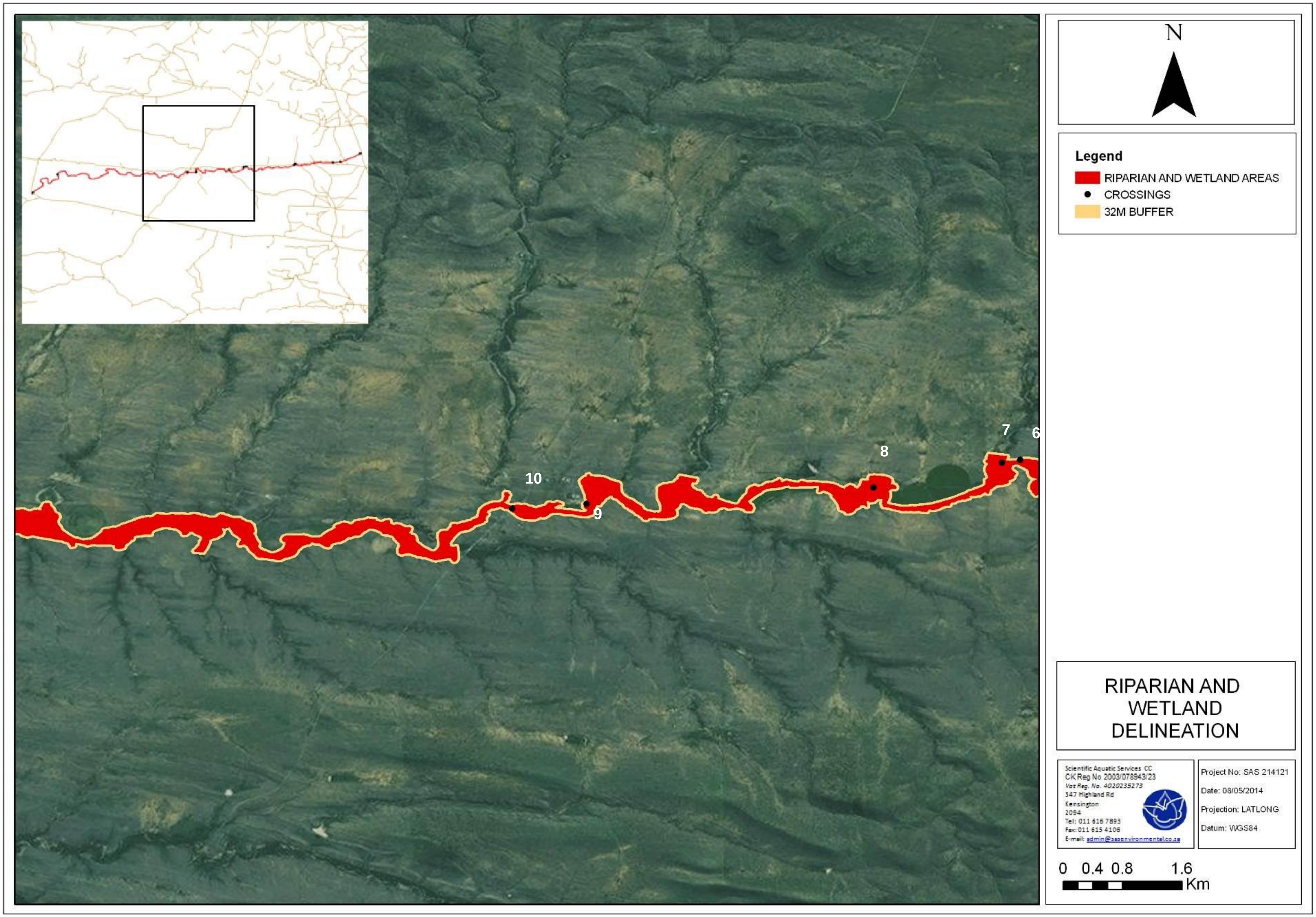

Figure 24: Skoenmakers riparian and wetland delineation indicating 32m buffer (centre).

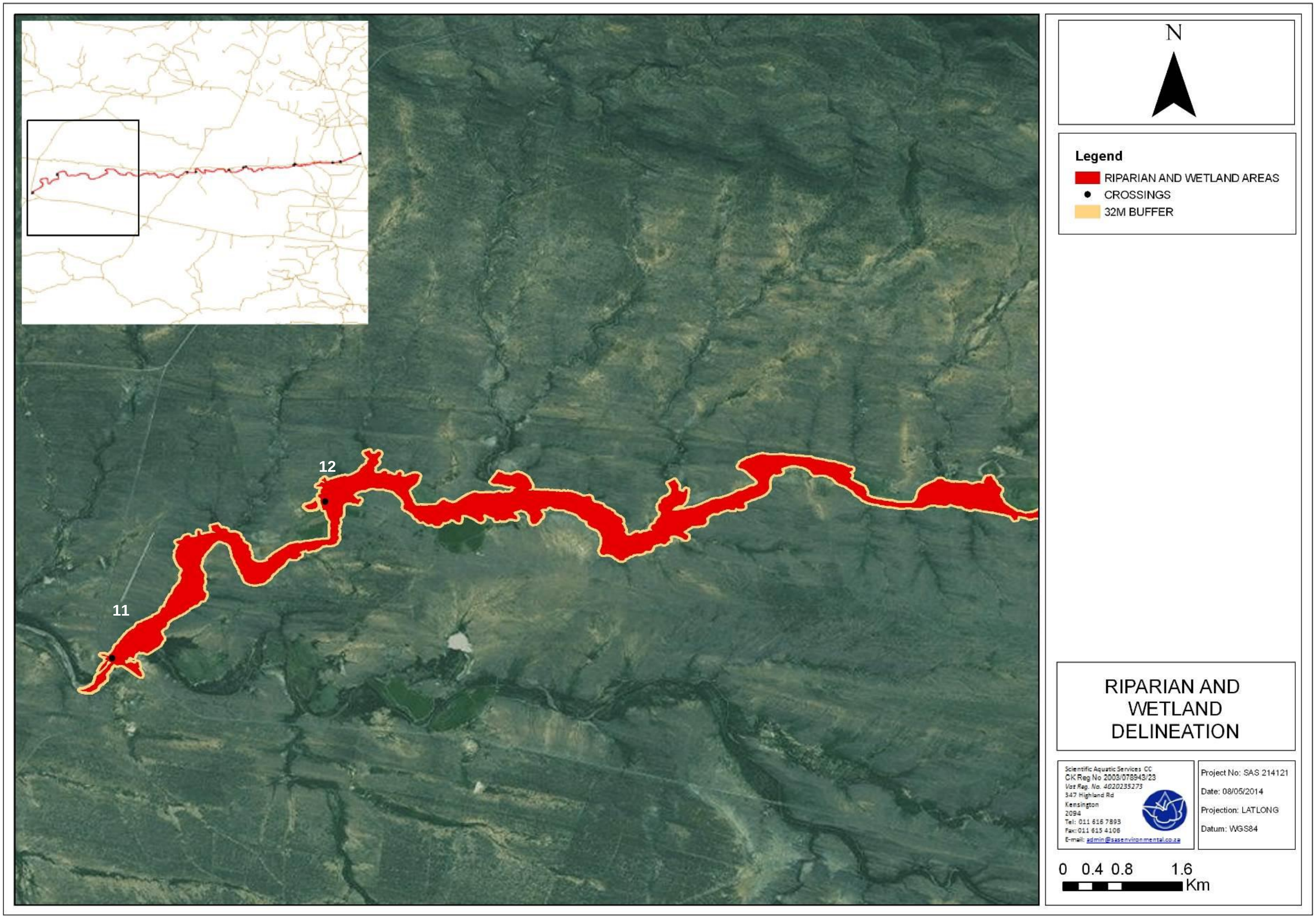

Figure 25: Skoenmakers riparian and wetland delineation indicating 32m buffer (west).

3.13 Visual Assessment

A photographic record of each site was compiled in order to document the condition of each assessment point, as observed during the field assessment. The photographs taken at each site are presented below. Table 11 summarises the observations for the various criteria made during the visual assessment undertaken at each site.

Biomonitoring site SM1(Bridge site 5):

Figure 26: Upstream view of Site SM1 showing bridge infrastructure. The bridge is currently operational.

Figure 27: Downstream view of the Site SM1 also showing bridge infrastructure.

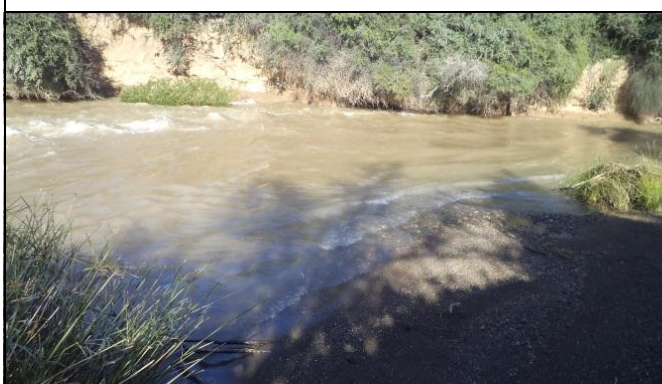

Figure 28: Habitat areas in the vicinity of site SM1 where SASS5 could be performed (SASS5 applied 50 to 200 m downstream of the bridge).

Figure 29: Habitat areas in the vicinity of site SM1 where fish sampling and SASS5 could be performed. Fish sampling was done both upstream and downstream of the bridge, whilst SASS5 was applied downstream of the bridge.

Biomonitoring site SM2(Bridge site 12):

Figure 30: Upstream view of Site SM2.

Figure 31: Downstream view of the Site SM2.

Figure 32: Bridge infrastructure at SiteSM2. The bridge is currently not operational.

Figure 33: Habitat area in the vicinity of site SM2 where SASS5 could be performed (SASS5 applied 200 to 400 m downstream of the bridge). Fish sampling was done both upstream and downstream of the bridge, whilst SASS5 was applied downstream of the bridge.

Table 11: Visual description of the assessment sites.

<table>
<tr><th>Site</th><th>Significance</th><th>Surrounding features</th><th>Riparian zone characteristics</th><th>Depth characteristics</th><th>Flow condition</th><th>Water clarity</th><th>Erosion potential</th></tr>
<tr><td>SM1

(Bridge site 5)</td><td>The site is located upstream of SM2 and together with the latter is considered most representative of the system assessed.</td><td>The bridge at this site is operational. Due to the depth and flow characteristics upstream of the bridge, the SASS5 assessment could only be performed downstream of the bridge. Surrounding agricultural activities present.</td><td>The riparian zone consists mostly of shrubs but also some reeds/grasses. Bank cover is variable with some sections showing very little cover on steep river banks, increasing risk of erosion and bank incision.</td><td rowspan="2">Depth conditions are variable with a deeper, slow run upstream of the bridge and some shallower areas downstream of the bridge. Average depth at sampling site (run) estimated around one meter.</td><td>Flow was variable at time on assessment depending on depth, with fast to medium flow in the deeper run upstream of the bridge, very fast flow immediately below the bridge and again medium to fast flow in downstream pools and runs.</td><td rowspan="2">The water was discoloured at both points at the time of the assessment.</td><td>Steep banks prone to bank incision and already some extensive erosion were observed at this point downstream of the bridge under current flow conditions. Erosion potential will significantly increase under high flow conditions.</td></tr>
<tr><td>SM2

(Bridge site 12)</td><td>The site is located upstream of SM2 and together with the latter is considered most representative of the system assessed.</td><td>The bridge at this site is not operational. Due to the depth and flow characteristics upstream of the bridge, the SASS5 assessment could only be performed downstream of the bridge
Surrounding agricultural activities present.</td><td>The riparian zone consists mostly of reeds/grasses. Bank cover on steep river banks appears more adequate compared to the SM1 site, reducing risk of erosion and bank incision.</td><td>At site SM2 water flowing over the bridge and not under the bridge resulted in turbulent flow directly below the bridge contributing to increased erosion potential</td><td>Steep banks prone to bank incision. Both incision and erosion observed at this point downstream of the bridge. Potential for erosion will significantly increase under high flow conditions.</td></tr>
</table>

3.14 Physico-Chemical Water Quality Data

The table below records the biota specific water quality of Sites SM1 and SM2.

Table 12: Biota specific water quality data along the Skoenmakers River.

SITE	EC (mS/m)	pH	TEMP (°C)
SM1 (bridge site 5)	81.5	8.2	14.9
SM2 (bridge site 12)	62.3	8.5	18.3

- EC concentrations recorded correspond with historical data. The Darlington (Mentz) Dam was constructed in 1922 to aid in the irrigation for citrus production. The wall was raised in 1935 by 1.5m and again in 1952 by 5.8m. In 1978 water is transferred from the Orange River system, via the Great Fish and the Little Fish Rivers to the Skoenmakers River and brought into the dam. During this transfer the salinity of the water increased from 33 to 94mS/m, mainly derived from agricultural return flows. (http://www.ru.ac.za/static/institutes/iwr//wetland/data/Sundays/SUNDAYSreport.pdf)

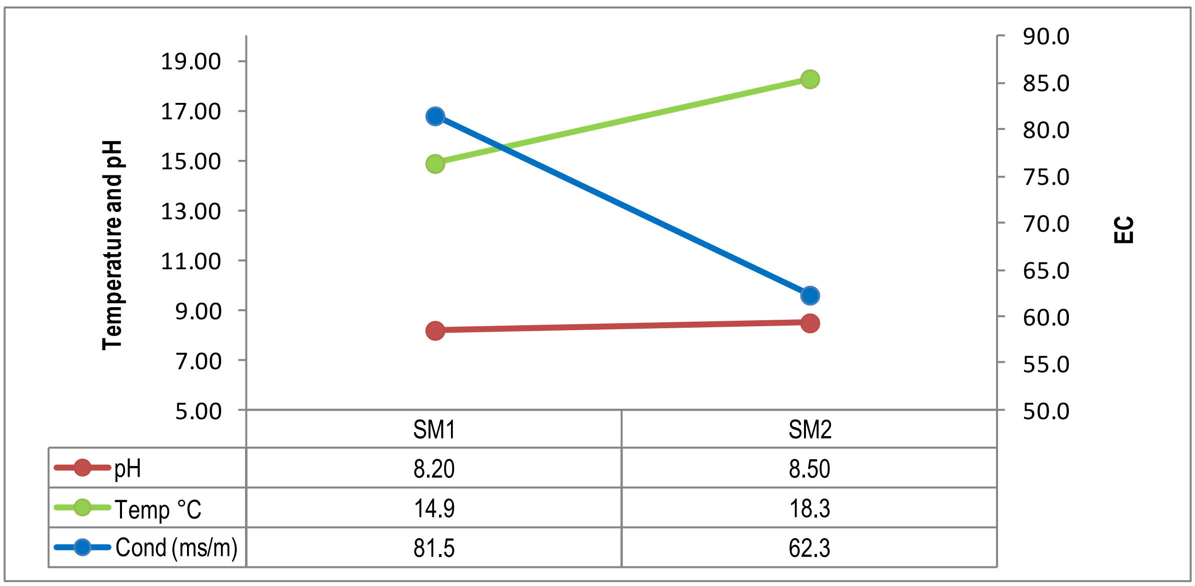

Figure 34: Graphic representation of the biota specific water quality data along the Skoenmakers River.

- Spatially, the EC level decreases by 23.6% between Sites SM1 and SM2 in a downstream direction. This degree of change exceeds the DWAF TWQR for aquatic ecosystems (DWAF, 1996) that stipulates that the EC level along a watercourse should not change by more than 15%, however, the reduction in EC can be considered a positive change toward more natural conditions. The change observed may potentially indicate that, within the system assessed, agricultural impact diminish in a downstream direction. Current sampling efforts cannot substantiate such a general statement and such a trend would need to be confirmed and monitored employing additional assessments in future.

- The pH levels at both sites were very similar, increasing by 3.7% in a downstream direction.
- The degree of change between Sites SM1 and SM2 complies with the DWAF TWQR for aquatic ecosystems (DWAF, 1996) that advocates a spatial change in pH level of not more than 5%. Current impact due to spatially altered pH on the aquatic community of the system is deemed unlikely.
- Temperatures can be regarded as normal for the time of year and time of day when assessment took place. The slight variation between the sites can be ascribed to natural diurnal variation between sampling times.

3.15 Habitat Integrity

3.15.1 Intermediate Habitat Integrity Assessment

The general habitat integrity of the Skoenmakers River as a whole was assessed, based on observations made at representative assessments sites SM1 and SM2. Assessment was based on the application of the Intermediate Habitat Integrity assessment for use in rapid and intermediate habitat assessments and is presented in Appendix C. Below a summary of the results is provided:

The general habitat integrity at both sites and hence the system as a whole, can be considered “largely modified” (Class D). The system achieved 51.2% for instream integrity, 47.8% for riparian zone integrity and an overall IHIA rating of 49.5%.

Instream impacts included small impacts on channel modifications and moderate impacts on water abstraction, water quality and exotic fauna. Large impacts on bed modification and inundation were evident with flow modification regarded a serious impact.

Small impacts on the riparian environment included water abstraction and water quality, whilst moderate impacts included vegetation removal, alien encroachment and inundation. Flow and channel modifications were considered large impacts whilst bank erosion was considered a serious impact.

As can be seen from the above discussion the majority of large and serious impacts (such as flow modification and inundation) pertains to, or are the result of (for example erosion), the inter-basin water transfer scheme operation.

3.15.2 Invertebrate Habitat Assessment System (IHAS)

Table 13 is a summary of the results obtained from the application of the Intermediate Habitat Assessment Index (IHAS) to the biomonitoring Sites SM1 and SM2. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates and is presented in Appendix 2.

Table 13: A summary of the results obtained from the application of the IHAS index to the assessment Sites SM1 and SM2.

SITE	SM1	SM2
IHAS Habitat score	51%	44%
Habitat adjustment score (illustrative purposes only)	+23	+23
McMillan, 1998 Habitat description	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community	
Stones habitat characteristics	Stones in and out of current present, providing stone habitat for colonisation by suitably-adapted macro-invertebrates.	Stones biotope present in current but absent out of current during the current assessment, limiting the habitat available for colonisation by suitably-adapted macro-invertebrates.
Vegetation habitat characteristics	Fringing/marginal vegetation was present at both points during the current assessment but aquatic vegetation absent. Leafy material was reduced at time of assessment, therefore limiting the habitat and cover available for suitably adapted macro-invertebrates.	
Other habitat characteristics	Sandy substrate dominated the site, with mud, gravel and bedrock absent at time of assessment. This may limit the diversity of suitably adapted macro-invertebrates. No algae were present.	Gravel substrate dominated the site with some bedrock also present. Sand and mud substrate was largely absent which may limit the diversity of suitably adapted macro-invertebrates. No algae were present.

SITE	SM1	SM2
IHAS general Stream characteristics	The system at this point is wide (5 to 10 meters), of medium depth (approximately 1 meter) and comprises of a fast-flowing run. The water is discoloured. There was a limited diversity of flow types and depth profiles under the current flow conditions. The riparian vegetation consisted of grass and shrubs with fair cover on the right bank. Bank erosion and incision is evident at this point.	The system at this point also comprises a fast, wide (> 10 meters) run on average 1 meter deep. The water is discoloured and there was limited diversity in flow and depth under the current flow conditions. The marginal vegetation consisted predominantly of grass with poor bank cover. Impacts in the form of bank erosion and incision were evident at this point.
Signs of impact	Agriculture.	Agriculture.

- Overall habitat conditions at both sites can be considered inadequate to support a diverse and sensitive macro-invertebrate community at the time of assessment. Thus, an aquatic macro-invertebrate community of limited diversity and sensitivity can be expected at these points during the current assessment.
- Some variation in habitat suitability for aquatic macro-invertebrates is evident between sites in terms of substrate types available. This is likely to influence the macro-invertebrate community structure to some degree during the current assessment. These observations will aid in the interpretation of the SASS data variation between the sites.

3.16 Aquatic Macro-Invertebrates

3.16.1 South African Scoring System 5 (SASS5)

The results of the aquatic macro-invertebrate assessment, according to the SASS5 index, are summarised in the tables below and is presented in Appendix 3. Table 14 indicates the results obtained at each site, per biotope sampled. Table 15 summarises the findings of the SASS assessment based on the analyses of the data for each site.

Table 14: Biotope specific summary of the results obtained from the application of the SASS5 index to Sites SM1 and SM2.

PARAMETER	SITE	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 SCORE	SM1	17	24	20	35
Number of taxa		3	6	5	8
ASPT		5.7	4.0	4.0	4.4
SASS5 SCORE	SM2	26	5	11	26
Number of taxa		5	1	2	5
ASPT		5.2	5.0	5.5	5.2

Table 15: Summary of the results obtained from the application of the SASS5 index to Sites SM1 and SM2.

Type of Result	SM1	SM2
Biotopes sampled	Stones in current; Fringing vegetation; Stones out of current; Sand.	Stones in current; Fringing vegetation; Gravel; Bedrock.
Sensitive taxa present	*Caenidae; Aeshnidae.*	*Caenidae; Aeshnidae.*
Sensitive taxa absent	*Pyralidae; Naucoridae; Hydroptilidae.*	*Pyralidae; Naucoridae; Hydroptilidae.*
SASS5 score	35	26
IHAS score	51	44
Adjustment value	+23	+23
Adjusted SASS5 score	58	49
ASPT score	4.4	5.2
SASS5 % of theoretical reference score*	33.7	25.0
ASPT % of theoretical reference score**	97.8	115.6
Dickens & Graham, 2001 SASS5 classification	E (Severely impaired)	E (Severely impaired)

***SASS5 reference score = 104; **ASPT reference score = 4.5**

- The SASS5 data at Sites SM1 and SM2 indicates that the aquatic macro-invertebrate community has suffered a significant loss in integrity throughout the area when compared to the reference score derived from taxa expected in the system.
- The aquatic macro-invertebrate community integrity at both Sites SM1 and SM2 may presently be classified as being in a severely impaired condition (Class E) according to the Dickens & Graham (2001) classification system.
- Spatially, the SASS5 score decreases by 25.7% between Sites SM1 and SM2, and the ASPT score increases by 18.2%. This indicates that no negative impact on the diversity or sensitivity of the macro-invertebrate community is likely to be occurring in a downstream direction.
- Instream and riparian habitat limitations and lack of diversity are also likely to have contributed to the low scores at both sites. The absence of mud substrate, the lack of aquatic vegetation available for sampling as well as steep banks with limited cover in the form of fringing vegetation within the system are very likely to result in limited colonisation by suitably-adapted macro-invertebrates. The lower IHAS score recorded from SM2 when compared to SM1 correlates with a lower SASS5 score at the former site.

- Any reductions in SASS5 and ASPT scores in future monitoring should be noted and the causal factors identified.
- As more data on the system is collected, better inferences on the ecological condition of the community will be possible.

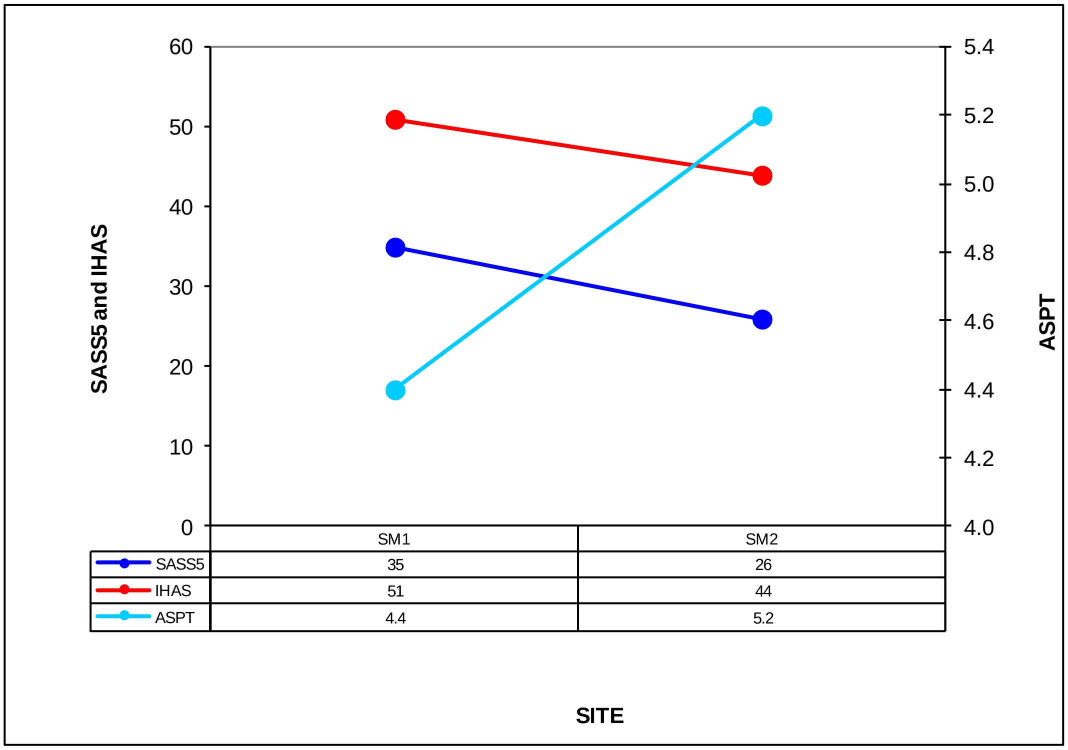

Figure 35: Graphic representation of the SASS5, ASPT and IHAS scores along the Skoenmakers River.

3.16.2 Macro-Invertebrate Response Assessment Index (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 16: Summary of the results obtained from the application of the MIRAI to the assessment sites, compared to classes awarded using SASS5.

Variable / Index	SM1	SM2
Ecological category score (MIRAI)	56.69	47.21
Ecological category classification (MIRAI)	D	D
Dickens and Graham (SASS5)	E (Severely impaired)	E (Severely impaired)

According to the MIRAI, both sites SM1 and SM2 are in a D (Largely impaired) state, whilst SASS5 (Dickens and Graham 2001) indicated an E (Severely impaired) state. From the table above it is evident that the MIRAI results, in terms of Ecological Category classification, follow similar trends as that obtained using the SASS5 class classifications according the Dickens and Graham classification system (2001). The fact that the same classifications were obtained for each site using each of the respective indices, confirms that the two sites selected are largely representative for the system as a whole. Close monitoring of temporal trends should take place in order to better understand the ecological condition of the macro-invertebrate community within this system.

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

The conditions at both sites SM1 and SM2 are very similar and deemed representative of the Skoenmakers River in the area assessed. As a result fish community assessments were performed for the Skoenmakers River system as a whole and not per individual site assessed. The Habitat Cover Rating (HCR) results for the system, as derived from conditions at both Sites SM1 and SM2, are provided in the figure that follows.

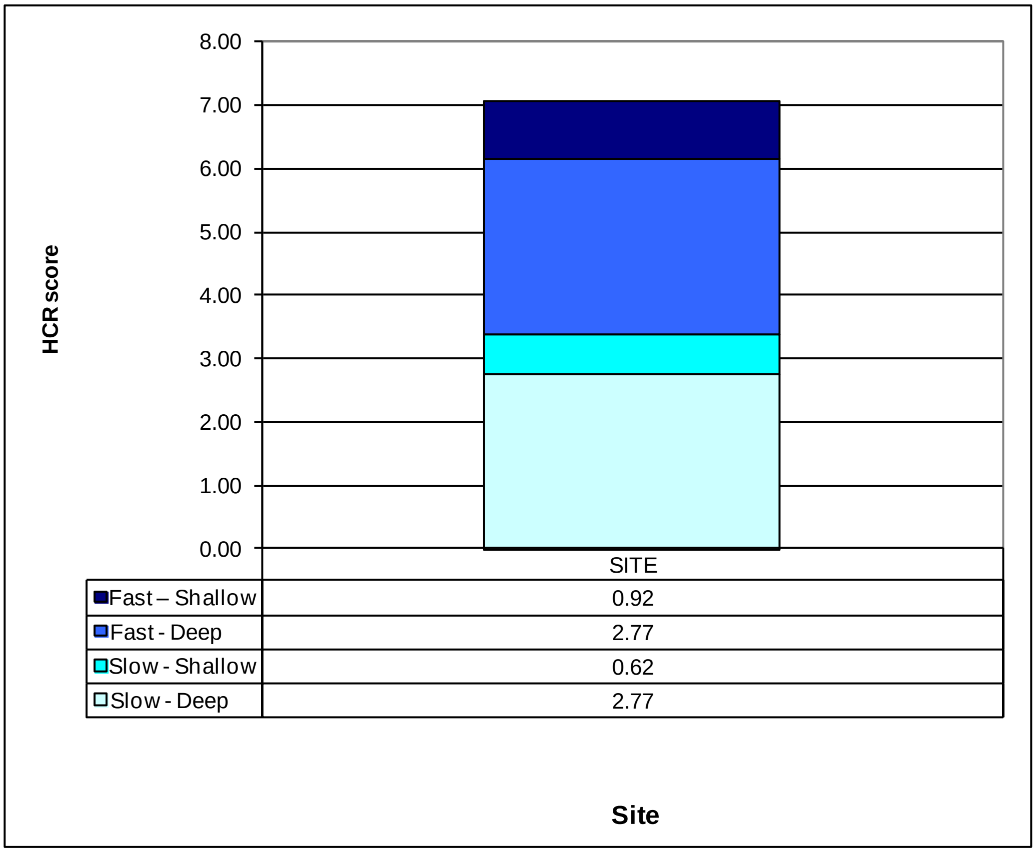

Figure 36: HCR score for the Skoenmaker River as represented by conditions at both Sites SM1 and SM2.

Results indicate that both slow-shallow and fast-deep conditions dominate the system. As variation in both depth (shallow and deep conditions) and flow speed (slow and fast conditions) is evident, a diverse fish community may be expected at Sites SM1 and SM2. However, fish that require fast-flowing rapid or riffle habitat (fast-shallow conditions) and hence demonstrate a high intolerance for deep or slow conditions, are expected to be less abundant.

3.18 Fish biota: Fish Response Assessment Index (FRAI)

The fish species expected to occur and frequency of occurrence (FROC) scores employed in the FRAI assessment were provided previously in the materials and methods section. As indicated previously fish biota will be considered for the system as a whole and not for each of the respective assessment sites. Only smallmouth yellowfish (*L. aeneus*) were collected from site SM1 and no fish from site SM2. However, both Orange River mudfish (*L. capensis*) and sharptooth catfish (*C. gariepinus*) were observed in the system during assessment.

Based on sampling and observations the following FROC scores were assigned to the fish species collected observed: *L. aeneus* 2.0, *C. gariepinus* 1.5 and *L. capensis* 1.0.

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 17: Summary of the results (ecological categories) obtained from the application of the FRAI to the Skoenmakers River.

Variable / Index	Skoenmakers River
Automated FRAI (%)	41.3
Refined FRAI (%)	40.3
Automated EC (FRAI)	D/E
Refined EC (FRAI)	D/E
Ecological category (EC) (MIRAI)	D

EC = Ecological category; * = No species expected/collected during assessments and habitat not conducive to known species being present based on sampling at the other sites.

From the above it is clear that the EC calculated for the FRAI corresponds well to that obtained for the MIRAI. This could be expected as changes in fish community and macro-invertebrate composition are subject to the same ecological drivers. Based on these observations it is evident that this segment of the Skoenmakers River is of limited ecological importance to fish as it is mostly characterised by "naturalised endemic" fish species transferred from the Orange River system by the IBT.

3.19 Aquatic EIS determination

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 as listed in the Table below.

Table 18: Aquatic EIS determination

Biotic Determinants	**Skoenmakers River**
Rare and endangered biota	0
Unique biota	0
Intolerant biota	2
Species/taxon richness	1
Aquatic Habitat Determinants	
Diversity of aquatic habitat types or features	3
Refuge value of habitat type	3
Sensitivity of habitat to flow changes	2
Sensitivity of flow-related water quality changes	2
Migration route/corridor for instream and riparian biota	2
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	3
RATING AVERAGE	**1.8**
EIS CATEGORY	**Moderate**

Based on the findings of the assessment it is evident that aquatic features associated with the Skoenmakers River have an EIS which can be considered moderate. The Skoenmakers River system can therefore be defined as being unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.

3.20 Aquatic assessment synopsis

The following summary table provides an overview of aquatic assessment results:

Table 19: Summary of the classification results (ecological categories) obtained from the application of various indices during aquatic assessment of the Skoenmakers River.

<table>
<tr><th>Site</th><th>IHIA</th><th>IHAS</th><th>SASS5</th><th>MIRAI</th><th>FRAI</th><th>VEGRAI*</th><th>IHIA</th><th>EIS</th></tr>
<tr><td>SM1</td><td>C</td><td>Inadequate</td><td>E</td><td>D</td><td>D/E</td><td rowspan="2">D</td><td rowspan="2">Moderate</td><td rowspan="2">C</td></tr>
<tr><td>SM2</td><td>C</td><td>Inadequate</td><td>E</td><td>D</td><td>D/E</td></tr>
</table>

4 REHABILITATION CRITERIA

During the design of the Riparian and Wetland Rehabilitation Plan and in defining the rehabilitation requirements for the riparian and wetland areas associated with proposed bridge crossing areas, several criteria were considered. The following sections briefly define the principles and aspects considered during the development of the Riparian and Wetland Rehabilitation Plan.

4.1 Wetland PES, Function and Ecoservices Provision and REC

The overall wetland PES falls within a Class D (Largely modified, a large loss of natural habitat, biota and basic ecosystem functions has occurred), with the wetland functioning and ecoservices provision within the vicinity of the study area achieving an average score of 1.7, which indicates that the watercourse and wetlands provide an intermediate benefit in terms of its ecological, economic and social benefits. In general the aquatic ecological integrity is lower and therefore with aquatic communities displaying a Class D level of integrity.

Based on the consideration of the above observations, the REC deemed appropriate to enhance and maintain current ecology, as well as functionality of the aquatic features within the study area is a Class C.

4.2 Extent and applicability of the rehabilitation plan

This rehabilitation plan is applicable to the activities directly associated with the construction and upgrade of the river crossings over the river and buffer area.

4.3 Sensitive habitats and landscapes

When effective rehabilitation takes place, the ecological service provision capability and sensitivity of the watercourse and natural areas will increase/ be restored to its pre-development status. The most pertinent threats which are currently posed to the system, over which the proponent for this development has control include erosion, incision and siltation of the watercourse, inundation of upstream areas, prevention and control of alien plant species invasion, loss of topsoil, management of compaction within the riparian and wetland areas and loss of vegetation cover.

Should these factors be mitigated and effective rehabilitation measures be implemented, the watercourse and natural areas will regain some of their ecological service provision capability. The rehabilitation plan can also aid in mitigating future impacts on the ecology of the area through protection from erosion, incision and sedimentation.

4.4 Alien and invasive species

The study area at present is not significantly affected by alien invasive species. However, the proliferation of alien vegetation species is expected within the watercourse and riparian and wetland areas during the implementation/construction and post-rehabilitation/operational phases of the development. Alien plant species contribute to habitat degradation and decrease the service provision capability of the system. Removal of alien plant species must take place according to the methods as set out in the Rehabilitation Plan and focus on problem areas. The alien control programme should take place during and after construction of the river crossings and continue for a minimum period of two years.

4.5 Soil disturbance

The development may contribute to further erosion and sedimentation within the watercourse and riparian and wetland areas. These disturbances may lead to permanent loss of habitat for wetland and riparian floral species and lowered vegetation cover adjacent to the river, increasing the amount of silt material being transported within the system. The loss of vegetation cover will also lead to reduced availability of cover and habitat for smaller faunal species that are likely to have colonised the area in the past.

Should the measures as set out in this report be adhered to and implemented efficiently, the ecological service provision levels associated with flood attenuation, erosion control, filtration and habitat provision will improve significantly and will allow the watercourse and riparian and wetland areas to continue functioning into the future.

4.6 Consideration of edge effects

During the design of the rehabilitation plan, consideration was given to the effects that the development and related infrastructure, such as access and service roads in its immediate vicinity may have on the watercourse and riparian and wetland areas.

The development activities will generate edge effects during its implementation/construction and post-rehabilitation/operational phases through soil disturbance, vegetation removal and generation of waste. The rehabilitation plan aims to address these issues in terms of erosion control, alien vegetation control and waste management. These effects are deemed to be suitably mitigated if the measures in the management plan are adhered to.

4.7 Ecological processes

The measures, as set out in the rehabilitation plan, are deemed sufficient for the conservation of ecological processes and provide a tool for managing and improving the PES of the area. If these measures are adhered to and well implemented, ecological processes will not only continue, but also in some instances improve in functionality.

5 REHABILITATION MANAGEMENT PLAN

This Riparian and Wetland Rehabilitation Plan is designed to manage, maintain and improve the PES and EIS of the riparian and wetland areas and surrounding terrestrial areas within the study area, with particular emphasis on the impacts that the development of a river crossing within the study area may have on the Skoenmakers River and associated riparian and wetland areas.

5.1 Rehabilitation objectives

The objectives of this plan are to:

- Ensure as far as is practicable that the measures contained in the report are implemented;
- Manage activities within the study area in order to maintain and/ or improve ecological integrity of the study area;
- Minimise adverse impacts on the receiving environment;

- Maximise the service provision and ecological functioning of the watercourse and wetland areas;
- Maximise the ecological functioning of the watercourse and wetland system and;
- Monitor the impact of the project on the receiving environment.

5.2 Rehabilitation context

The rehabilitation and management plan fits into the overall planning process of the development activities and should be implemented by the proponent as soon as possible once construction on the watercourse has reached a stage where rehabilitation activities become viable. This document serves as a rehabilitation and management plan to manage the ecological characteristics of the study area during the design, construction/implementation and post-rehabilitation/operational phases of the development.

5.3 Monitoring of the rehabilitation works

During implementation/construction, the monitoring of the rehabilitation works will form part of the activities of the Environmental Control Officer (ECO). Monitoring should include, but not be limited to, the following parameters:

- Determining if the final landforms of backfilled and reprofiled areas are in line with the natural surroundings;
- Assessment of surface and slope stability;
- Assessment of adequate functioning of rehabilitation structures;
- Measuring the depth of topsoil replaced within rehabilitated areas;
- Determining erosion levels;
- Calculating ground cover percentages within revegetated areas including vegetation basal cover, litter and rock; and
- Determining plant community composition and structure of rehabilitated areas.

Upon completion of rehabilitation works on site, the ECO or a suitably qualified specialist should continue to monitor the rehabilitation works for three months on a monthly basis. Thereafter, one monitoring site visit is recommended after 6 months from completion of rehabilitation works and final sign-off of rehabilitation works should take place after one year.

5.4 Roles and responsibilities

The construction contractor or consulting engineers will be responsible for the appointment of the ECO and relevant specialists and contractors to perform rehabilitation and monitoring activities as well as alien vegetation removal and control.

Implementation/Construction Phase

- The ECO will ensure that the contractor and all subcontractors are aware of all the specifications pertaining to the project;
- Any damage to the environment will be repaired as soon as possible after consultation between the ECO, Consulting Engineer and Contractor;
- The ECO will ensure that the project staff and/or contractor are adhering to all stipulations of the Rehabilitation Management Plan;
- The ECO will be responsible for monitoring the rehabilitation works throughout the project by means of site visits and meetings. All site visits and meetings will be documented as part of the site meeting minutes which will be made available for inspection at any time;
- The ECO will ensure that all clean up and rehabilitation or any remedial actions required are completed swiftly as and when required.
- The contractor should not be permitted to leave site until the rehabilitation works have been signed off by a suitably qualified ECO.

Post-rehabilitation/Operational Phase

- During the operational phase, the body that presides over the administration of the development will be responsible for the maintenance of the rehabilitation plan and management thereof. This is particularly pertinent with reference to the two year monitoring of alien vegetation, as well as erosion and incision control for the operational life of the development as defined in this rehabilitation plan.

5.5 Mitigation and management

The section below will define and describe the various environmental impacts affecting the integrity of the riparian and wetland areas associated with the development activities and proposed management and mitigation measures related to each impact will be presented.

The table below serves to describe and explain the rehabilitation and management measures deemed necessary to effectively manage, maintain, rehabilitate and improve the ecological characteristics and functioning of the study area.

6 RIPARIAN AND WETLAND REHABILITATION PLAN PHASES

6.1 Design Phase

The measures outlined below should be implemented as part of the design phase of the development.

Table 20: Design Phase Mitigation and Rehabilitation Measures

Impact	Activities resulting in impact	Objective or requirement	Mitigation and Rehabilitation measures
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE	• Inappropriate design of infrastructure leading to changes to riparian and wetland habitat; • Inappropriate design of infrastructure leading to pollution of soils and ground water; and • Indiscriminate driving of vehicles through riparian and wetland areas.	General	● The proposed development footprint areas should remain as small as possible; ● Consideration must be given to relevant DWAF licencing when determining the development layout; and ● Vehicles must be restricted to designated roadways.
IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION	• Poor planning of infrastructure placement and design; • Inappropriate design of infrastructure leading to changes in riparian and wetland function; and • Inappropriate design of infrastructure leading to pollution of soils and ground water	General	● Refer to mitigation measures as listed for Impact1.

Impact	Activities resulting in impact	Objective or requirement	Mitigation and Rehabilitation measures
IMPACT 3: **MPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION AND SEDIMENT BALANCE**	• Poor planning of infrastructure placement and design leading to altered hydrological function.	Ensure that the hydraulic connectivity of the watercourse is maintained between the areas upstream and downstream of the crossing	● The bridge design must limit the degree of upstream ponding that occurs. Ponding should only occur for a very short period (a few hours) after heavy rainfall events; ● The tie of the bridges to the river banks should be done in such a way as to ensure that the bridge is stable and that no head erosion or scouring takes place at the tie in points to the stream banks; ● Bridge structures must eliminate the creation of turbulent flow. In this regard specific mention is made of the need to not construct any support structures within the active stream channel, if possible; ● Bridge structures must not lead to concentration of flow. No narrowing of the river bed should take place through the construction of the bridge structures; and ● Adequate storm water management must be incorporated into the design of the works in order to prevent erosion and the associated sedimentation of the watercourse.

6.2 Implementation/Construction Phase

The measures outlined below should be implemented immediately and as part of the construction phase of the development.

Table 21: Implementation/Construction Phase Mitigation and Rehabilitation Measures

Impact	Activities resulting in impact	Objective or requirement	Mitigation and Rehabilitation measures
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE	● Site clearing, disturbance of soils and the removal of riparian and wetland habitat; ● Construction of bridge infrastructure within riparian and wetland areas; ● Movement of construction vehicles as well as access road construction within the riparian and wetland habitat; ● Compaction of soils due to construction activities; ● Loss of riparian and wetland biodiversity due to disturbance associated with construction activities; ● Alien vegetation proliferation; ● Spillages and deliberate dumping of pollutants into the surrounding environment; and ● Disturbance of soil leading to increased runoff and erosion.	To educate involved parties about the importance of the natural environment contained within the development.	● The riparian and wetland rehabilitation plan must be made available to all contractors and subcontractors, as well as to any other management bodies involved in the development; ● All members of the construction teams must be informed of the contents and importance of the Rehabilitation Plan; ● The boundaries of the sensitive riparian and wetland areas, including the buffer zones and the designated construction areas must be clearly communicated to the employees and construction workers; ● An environmental incident management reporting procedure must be implemented and communicated to all parties mentioned above prior to commencement of rehabilitation works; ● The natural features of the site, including both terrestrial and aquatic environments should be managed in a holistic manner; ● If possible, implementation/construction activities should be scheduled for the drier months/ low flow season to decrease the risk of erosion during heavy thunderstorms; ● All earthworks within the riparian and wetland areas and surrounding terrestrial areas impacted by construction works must be rehabilitated after construction; ● During the river crossing construction period, all care should be taken to prevent further impacts on the watercourse and riparian areas and the surrounding natural environment by keeping the construction footprint as small as possible; ● Flow must be maintained throughout the construction phase of the development and all contractors must be made aware of the high importance of instream flow maintenance; ● The duration of impacts on the riparian and wetland areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible; ● No vehicles should be allowed to indiscriminately drive through the riparian and wetland areas and buffer areas. Vehicles should remain on existing access roads and upon rehabilitation of existing access roads, should be restricted to driving on the single access road associated with the river crossing; and ● The relevant approvals must be obtained from DWA for any activities within the riparian and wetland areas and associated buffers. In this regard special mention is made of water use licences in terms of section 21 c and i of the National Water Act as well as any authorisation that may apply as part of General Notice 1199 as published in the Government Gazette 32805 of 2009 as it relates to the National Water Act, 1998 (Act 36 of 1998).
		Removal of dumped material, litter, waste, refuse and rubble, as well as construction rubble from the vicinity of the proposed bridge and	● It must be ensured that all construction personnel involved in the river crossing development are aware of problems of illegal dumping and littering; ● Concrete structures which have been washed into the active channel of the river from degraded bridge structures must be removed; ● All excess topsoil and soft excavated material should be removed and stockpiled outside of the riparian and wetland buffer and protected for future use;

		adjacent riparian and wetland areas.	● During construction of the river crossing, no waste material or rubble may be dumped within the riparian and wetland areas; ● No stockpiles and storage of construction material may be located within the riparian and wetland areas or buffer zones; ● Any litter or waste material potentially generated on site as part of the construction process and excavation activities must be removed from the riparian and wetland areas and disposed of at a suitable landfill site; ● All effort to prevent contamination of the riparian and wetland areas must be made. In this regard special mention is made of the need to service and refuel all vehicles off site; ● If any spills of diesel or similar occur, this area should be immediately cleaned up. Removal of polluted materials is obligatory. Hydrocarbon spills may be biodegraded in situ, but should this however not be possible, such contaminated soils are to be lifted and disposed of at a suitable hazardous waste facility. Spill kits should remain available on site at all times; ● Care should be taken to avoid spillage of hydrocarbons into the Skoenmakers River; and ● Upon completion of construction works, all waste material, rock and rubble potentially occurring within the study area must be cleared and removed immediately and all affected footprint areas should be rehabilitated immediately.
		Clearing of alien vegetation in the vicinity of the riparian and wetland areas.	● All existing alien vegetation is to be removed manually (by hand) from the development areas within the riparian and wetland habitat; ● Alien vegetation may emerge and proliferate within the study area due to disturbance from construction works. The involved Environmental Control Officer (ECO) is to monitor the emergence of alien species on a two-weekly basis and clearly indicate such species on site through marking with danger tape or similar; ● The use of herbicides is to be avoided. Should hardy weed species justify the use of herbicides, the use thereof is to be approved by the ECO upon appropriate motivation. Should herbicides be used, only herbicides approved by the DWA may be used within riparian and wetland areas and care should be taken with the choice of herbicide to ensure no additional impacts on the riparian areas or indigenous floral species occur due to the herbicide used; ● Footprint areas should be kept as small as possible when removing alien vegetation; ● No vehicles should be allowed to drive indiscriminately through designated riparian and wetland and open space areas during eradication of alien and weed species; ● All removed alien plant species must be disposed of at a registered garden refuse site and certification thereof should be kept available on site; ● All plant material should be covered with a sail that is tied down during transportation by road to prevent any blow-off from the vehicle; and ● Removal of alien and invasive species must take place throughout the implementation/construction phase.
		Managing erosion that has occurred and preventing erosion that may occur as a result of construction activities, and minimising sedimentation of the watercourse and riparian areas.	● Erosion and incision within riparian and wetland areas are to be prevented during the implementation/construction phase of the proposed development. Where areas within the riparian and wetland habitat are at risk of such erosion and incision, immediate measures have to be taken in order to prevent erosion from occurring. This is applicable to the area immediately downstream of crossings; ● As far as possible all earthworks for reshaping and reprofiling of eroded river banks downstream of the river crossings and any erosion areas noted within the adjacent riparian and wetland areas should take place as soon as possible; ● These steep slopes are to be re-profiled to 1:3 slopes and any incised soils noted are to be ripped, filled and levelled with good quality, weed-free topsoil; ● Any compacted soils must be loosened to a depth of 100mm with handheld equipment to ensure suitable substrate for revegetation; ● Soft excavated material must be removed as quickly as possible from the construction area; ● No fertilisers or chemical soil ameliorants may be used due to close proximity to the watercourse;

			● It must be ensured that topsoil used is clear of any alien and invasive species before being reinstated on re-profiled areas; ● Within areas where re-profiling is to take place, this must be done in a manner such as to avoid straight lines and must be done so as to mimic natural conditions and to assist in habitat provision and natural wetting patterns; ● The re-profiled exposed soils occurring on gradients must be covered with staked geotextile/ hessian sheets until vegetation growth allows for sufficient stabilisation of soils on the stream banks to ensure that newly established topsoil and loosened soils do not erode due to rain or water flow associated with the watercourse; ● Reprofiled areas should be revegetated as per the 'Revegetation' section outlined below; ● Sheet runoff from cleared areas and access roads in the vicinity of the river crossing needs to be curtailed through the strategic placement of berms; ● Measures to limit erosion immediately downstream of the bridges where turbulent flow may occur must be implemented. Measures such as the application of reno-mattresses may need to be considered; and ●The river crossing tie-in points to the adjacent land are to be clad with rock or fitted with gabions to prevent erosion.
		Revegetation in the vicinity of the watercourse and within buffer areas must be performed by utilising indigenous/ endemic species to minimise erosion and potentially reduce alien vegetation encroachment	● Revegetation of all reprofiled areas with an indigenous veldgrass mixture should take place as soon as possible after soil reprofiling, levelling, topsoiling and implementation of erosion control structures are in order to minimise the amount of time during which soils are exposed and thus susceptible to erosion; ● In addition to reprofiled areas, any bare soils noted in the vicinity of the watercourse, including terrestrial area, are also to be revegetated; ● For revegetation purposes, Mayford's Biomosome Reclamation Veld Seed Mixture for the Karoo will be suitable, which is an eco-matched veld seed mix. ● The following should be considered when utilising this product: o The product may be irritating to the eyes. Eye protection is advisable when handling the seed; o Thoroughly mix the contents of each bag immediately before planting, as components are packed separately and settle at different rates during handling and transport; o Seed of most veld harvested species is characterised by the presence of straw. As this hinders the flow of seed in the planting process a spreading agent is advantageous. The seed should be blended with the spreading agent to achieve a uniform mix of seed in the material; o Commonly used spreading agents are river sand, bran, finely sifted kraal manure or a mixture in equal quantity of agricultural lime and granular fertilizer. The latter has the added advantage of visibility of areas seeded. The quantity of spreading agent should be sufficient for smooth flow using the planting method selected. Typically the volume of spreading agent should be equal to the volume of seed being mixed. Only as much should be mixed as will be required on the day of seeding in order not to damage seed in storage; and o The seed is packed in bags 5 kg maximum. Before each planting, mix the contents of the bag thoroughly before taking whatever quantity is required. If more than one bag is required for a planting, separate batches per bag of seeds should be blended into spreading agent to maintain the integrity of the composition of species. In larger quantities the components will shift too much due to differences in shape, texture, size and specific gravity of the seed. ● Hand seeding is recommended in order to avoid further impacts from machinery such as hydroseeding equipment within the riparian and wetland areas; ● The seed mixture used for re-vegetation must be certified weed-free; ● Large excavated rocks and boulders removed from the streambed during the construction phase are to be retained on site and placed in groupings within bare areas in the vicinity of the terrestrial and the riparian areas in order to provide habitat for faunal species and specialised flora; ● Due to clearing of alien vegetation within riparian and wetland areas, soils will be exposed and

			reseeding should therefore take place immediately to prevent soil loss; ●All disturbed areas created as a result of construction activities must be reseeded using the specified indigenous veldgrass mixture; ● In addition to reseeding with veldgrass, a mixture of indigenous forbs are to be planted within the reseeded areas (at a density of 2-3plants/m² and from 4L containers) in the vicinity of the bridge. This is in order to improve the overall ecological value of the development and surrounding areas and to assist in habitat provision for wetland faunal species. Suitable species include: *Aloe striata*, *Gasteria bicolor, Ophionella arcurata* subsp. *arctuata, Platythyra hackeliana, Senecio radicans, Stapeliopsis pillansii; Bulbine frutescens, Drimia anomala, Eriospermum dregei, Ornithogalum dyeri; Gazania krebsiana, Hermannia pulverata, Hibiscus pusillus; Cotyledon campanulata, Drosanthemum lique, Euphorbia meloformis, Euphorbia. rectirama, Faucaria britteniae, Faucaria. tigrina* and *Mestoklema tuberosum;* ● *Acacia karroo* (Sweet Thorn) trees from 50L containers are to be planted in the vicinity of the bridge and within the riparian and wetland buffer areas. At least 10 new trees are to be planted at a spacing of 8-10m apart. Trees are to be planted in natural groupings and not in rows.
IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION	● Site clearing, disturbance of soils and the removal of vegetation; ● Construction of bridge infrastructure within riparian and wetland areas; ● Inadequate management of edge effects during construction; ● Earthworks in the vicinity of riparian and wetland areas; ● Loss of riparian and wetland structure and function due to contamination of ground water through spillage or waste; and ● Compaction and loss of soils due to movement of construction vehicles.	Removal of dumped material, litter, waste, refuse and rubble, as well as construction rubble from the vicinity of the proposed bridge and adjacent riparian and wetland areas.	● Refer to mitigation measures as listed above in Impact 1.
		Clearing of alien vegetation in the vicinity of the riparian and wetland areas.	● Refer to mitigation measures as listed above in Impact 1.
		Managing erosion that has occurred and preventing erosion that may occur as a result of construction activities, and minimising sedimentation of the riparian and wetland areas.	● Refer to mitigation measures as listed above in Impact 1.
		Revegetation in the vicinity of the watercourse and within buffer areas must be performed by utilising indigenous/ endemic species to minimise erosion and potentially reduce alien vegetation encroachment	● Refer to mitigation measures as listed above in Impact 1.
IMPACT 3: MPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION	● Site clearing and the removal of vegetation and disturbance of soils leading to increased runoff and	Ensure that the hydraulic connectivity of the watercourse is maintained	● The duration of impacts on the watercourse should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised; ● Loss of stream continuity should be prevented during the construction phase;

AND SEDIMENT BALANCE	erosion; ● Earthworks in the vicinity of riparian and wetland areas leading to increased runoff and erosion, sedimentation and altered runoff patterns; ● Ineffective stormwater drainage; and ● Compaction and loss of soils.	between the areas upstream and downstream of the crossing	● No obstruction of the watercourse may occur as a result of construction activities; ● Bridge structures must eliminate the creation of turbulent flow. In this regard specific mention is made of the need to not construct any support structures within the active stream channel, if possible; ● Bridge structures must not lead to concentration of flow. No narrowing of the river bed should take place through the construction of the bridge structures; ● The tie of the bridges to the river banks should be done in such a way as to ensure that the bridge is stable and that no head erosion or scouring takes place at the tie in points to the stream banks; and ● All earthworks, including construction of bridge foundations, within the watercourse must be rehabilitated as outlined in the revegetation section above (Impact1).
		Managing erosion that has occurred and preventing erosion that may occur as a result of construction activities, and minimising sedimentation of the riparian and wetland areas.	● Refer to mitigation measures as listed above in Impact 1.
		Revegetation in the vicinity of the watercourse and within buffer areas must be performed by utilising indigenous/ endemic species to minimise erosion and potentially reduce alien vegetation encroachment	● Refer to mitigation measures as listed above in Impact 1.

6.3 Post-rehabilitation/ Operational Phase

The measures outlined below should be implemented as soon as the construction and rehabilitation of the river crossing has been completed.

Table 22: Post- rehabilitation/Operational Phase Mitigation and Rehabilitation Measures

Impact	Activities resulting in impact	Objective or requirement	Mitigation and Rehabilitation measures
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE	● Impacts on riparian and wetland habitat due to alien plant species proliferation; ● Contamination of soils due to a lack of infrastructure maintenance; ● Ineffective monitoring leading to continued erosion and increased siltation of riparian and wetland areas.	Clearing of alien vegetation in the vicinity of the wetland and watercourse.	● Removal of alien and invasive species must continue for a two years maintenance period after development on a monthly basis; and ● After the two year period, an annual eradication exercise using non-mechanised methods is deemed suitable for management of alien species for the life of the proposed development.
		Maintenance of infrastructure	● Maintenance of bridge infrastructure must be undertaken to prevent degradation of the structures and contamination of surrounding riparian and wetland areas.
		Monitoring of rehabilitation works	● Upon completion of rehabilitation works on site, the ECO or a suitably qualified specialist should continue to monitor the rehabilitation works for three months on a monthly basis. Thereafter, one monitoring site visit is recommended after 6 months from completion of rehabilitation works and final sign-off of rehabilitation works should take place after one year.
		Revegetation	●All bare and exposed soils noted during a two year maintenance period, including areas where alien vegetation is periodically removed, must be reseeded using the specified indigenous veldgrass mixture.
IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION	● Alien vegetation proliferation resulting in loss of riparian and wetland floral species and assimilation capability.	Clearing of alien vegetation in the vicinity of the wetland and watercourse.	● Refer to mitigation measures as listed for Impact1.
IMPACT 3: MPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION AND SEDIMENT BALANCE	● Inefficient aftercare and maintenance leading to continued latent impacts on riparian and wetland areas; and ● Ineffective monitoring leading to continued erosion and increased siltation of riparian and wetland areas.	Ensure that the hydraulic connectivity of the watercourse is maintained between the areas upstream and downstream of the crossing	● Loss of stream continuity should be prevented through ensuring that no obstructions of natural stream flow patterns occurs; ● Bridges and culverts should be regularly inspected to ensure that no blockages occur; ● Maintenance of bridge infrastructure must be undertaken to prevent degradation of the structures and impacts on wetland/riparian hydrology; ● Upon completion of rehabilitation works on site, the ECO or a suitably qualified specialist should continue to monitor the rehabilitation works for three months on a monthly basis. Thereafter, one monitoring site visit is recommended after 6 months from completion of rehabilitation works and final sign-off of rehabilitation works should take place after one year.

7 IMPACT ASSESSMENT

7.1 Riparian and wetland Impact Assessment

The tables below serve to summarise the significance of potential impacts on the riparian and wetland ecology of the study area. Impacts have been assessed separately for the design phase, for the implementation/construction phase and for the post rehabilitation/operational phase of the development. The sections below present the impact assessment according to the method described in Appendix A. In addition, it also indicates the required mitigatory and management measures needed to minimise potential ecological impacts and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures, assuming that they are fully implemented.

7.1.1 Design Phase

The inappropriate design of bridge infrastructure may result in permanent impacts to riparian and wetland habitat. Inappropriately designed bridge infrastructure may result in the unnecessary loss of riparian and wetland habitat and the loss of wetland function and service provision as well as hydrological function and sediment balance. However, with the implementation of mitigation measures the significance of impacts may be reduced to low levels.

Table 23: Impacts associated with the Design Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE															
• Inappropriate design of infrastructure leading to changes to riparian and wetland habitat; • Inappropriate design of infrastructure leading to pollution of soils and ground water; and • Indiscriminate driving of vehicles through riparian and wetland areas.	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.1 for the design phase of the Rehabilitation Plan, Impact 1.	2	1	2	1	5	**30 (-ve)**	**L (-ve) No Management Required**

IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION															
• Poor planning of infrastructure placement and design; • Inappropriate design of infrastructure leading to changes in riparian and wetland function; and • Inappropriate design of infrastructure leading to pollution of soils and ground water.	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.1 for the design phase of the Rehabilitation Plan, Impact 2.	2	1	2	1	5	**30 (-ve)**	**L (-ve) No Management Required**
IMPACT 3: IMPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION AND SEDIMENT BALANCE															
• Poor planning leading to the placement of infrastructure within riparian and wetland areas leading to altered hydrological function; and • Inadequate design of infrastructure leading to pollution of soils and ground water	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.1 for the design phase of the Rehabilitation Plan, Impact 3.	2	1	2	1	5	**30 (-ve)**	**L (-ve) No Management Required**

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.1.2 Implementation/Construction Phase

Construction of bridge structures and ineffective rehabilitation of riparian areas may result in negative impacts on riparian and wetland habitat, function and service provision as well as hydrological function and sediment balance. However, with the implementation of mitigation and rehabilitation measures, the significance of new as well as existing impacts on the riparian habitat may be reduced and the implementation of the rehabilitation plan may result in an overall positive impact rating.

Table 24: Impacts associated with the Implementation/Construction Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE															
• Site clearing, disturbance of soils and the removal of riparian and wetland habitat; • Construction of bridge infrastructure within riparian and wetland areas; • Movement of construction vehicles as well as access road construction within the riparian and wetland habitat; • Compaction of soils due to construction activities; • Loss of riparian and wetland biodiversity due to disturbance associated with construction activities; • Alien vegetation proliferation; • Spillages and deliberate dumping of pollutants into the surrounding environment; and • Disturbance of soil leading to increased runoff and erosion.	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.2 for the implementation/construction phase of the Rehabilitation Plan, Impact 1.	3	3	5	1	5	**66 (+ve)**	**LM (+ve)**

IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION															
•Site clearing, disturbance of soils and the removal of vegetation; •Construction of bridge infrastructure within riparian and wetland areas; •Inadequate management of edge effects during construction; •Earthworks in the vicinity of riparian and wetland areas; •Loss of riparian and wetland structure and function due to contamination of ground water through spillage or waste; and •Compaction and loss of soils due to movement of construction vehicles.	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.2 for the implementation/construction phase of the Rehabilitation Plan, Impact 2.	3	3	5	1	5	**66 (+ve)**	**LM (+ve)**
IMPACT 3: IMPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION AND SEDIMENT BALANCE															
• Site clearing and the removal of vegetation and disturbance of soils leading to increased runoff and erosion; • Earthworks in the vicinity of riparian and wetland areas leading to increased runoff and erosion, sedimentation and altered runoff patterns; • Ineffective stormwater drainage; and • Compaction and loss of soils.	3	3	5	1	5	**66 (-ve)**	**LM (-ve) Improve current management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.2 for the implementation/construction phase of the Rehabilitation Plan, Impact 3.	3	3	5	1	5	**66 (+ve)**	**LM (+ve)**

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.1.3 Post Rehabilitation/Operational Phase

Inefficient aftercare and maintenance, ineffective monitoring and the proliferation of alien and invasive species during the post-rehabilitation/operational phase may result in a negative impact on wetland/riparian areas. However, with the implementation of mitigation measures impacts may be reduced to low and very low levels.

Table 25: Impacts associated with the Post Rehabilitation/Operational Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON RIPARIAN AND WETLAND HABITAT AND ECOLOGICAL STRUCTURE															
• Impacts on riparian and wetland habitat due to alien plant species proliferation; • Contamination of soils due to a lack of infrastructure maintenance; and • Continued erosion of areas disturbed during construction.	3	3	5	5	5	**110**	**H (-ve) Improve Current Management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.3 for the post-rehabilitation/operational phase of the Rehabilitation Plan, Impact 1.	2	1	2	3	3	**30**	**L (-ve) No Management Required**

IMPACT 2: IMPACT ON RIPARIAN AND WETLAND FUNCTION AND SOCIO-CULTURAL SERVICE PROVISION															
Alien vegetation proliferation resulting in loss of riparian and wetland floral species and assimilation capability.	3	3	5	5	5	**110**	**H (-ve) Improve Current Management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.3 for the post-rehabilitation/operational phase of the Rehabilitation Plan, Impact 2.	2	1	2	3	3	**30**	**L (-ve) No Management Required**
IMPACT 3: IMPACT ON RIPARIAN AND WETLAND HYDROLOGICAL FUNCTION AND SEDIMENT BALANCE															
• Inefficient aftercare and maintenance leading to continued latent impacts on riparian and wetland areas; • Ineffective monitoring leading to continued erosion and increased siltation of riparian and wetland areas.	3	3	5	3	5	**88**	**MH (-ve) Improve Current Management**	• Refer to mitigation and rehabilitation measures as listed in Section 6.3 for the post-rehabilitation/operational phase of the Rehabilitation Plan, Impact 3.	1	1	2	1	1	**8**	**VL (-ve) No Management Required**

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.2 Aquatic Impact Assessment

The following potential impacts on the aquatic ecosystem were identified and are assessed in the sections that follow:

- Impact on in-stream flow and hydrological function;
- Changes to in-stream habitat and loss of aquatic habitat;
- Impacts on in-stream biota and loss of aquatic biodiversity and sensitive taxa;
- Impacts on stream connectivity and migratory taxa;
- Impacts on water quality affecting aquatic ecology

7.2.1 Design Phase

The inappropriate design of bridge infrastructure may result in permanent impacts aquatic habitats and functioning in terms of flow and hydrology. Impacts resulting from poor infrastructure are often permanent. However, poor planning or project design in terms of construction methodology and human activities relating to them may result in temporary shorter negative impacts during the construction phase. However, with the implementation of mitigation measures during the significance of impacts may be reduced to low levels.

Table 26: Impacts associated with the Design Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON IN-STREAM FLOW AND HYDROLOGICAL FUNCTION															
Poor design could potentially lead to impacts on in-stream flow patterns during the operational phase of the crossing, for example small spans with piers obstructing the active stream channel will hamper natural flow and hydrological function.	3	4	5	1	5	**72 (-ve)**	**LM (-ve) Improve current management**	The bridge should span the entire active channel (normal to moderately high flows) and no or a limited number of support piers should occur within the active channel; The duration of construction works needs to be kept to the absolute minimum and all project planning must be very well orchestrated to reach this goal. Refer to mitigation measures as discussed for the construction phase, as these will already have to be considered during the planning phase.	2	1	5	1	5	**48 (-ve)**	**L (-ve) Maintain current management**
IMPACT 2: CHANGES TO IN-STREAM HABITAT AND LOSS OF AQUATIC HABITAT															
Poor planning leading to an increased footprint in the vicinity of the active stream channel, resulting in excessive alteration of the in-stream habitat. This may include ongoing erosion, altered in-stream habitats and inadequate planning of rehabilitation leading to permanent impacts on in-stream habitat	3	3	5	2	5	**77 (-ve)**	**MH (-ve) Improve current management**	Refer to mitigation measures as discussed for the construction phase, as these will already have to be considered during the planning phase.	2	1	3	2	3	**30 (-ve)**	**L (-ve) Maintain current management**
IMPACT 3: IMPACTS ON IN-STREAM BIOTA AND LOSS OF AQUATIC BIODIVERSITY AND SENSITIVE TAXA															

Poor planning leading to an increased footprint in the vicinity the active stream channel, with nnegative impacts on flow and habitat availability (impacts 1 and 2), will invariably result in negative impacts on the aquatic community. However, changes in conditions or water quality will also directly affect sensitive taxa.	3	3	3	1	5	**54 (-ve)**	**LM (-ve) Improve current management**	Refer to mitigation measures as discussed for the construction phase, as these will already have to be considered during the planning phase.	2	1	2	1	4	**25 (-ve)**	**VL (-ve) Maintain current management**
IMPACT 4: IMPACTS ON STREAM CONNECTIVITY AND MIGRATORY TAXA															
Changes in flow or creation of physical barriers resulting from poor planning will negatively affect stream connectivity within the larger system and hence also negatively affect migratory movement of more mobile aquatic taxa	3	4	5	1	5	**72 (-ve)**	**LM (-ve) Improve current management**	Refer to mitigation measures as discussed for the construction phase, as these will already have to be considered during the planning phase.	2	3	2	1	4	**35 (-ve)**	**L (-ve) Maintain current management**
IMPACT 5: IMPACTS ON WATER QUALITY AFFECTING AQUATIC ECOLOGY															
Poor planning of the construction methods, as well as human activities associated with construction, could lead to pollution of both surface and ground water.	3	3	3	2	4	**54 (-ve)**	**LM (-ve) Improve current management**	Refer to mitigation measures as discussed for the construction phase, as these will already have to be considered during the planning phase.	2	1	2	1	2	**15 (-ve)**	**VL (-ve) Maintain current management**

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.2.2 Implementation/Construction Phase

Construction of bridge structures and ineffective rehabilitation of riparian areas may result in negative impacts on aquatic habitat, function and service provision. However, with the implementation of mitigation and rehabilitation measures, the significance of new as well as existing impacts on the aquatic habitat may be reduced.

Table 27: Impacts associated with the Implementation/Construction Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON IN-STREAM FLOW AND HYDROLOGICAL FUNCTION															
Vehicles and equipment accessing area through riparian area and areas of natural bankside vegetation, leading to altered streamflow patterns with special mention of the creation of turbulent flow and the concentration of flow. Such access may potentially also result in localised changes to habitat types, abundance and cover availability and types. Construction of any stream diversions, coffer dams and temporary crossings for construction vehicles leading to upstream ponding and inundation for the duration of construction and creation of turbulent flow and the concentration of flow downstream of the crossing Construction activities will lead to sedimentation and the alteration of instream habitat and the smothering of benthos.	4	4	5	1	5	78 (-ve)	MH (-ve) Improve current management	All crossing construction or repairs should be undertaken when low flows are present in the system which can be controlled by the IBT scheme. The construction infrastructure and coffer dams and stream diversions must at no time lead to upstream ponding and inundation or lead to the constriction of flow and downstream erosion. Minimise disturbance of instream and bankside areas and minimise activities in these areas. As far as possible keep all instream areas and stream banks off limits to general activity during the construction phase. Any construction-related waste must not be placed in the vicinity of any riparian areas. Ensure that on-site camp fires are forbidden.	2	1	5	1	5	48 (-ve)	L (-ve) Maintain current management

Incorrect rehabilitation and reshaping of the stream bed and banks in areas of disturbance. Inadequate removal of waste construction material from the stream bed. Construction activity will affect riparian soils and habitats which in turn will affect riparian vegetation cover and assemblage.								Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing. During construction, drift fences constructed from hessian sheets should be installed at erodible areas to minimise erosion. Silt traps should also be provided to remove sand/silt particles from runoff. Limit the footprint area of the construction activity to what is absolutely essential in order to minimise environmental damage. Riparian areas that may have been disturbed during construction should be rehabilitated through reprofiling and revegetation upon completion of the construction phase. Desilt all riparian areas affected by construction activities. Reprofiling of the banks of disturbed drainage areas to a maximum gradient of 1:3 to ensure bank stability if necessary. Reinforce banks and drainage features where necessary with gabions, reno mattresses and geotextiles.							
IMPACT 2: CHANGES TO IN-STREAM HABITAT AND LOSS OF AQUATIC HABITAT															

Direct impact on instream habitat and the associated impact on instream biota due to construction activity Earthworks in the vicinity of the channel leading removal of riparian vegetation and the disturbance of soils to increased runoff and erosion and altered runoff patterns Construction activities and disturbances leading to altered stream substrate and flows leading to altered flow and depth cover classes Construction activities with special mention of temporary access roads leading to inundated areas upstream of the bridge and ponding Dumping of construction material within or near the channel and the compaction of riparian soils Potential contamination of soil and water from the fuel of construction vehicles	4	3	2	2	5	**63 (-ve)**	**LM (-ve) Improve current management**	Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing; As far as possible, all construction activities should occur in the low flow season, during the drier winter months; All waste rock and other construction material should be removed from the stream bed and banks upon completion of construction; Implement of an alien vegetation control program within riparian areas is recommended; All sharp edged rocks and material should be removed from the stream bed and banks; Also please refer to the mitigation measures presented in impact 1.	2	1	2	2	3	**25 (-ve)**	**L (-ve) Maintain current management**
IMPACT 3: IMPACTS ON IN-STREAM BIOTA AND LOSS OF AQUATIC BIODIVERSITY AND SENSITIVE TAXA														
Direct impact on instream habitat and the associated impact on instream biota Reduced instream and riparian community diversity, abundance and structure with special mention of more sensitive taxa Capturing of biota from the system with special mention of fish by construction personnel. Sedimentation leading to the smothering of benthos and their associated habitat	3	3	3	2	5	**63 (-ve)**	**LM (-ve) Improve current management**	Edge effects (impacts on areas beyond the construction footprint due to less than desirable care and management) during construction and operation need to be strictly controlled through ensuring good housekeeping and strict management of activities near the stream crossing; As far as possible, all construction activities should occur in the low flow season, during the drier winter months; Ongoing aquatic biomonitoring commencing at least 6 months before construction and for at least year after construction is to take place to monitor the impacts on aquatic biota and in order to allow the identification of required	2	1	2	2	3	**25 (-ve)**	**VL (-ve) Maintain current management**

								impact minimisation measures for each system; Please refer to the mitigation measures presented in impact 1 and 2 above for recommendations pertaining to hydrological and habitat management controls which will minimise the impact on biota; Implement an alien vegetation control program within riparian areas; All sharp edged rocks and material should be removed from the stream bed and banks; Also please refer to the mitigation measures presented in impacts 1 and 2.							
IMPACT 4: IMPACTS ON STREAM CONNECTIVITY AND MIGRATORY TAXA															
An impact on migratory fish species, with specific reference to eels, due to temporary structures affecting stream connectivity.	3	4	3	2	4	**60 (-ve)**	**LM (-ve) Improve current management**	It must be ensured that migratory connectivity and stream continuity is maintained throughout the construction phase of the project; Also please refer to the mitigation measures presented in impacts 1, 2 and 3.	2	3	2	1	3	**28 (-ve)**	**L (-ve) Maintain current management**
IMPACT 5: IMPACTS ON WATER QUALITY AFFECTING AQUATIC ECOLOGY															
Indiscriminate construction methods, as well as human activities associated with construction, could lead to pollution of both surface and ground water.	4	3	3	2	4	**60 (-ve)**	**LM (-ve) Improve current management**	Limit the footprint of activity as far as possible throughout the construction phase of the project; Ensure adequate processes for waste management and removal of wastes associated with construction; Ensure adequate processes such as dedicated parking areas and fuel storage that would preclude leakage or spillage into the aquatic environment; Ensure adequate and well-placed sanitation facilities for personnel that would preclude leakage or spillage into the aquatic	2	1	3	1	2	**18 (-ve)**	**VL (-ve) Maintain current management**

								environment; Also please refer to the mitigation measures presented in impacts 1, 2, 3 and 4.							

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.2.3 Post Rehabilitation/Operational Phase

Inefficient aftercare and maintenance and ineffective monitoring during the post-rehabilitation/operational phase may result in a negative impact on aquatic systems. However, with the implementation of mitigation measures impacts may be reduced to low and very low levels.

Table 28: Impacts associated with the Post Rehabilitation/Operational Phase of the development.

POTENTIAL ENVIRONMENTAL IMPACT (NATURE OF THE IMPACT)	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
	Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline		Consequence			Likelihood (Probability)		Significance (Degree to which impact may cause irreplaceable loss of resources)	SRK Guideline
	Se	Sp	Du	Fa	Fi				Se	Sp	Du	Fa	Fi		
IMPACT 1: IMPACT ON IN-STREAM FLOW AND HYDROLOGICAL FUNCTION															
Incorrect rehabilitation and reshaping of the stream bed and banks in areas of disturbance leading to ongoing deterioration of stream banks, in turn leading to altered streamflow patterns with special mention of the creation of turbulent flow, concentration of flow and potential upstream inundation and ponding. Altered structure of riparian habitat and riparian vegetation assemblages due to altered hydrology and ongoing erosion. Latent impacts due to inadequate design leading to degrading instream habitat and cover as well as migratory connectivity and riparian habitat and vegetation structures. Proliferation of alien vegetation leading to altered habitat for indigenous riparian fauna and flora. Water quality impacts from chemical,	3	4	5	5	4	**108 (-ve)**	**H (-ve) Improve current management**	Implementation of recommendations made during construction phase to ensure effective operation - refer to mitigation measures as discussed for the construction phase. Sheet runoff from access roads and the final road structure needs to be curtailed and slowed down by the strategic placement of energy dissipation structures; Adequate stormwater management must be incorporated into the design of the proposed structure in order to prevent erosion and the associated sedimentation of the system for the life of the structure; As far as possible, all construction activities should occur in the low flow season, during the drier summer months; Ongoing aquatic biomonitoring on a minimum of a quarterly basis must take place from 6 months prior to construction till 1 year after construction to determine trends in ecology and	2	1	5	2	3	**40 (-ve)**	**L (-ve) Maintain current management**

cement and fuel spills.							define any impacts requiring mitigation. During the operational phase an annual assessment should be undertaken to determine if any excessive erosion of the structure is occurring. Photographic records should be maintained and any necessary maintenance and rehabilitation implemented.								
IMPACT 2: CHANGES TO IN-STREAM HABITAT AND LOSS OF AQUATIC HABITAT															
Ongoing erosion of the stream channel and potential incision of the river system Sedimentation due to erosion from the activities associated with the development Ineffective rehabilitation may lead to instream habitat transformation leading to lower abilities to support aquatic biota Altered riparian vegetation and instream community structures Loss of stream connectivity and migratory connectivity Contamination of water and sediment within the channel resulting in algal proliferation if any road users spill hazardous materials in the vicinity of the river crossing Ongoing disturbance as a result of maintenance activities in the road reserve leading to altered riparian vegetation community structures	3	3	5	5	4	**99 (-ve)**	**MH (-ve) Improve current management**	Implementation of recommendations made during construction phase to ensure effective operation - refer to mitigation measures as discussed for the construction phase. Adequate processes to ensure efficient maintenance of road and bridge structures; Routine and effective assessment of structures and monitoring of conditions within the system;	2	1	5	4	2	**48 (-ve)**	**L (-ve) Maintain current management**
IMPACT 3: IMPACTS ON IN-STREAM BIOTA AND LOSS OF AQUATIC BIODIVERSITY AND SENSITIVE TAXA															

Ongoing erosion of the stream channel and potential incision of the river system leading to reduced instream and riparian community diversity, abundance and structure with special mention of more sensitive taxa Capturing of biota from the system with special mention of fish due to increased accessibility of the area Ongoing disturbance as a result of maintenance activities in the road reserve leading to altered riparian vegetation community structures	3	3	3	1	5	**54 (-ve)**	**LM (-ve) Improve current management**	Implementation of recommendations made during construction phase to ensure effective operation - refer to mitigation measures as discussed for the construction phase. Removal of alien vegetation and good housekeeping within the road reserve must take place at all times; Any spills by maintenance teams or road users should be cleaned up immediately and all work overseen by a suitably qualified professional	2	1	5	1	4	**40 (-ve)**	**L (-ve) Maintain current management**
IMPACT 4: IMPACTS ON STREAM CONNECTIVITY AND MIGRATORY TAXA															
An impact on migratory fish species due to possible impacts on in-stream flow and connectivity	3	4	5	4	4	**96 (-ve)**	**MH (-ve) Improve current management**	Implementation of recommendations made during construction phase to ensure effective operation - refer to mitigation measures as discussed for the construction phase; It must be ensured that migratory connectivity and stream continuity is maintained throughout the operational phase of the project.	2	3	5	1	4	**50 (-ve)**	**L (-ve) Maintain current management**
IMPACT 5: IMPACTS ON WATER QUALITY AFFECTING AQUATIC ECOLOGY															
Poor housekeeping during routine maintenance actions in terms of potential pollution from vehicles, sanitation and litter may negatively affect water quality.	2	2	5	4	3	**63 (-ve)**	**LM (-ve) Improve current management**	Implementation of recommendations made during construction phase to ensure effective operation - refer to mitigation measures as discussed for the construction phase; Maintain processes to ensure good housekeeping practises during operational phase.	2	1	5	1	2	**24 (-ve)**	**VL (-ve) Maintain current management**

* S – Severity, SS – Spatial Scope; D - Duration of impact; FA – Frequency of Activity; FI – Frequency of Impact

7.2.4 Impact assessment conclusion

Based on the above assessment it is evident that there are three major impacts that have an impact on the overall riparian and wetland ecology of the study area and five major impacts that may have an effect on the overall aquatic integrity of the aquatic resources in the vicinity of the proposed bridge crossings. The tables below summarise the findings indicating the significance of the impacts before mitigation takes place as well as the significance of the impacts if appropriate management and mitigation takes place.

Table 29: Summary of impact significance of the bridge upgrade project on the Skoenmakers River from an aquatic assessment perspective.

No.	Impact	Design Phase		Implementation/ Construction		Post Rehabilitation/ Operational	
		Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation
1	Impact on riparian and wetland habitat and ecological structure	LM (-)	L (-)	LM (-)	LM (+)	H (-)	L (-)
2	Impact on riparian and wetland function and socio-cultural service provision	LM (-)	L (-)	LM (-)	LM (+)	H (-)	L (-)
3	Impact on riparian and wetland hydrological function and sediment balance	LM (-)	L (-)	LM (-)	LM (+)	MH (-)	VL (-)

VL = Very low; L = Low; LM = Low-medium; MH = Medium-high; H = High

Table 30: Summary of impact significance of the bridge upgrade project on the Skoenmakers River from an aquatic assessment perspective.

No.	Impact	Design Phase		Implementation/ Construction		Post Rehabilitation/ Operational	
		Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation	Prior to mitigation	Post mitigation
1	Impact on in-stream flow and hydrological function	LM	L	MH	L	H	L
2	Changes to in-stream habitat and loss of aquatic habitat	MH	L	LM	L	MH	L
3	Impacts on in-stream biota and loss of aquatic biodiversity and sensitive taxa	LM	VL	LM	VL	LM	L
4	Impacts on stream connectivity and migratory taxa	LM	L	LM	L	MH	L
5	Impacts on water quality affecting aquatic ecology	LM	VL	LM	VL	LM	VL

VL = Very low; L = Low; LM = Low-medium; MH = Medium-high; H = High

The design phase has bearing on both the implementation/construction and post-rehabilitation/operational phases, as recommendations drafted during the former needs to be applied in the implementation/construction phase, with largely permanent implications in the post-rehabilitation/operational phase. As a result mitigatory measures highlighted during the design phase should also be consulted during the other phases. Envisioned impacts during the design phase are largely low-medium to medium-high before mitigation but very low to low after mitigation.

Impacts encountered during the implementation/construction phase are often more significant or severe, but shorter in duration, than those generally encountered in the post-rehabilitation/operational phase of any proposed development. However, in the case of in-stream alterations the impacts during the post-rehabilitation/operational phase are often scored as permanent and this translates into a higher impact score.

Envisioned aquatic impacts during the implementation/construction phase are largely low-medium to medium-high before mitigation but very low to low after mitigation. Envisioned riparian and wetland impacts during the construction phase are largely low-medium before mitigation. However, rehabilitation measures implemented during the implementation/construction phase are likely to result in an increase in the PES of River crossing areas and impacts are therefore considered to be low-medium positive after mitigation.

Envisioned impacts during the operational phase are largely low-medium to high before mitigation but very low to low after mitigation. As mentioned the high impact score pertains to the fact that any impacts resulting from structural sources will be permanent.

8 CONCLUSION

SAS was appointed to conduct a wetland and aquatic assessment and to develop a Riparian and Wetland Rehabilitation Plan for the upgrade and construction of bridge structures crossing the Skoenmakers River near Somerset East in the Eastern Cape Province. The portion of the river to be assessed is located to the east of the R400 and to the west of the R335 and will hereafter be referred to as the study area.

A site visit was undertaken in May 2014 to determine the present state of the study area and to identify any current impacts and issues, as well as potential future impacts, which threaten the ecological integrity of this portion of the Skoenmakers River and downstream areas.

Aquatic assessment results indicated that the habitat is not suitable to support a diverse macro-invertebrate community. Both the macro-invertebrate and fish fauna community assessment results indicated loss of aquatic ecosystem integrity in this moderately sensitive ecological system, with a D/E classification. Five potential negative impacts on general aquatic integrity have been identified during the aquatic impact assessment. Key mitigation recommendations pertain to design of bridge structure as it relates to in-stream flow, housekeeping, rehabilitation and management procedures during the construction phase and maintenance and monitoring during the operational phase. Following mitigation envisioned impacts are considered to be low to very low.

The overall wetland PES was calculated to fall within Class D (Largely modified, a large loss of natural habitat, biota and basic ecosystem functions has occurred), with the wetland functioning and ecoservices provision within the vicinity of the study area achieving an average score of 1.7, which indicates that the watercourse and wetlands provide an intermediate benefit in terms of their ecological, economic and social benefits. The REC deemed appropriate to enhance and maintain current ecology as well as functionality of the aquatic features within the study area is a Class C.

Several historic and present impacts were identified and are listed below:

- A few isolated areas of cultivated land were encountered;
- The hydrology of the system has been significantly altered as a result of a large interbasin transfer scheme which transfers significant volumes of water from the Little Fish River into the upper reaches of the system. The increased volume and velocity of water running through the system has resulted in the significant erosion and incision of the banks of the river;
- Where current bridge structures traverse the river an increase in the erosion and incision of the river banks was noted downstream of the bridge structures. This has been caused as a result of the turbulent flow created by the passage of water through pipes and culverts below bridge structures;

- Disturbance associated with the development of bridge structures has also resulted in the encroachment of alien and invasive floral species such as *Opunti ficus-indica, Opuntia aurantiaca, Verbesina encelioides, Atriplex lindleyii, Atriplex semibaccata, Atriplex versicaria, Pennisetum setaceum* and *Pennisetum clandestinum* into the surrounding area. However these species are largely restricted to areas of disturbance with only a few scattered individuals encountered elsewhere within the study area.

A number of impacts including invasion of the watercourse and wetland areas by alien plant species, further erosion, siltation, loss of bank stability and an increase in soil compaction have been identified, which may occur as a result of the proposed development and therefore requires suitable management during the implementation/construction and post-rehabilitation/operational phases thereof.

A Riparian and Wetland Rehabilitation Plan including management measures was developed to effectively manage, maintain and improve the ecological characteristics of the study area. Key management factors identified in the rehabilitation plan were the:

- Minimisation of impacts from the proposed construction activities;
- Reshaping and levelling of rehabilitated areas to resemble pre-construction environments as far as possible;
- Reconstruction of river banks to tie in with existing river banks;
- Re-vegetation of disturbed areas;
- Measures to prevent erosion and sedimentation of aquatic resources;
- Alien plant species control within the construction footprint and surrounding areas;
- Removal of all construction material within the riparian and wetland areas upon decommissioning; and
- Re-profiling and sloping of areas at risk of erosion and incision as a result of construction activities in order to maintain the ecological functionality.

The measures as set out in the Riparian and Wetland Rehabilitation Plan are deemed sufficient for the conservation of ecological processes and provide a tool for managing and improving the current ecological state of the area in the vicinity of the river crossings. If the measures as set out in the rehabilitation plan are adhered to, ecological processes within the area will not only re-establish, but also allow for the continued improvement of the functionality of the wetland and watercourse system.

If these measures are implemented along with measures to minimise implementation/construction and post-rehabilitation/operational footprint areas within the watercourse and wetland areas, impacts on the system can be adequately minimised.

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APPENDIX A

Method of Assessment

WETLAND ASSESSMENTS

A – 1 Desktop Study

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 subject property included:

- National Freshwater Ecosystem Priority Areas (NFEPAs) (2011)
  - NFEPA water management area (WMA);
  - NFEPA wetlands/National wetlands map;
  - Wetland and estuary Fresh Water Ecosystem Priority Areas (FEPA);
  - FEPA (sub)WMA % area;
  - Sub water catchment area FEPAs;
  - Water management area FEPAs;
  - Fish sanctuaries;
  - Wetland ecosystem types;
- Prioritisation of City Wetlands

A – 2 Classification System for Wetlands and other Aquatic Ecosystems in South Africa

All wetland features encountered within the subject property 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 1 and 2, below.

Table 1: 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 2: 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

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
	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)
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)

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***[2] (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.

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 Department of Water Affairs (DWA) 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.

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] 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.

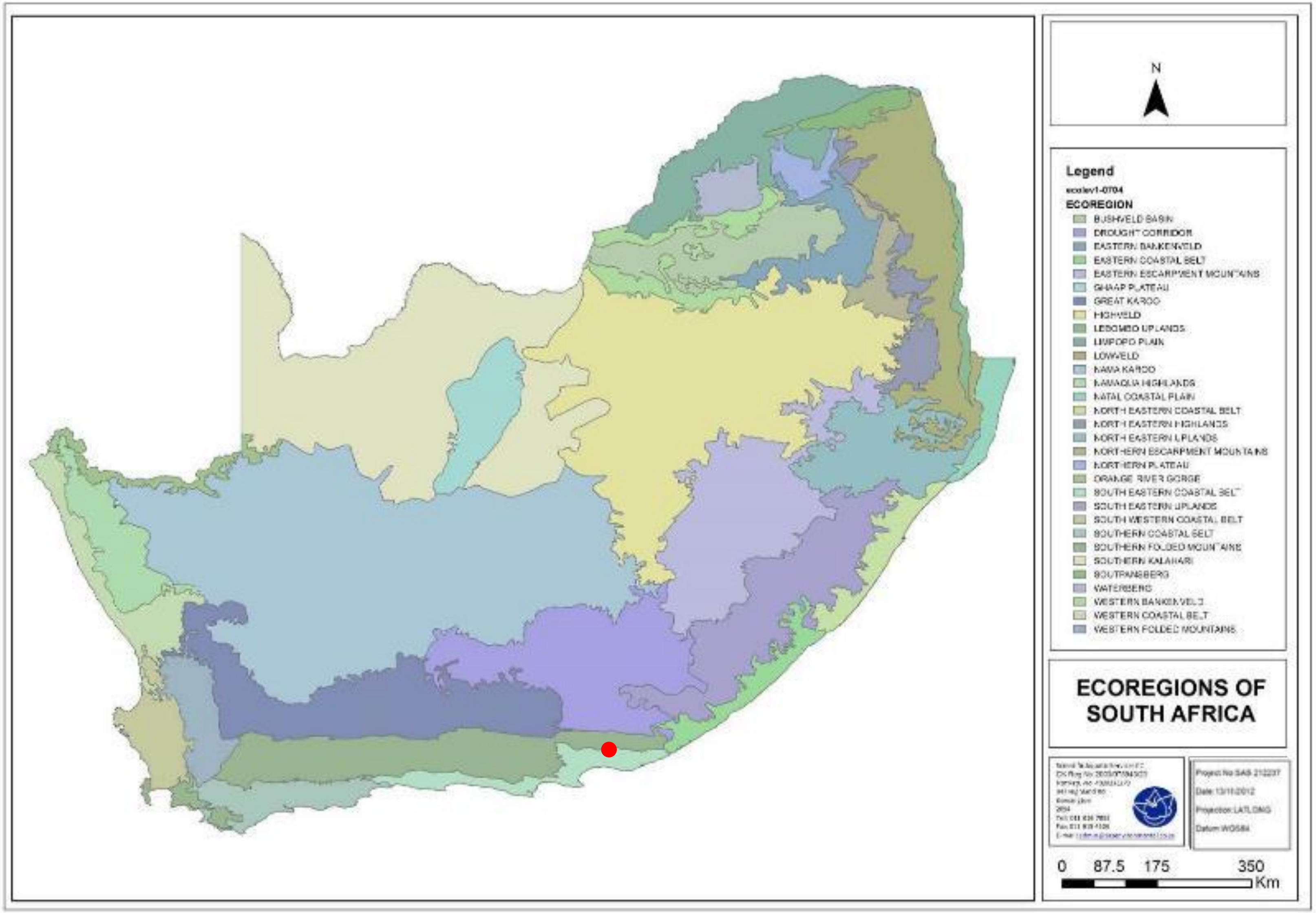

Figure 1: Map of Level 1 Ecoregions of South Africa, with the approximate position of the subject property indicated in red.

Level 3: Landscape Setting

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

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

Level 4: Hydrogeomorphic Units

Eight primary HGM Types are recognised for Inland Systems at Level 4A of the proposed National Wetland Classification Systems (NWCS), 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.,* 2009) and WET-EcoServices (Kotze *et al.,* 2008).

A – 3 Index of Habitat Integrity (IHI)

To assess the Present Ecological State (PES) of the drainage feature the Index of Habitat Integrity (IHI) for South African floodplain, channelled and channelled valley bottom wetland types (DWAF Resource Quality Services, 2007) were used.

The WETLAND-IHI is a tool developed for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (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 3 below), and provide a score of the PES of the habitat integrity of the wetland system being examined.

Table3: 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.

A – 4 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".[3] The assessment of the ecosystem services supplied by the identified wetlands was conducted according to the guidelines as described by Kotze *et al* (2008). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

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

[3] Department of Water Affairs and Forestry, South Africa *Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999*

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

Table 4: 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
0.6-1.2	Moderately low
1.3-2	Intermediate
2.1-3	Moderately high
>3	High

A – 5 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[4]. 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 5: 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

4 Kleynhans et al, 2007

A – 6 Defining Ecological Importance and Sensitivity

The method used for the Ecological Importance and Sensitivity (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. A confidence score is also provided on a scale of 0 to 4, where 0 indicates low confidence and 4 high confidence.

Table 6: EIS Category definitions

EIS Category	Range of Median	Recommended Ecological Management Class[5]
Very high Wetlands/rivers 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/rivers 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/rivers 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/rivers that is 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

A – 7 Recommended Ecological Category

"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 Present Ecological State (PES), reference conditions and Ecological Importance and Sensitivity of the resource (sections above). 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 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.

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

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

Table 7: Description of REC classes.

Class	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified

A – 8 Wetland Delineation

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

The wetland zone delineation 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 Department of Water Affairs and Forestry (DWAF) in February 2005. Attention was also paid to wetland soil guidelines as defined by Job (2009) for the Western Cape. The foundation of the method is based on the fact that wetlands have several distinguishing factors including the following:

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

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 (DWAF 2005).

Riparian and wetland zones can be divided into three zones (DWAF 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.

A – 9 Ecological Impact Assessment

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

- An **activity** is a distinct process or task undertaken by an organization for which a responsibility can be assigned. Activities also include facilities or pieces of infrastructure that are possessed by an organization.
- An environmental aspect is an 'element of an organizations activities, products and services which can interact with the environment'. 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. 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 aquifers, flora and palaeontology. In the case where the impact is on human health or well-being, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.

- **Receptors** comprise, but are not limited to people or man-made structures.
- **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 scope** 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 was assessed by rating each variable numerically according to defined criteria as outlined in Table 9. 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 Table 11: is used to determine whether mitigation is necessary [1].

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

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

Table 8: Criteria for assessing significance of impacts

SEVERITY OF IMPACT	RATING
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5

SPATIAL SCOPE OF IMPACT	RATING
Activity specific	1
Right-of-way specific (within right-of-way)	2
Local area	3
Regional	4
National	5

DURATION OF IMPACT	RATING
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure / permanent	5

CONSEQUENCE

FREQUENCY OF ACTIVITY / DURATION OF ASPECT	RATING
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5

FREQUENCY OF IMPACT	RATING
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

LIKELIHOOD

Table 9: 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 10: Positive/negative mitigation ratings

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very high	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-high	76-100	Improve current management	Maintain current management
	Low-medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very low	1-25	Maintain current management	Improve current management

The following abbreviations have been applied to reduce the size of the Impacts Tables.

S – Severity
SS – Spatial Scope
D - Duration of impact
FA – Frequency of Activity
FI – Frequency of Impact
SIG – Significance of Impact

AQUATIC ASSESSMENTS

A – 10 Visual Assessment

The sites were investigated in order to identify visible impacts with specific reference to impacts from surrounding activities. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system were assessed by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site-specific visual assessments included the following:

- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area;
- Other life forms reliant on aquatic ecosystems;

Signs of impact related to water quality.

A – 11 Physico-Chemical Water Quality Data

On site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity, dissolved oxygen concentration and temperature. 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). In addition the dissolved oxygen levels were measured to determine the percentage saturation level at the time of sampling and tabulated in accordance to the United States Environmental Protection Agency (USEPA) calculations (APHA, 1992).

A – 12 Intermediate Habitat Integrity Assessment

The general habitat integrity of each site was discussed based on the application of the Intermediate Habitat Integrity Assessment (IHIA) for use in rapid and intermediate habitat assessments (Kemper, 1999). It is important to assess the habitat of each site in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration.
This method describing the Present Ecological State (PES) of both the instream and riparian habitat at each site are included in the assessment.
The method classifies Habitat Integrity into one of six classes, ranging from Unmodified/Natural (Class A), to Critically Modified (Class F) (Table 11). Reference conditions for the area were considered to be Class C see section 3.1.2).

Table 11: Classification of Present State Classes in terms of Habitat Integrity (Kleynhans, 1996).

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications.	80-90
C	Moderately modified.	60-79
D	Largely modified.	40-59
E	Extensively modified.	20-39
F	Critically modified.	<20

A – 13 Invertebrate Habitat Assessment System (IHAS)

The Invertebrate Habitat Assessment System (IHAS) was applied 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.

A – 14 South African Scoring System 5 (SASS5)

Aquatic macro-invertebrate communities of the selected sites 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. The assessment was undertaken according to the protocol as defined by Dickens and Graham (2001). All work was undertaken by an accredited 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 using taxa expected in the SQC in question. As a result a SASS5 reference score of 86 and an ASPT reference score of 4.5 were calculated for the Skoenmakers River. 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) (Table 12).

Table 12: Definition of Present State Classes in terms of SASS 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

A – 15 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 SM1 and SM2 following the 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).

A – 16 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 site was graphically expressed as habitat cover ratings (HCR) for different flow-depth classes as a stacked bar chart.

A – 17 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) (Table 2 and Figure 2). Fish samples were collected by means of a fixed generator driven electro-fishing device. Fish species identified were compared to those expected to be present at the sites, which were compiled from a literature survey including Traas (2009), Kleynhans *et al.* 2007 and and Skelton (2001). Fish expected to occur in the system is summarised in Table 13. Comparisons between upstream and downstream points were made where applicable.

Table 13: Intolerance ratings for naturally occurring fish species expected to occur in the area (Kleynhans et al., 2007).

SPECIES NAME[1]	COMMON NAME	INTOLE-RANCE RATING[5]	FROC score[6]	COMMENTS
Anguilla mossambica[2]	Longfin eel	2.8	0.5	East coast from Kenya south to Cape Agulhas
Barbus anoplus[2]	Chubbyhead Barb	2.6	1.0	Widely distributed from Highveld, Limpopo to upland KwaZulu-Natal, Transkei and the Orange Basin including the Karoo.
Barbus pallidus[2]	Goldie Barb	3.1	0.5	Coastal streams of the Eastern Cape and also tributaries of the Vaal.
Clarias gariepinus[3]	Sharptooth Catfish	1.4	2.5	Widespread throughout southern Africa.
Cyprinus carpio[3]	Carp	1.4	1.0	Widespread throughout southern Africa.
Gambusia affinis[3]	Mosquitofish	2.0	1.5	Isolated populations including Eastern Cape localities.
Glossogobius callidus[2]	River Goby	2.3	0.5	East coast rivers from Mozambique south to the Swartvlei region of the Western Cape.
Labeo capensis[3]	Orange River Labeo	3.2	1.0	Orange-Vaal system.
Labeo umbratus[2]	Moggel	2.3	1.0	Orange-Vaal system and

SPECIES NAME[1]	COMMON NAME	INTOLE-RANCE RATING[5]	FROC score[6]	COMMENTS
				systems of the Cape coastal regions.
Labeobarbus aeneus[3]	Smallmouth Yellowfish	2.5	3.0	Natural range Orange-Vaal system, Cape coastal rivers, and the Limpopo River.
Micropterus salmoides[4]	Largemouth Bass	2.2	0.5	Widespread in Western and Eastern Cape coastal drainages.
Oreochromis mossambicus[3]	Mozambique Tilapia	1.3	2.5	East coastal rivers from the Lower Zambezi River south to the Bushman's system, Eastern Cape.
Tilapia sparrmanii[3]	Banded Tilapia	1.3	1.0	Extensively translocated south of the Orange in the Cape.

[1] Checklist of freshwater and estuarine fish found in the freshwater section (which includes the Skoenmakers River) of the Greater Addo Elephant National Park as listed by Traas (2009);
[2] Indigenous species;
[3] Alien species translocated from the Orange-Fish water transfer scheme;
[4] Stocked alien species;
[5] Intolerance ratings: Tolerant: 1-2; moderately tolerant :> 2-3; Moderately Intolerant: >3-4; Intolerant: >4
[6] Frequency of occurrence (FROC) score not listed for the Skoenmakers River or catchment N23A in Kleynhans *et al.* 2007. For the purposes of this study relative FROC scores were allocated based on relative abundance data as reported by Traas (2009) – see figure and discussion below.

Traas (2009) reported on the relative abundance of fish species in the Skoenmakers River and compared it to a study performed in 1996. For the purposes of this report the 2009 data as reported by Traas (2009) was used as primary guideline to allocate the FROC scores listed in Table 13.

However, historical data (1996) were also considered in conjunction with observation made during this assessment, specifically with reference to *L. aeneus.*

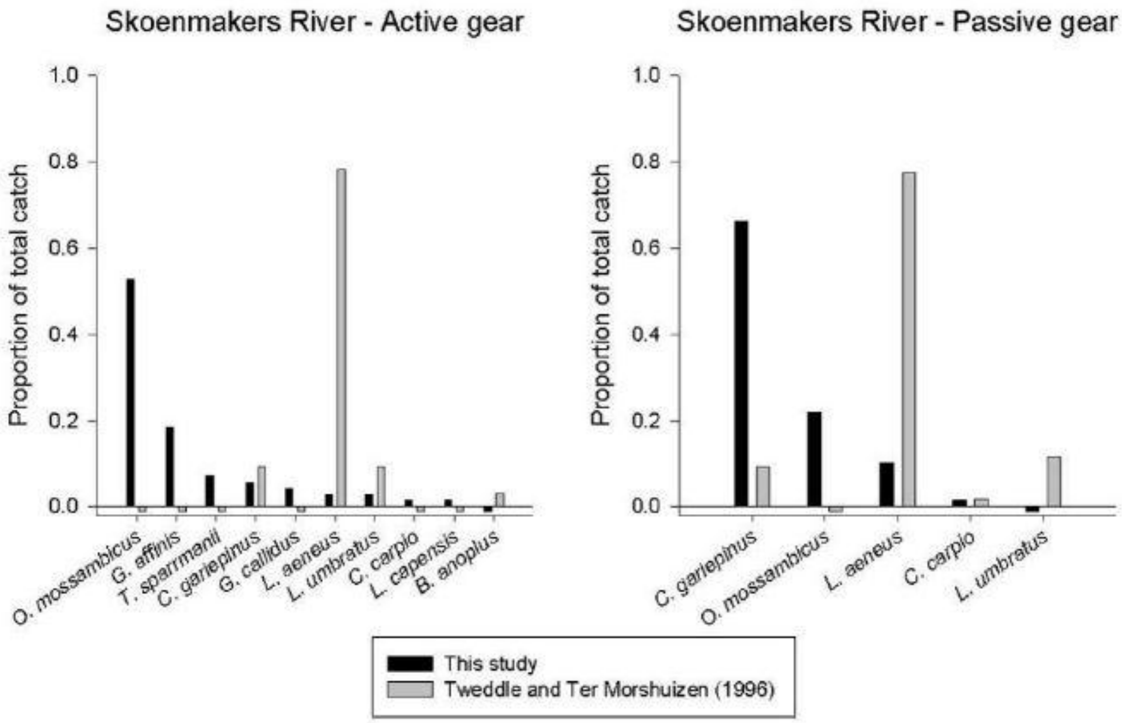

Figure 2: Relative abundance fish data from the Skoenmakers River as reported by Traas (2009). Please note that "This study" in the legend caption thus refers to the Traas (2009) study from which the graph was obtained.

The three most abundant species expected were *O. mossambicus, C. gariepinus* and *L. aeneus.* These were allocated FROC scores of 2.5, 2.5 and 3.0 respectively. Species on the checklist but for which no abundance data were reported were allocated a FROC score of 0.5. Species listed on the checklist for which low abundances were reported, were given a FROC score of 1.0.

Ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred, (DWA 1999). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity.

In terms of this assessment, ecological importance and sensitivity is a general and unrefined estimation. It is strongly biased towards the potential importance and sensitivity of the particular stream delineation as it would expect to be under unimpaired conditions. This means that the present ecological status or condition (PESC) is generally not considered in determining the ecological importance and sensitivity *per se* (DWA 1999).

The following ecological aspects should be considered as the basis for the estimation of ecological importance and sensitivity:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity should be taken into account for both the instream and riparian components of the river;
- Habitat diversity should also be considered. This can include specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc. (DWA 1999);
- With reference to points 1 and 2, biodiversity in its general form should be taken into account as far as the available information allows;

- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species should be considered;
- The presence of conservation or relatively natural areas along the river section should also serve as an indication of ecological importance and sensitivity; and
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes should also be considered. Consideration of both the biotic and abiotic components is included in this sensitivity analyses.

A – 18 Aquatic EIS assessment

The EIS method considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table 14). The median of the resultant score is calculated to derive the EIS category.

Table 14: Ecological importance and sensitivity categories (DWAF, 1999)

EISC	General Description	Range of median
Very high	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations that is not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

APPENDIX B

SASS Scoresheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
DATE: 26/05/2014																		
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: SM 1(Site 5 reference)	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: SKOENMAKERS RIVER (US)	Oligochaeta	1		A	A	B	Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION: UPSTREAM REFERENC	Leeches	3					Naucoridae*	7					Culicidae*	1		A		A
WEATHER CONDITION: WARM / OVERCAST	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 14.9 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.2	Potamonautidae*	3		1		1	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 815 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5			A	A
SIC:	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	A	A	A	B	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	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: FAST	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			A	
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		17	24	20	35
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		3	6	5	8
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	4.0	0	4.4
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		51%			
	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	A	B	SWC = South Western Cape					
	Aeshnidae	8		1		1	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					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: 26/05/2014	**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: SM 2 (Site 12 reference bridge)	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: SKOENMAKERS RIVER (DS)	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1	**A**			**A**
WEATHER CONDITION: WARM / OVERCAST	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 18.3 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 8.5	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 62.3 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC:	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	**A**		**A**	**B**	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	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: FAST	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:**		26	5	11	26
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		5	1	2	5
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		5	0.0	6	5.2
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		44%			
	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**	**A**	**B**	SWC = South Western Cape					
	Aeshnidae	8	**A**			**A**	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					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					

APPENDIX C

IHAS scoresheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SKOENMAKERS RIVER (US)
Site Name: SM 1
Date: 26/05/2014

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	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					6	
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):					32	

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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 45):						19
TOTAL IHAS SCORE (%):					51	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: SKOENMAKERS RIVER
Site Name: SM2
Date: 26/05/2014

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):				15		
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	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					6	
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):					11	
HABITAT TOTAL (MAX 55):					32	

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)	>2	>1-2	1	>½-1	½	<½
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)***	flood	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	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX						12
TOTAL IHAS SCORE (%):					44	

APPENDIX D

IHIA RESULTS

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
Skoen-makers	26 May 2014	8	16	15	2	7	12	0	7	0	51.2	D (largely modified)

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
Skoen-makers	26 May 2014	6	8	16	2	13	11	4	9	47.8	D (largely modified)

None	Small	Moderate	Large	Serious	Critical

REACH	ASSESSMENT DATE	INSTREAM HABITAT	RIPARIAN ZONE	IHI SCORE	CLASS
Skoenmakers	26 May 2014	51.2	47.8	49.5	D (largely modified)

Note: "Skoenmakers" refer to the Skoenmakers River as a whole based on assessment of both sites SM1 and SM2.