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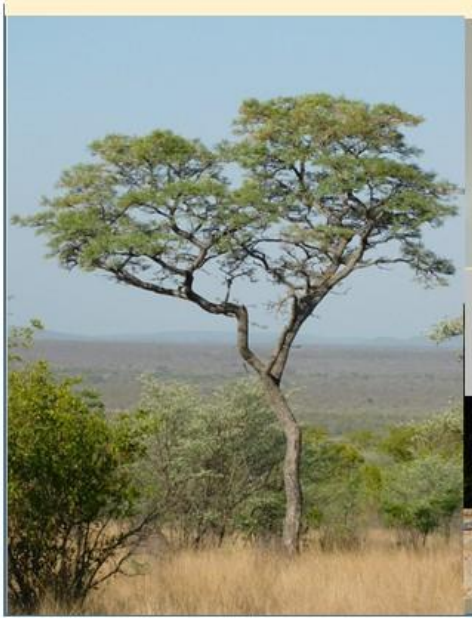
Specialist assessment: Environmental Impacts on Aquatic Biodiversity.



DR ANDREW DEACON

November 2021

KAINGO PRIVATE NATURE RESERVE: THE DEVELOPMENT OF A LOW WATER CROSSING OVER THE MOKOLO RIVER

An Aquatic Biodiversity Specialist Assessment for the development of a low water crossings over the Mokolo River within the Kaingo Private Nature Reserve (PNR), in the Vaalwater area, Limpopo Province, South Africa.

Specialist assessment: Environmental Impacts on Aquatic Biodiversity.

November 2021

Dr Andrew Deacon (PhD Zoology)

Registered with the South African Council for Natural Scientific Professions

(Registration number: 116951)

Executive Summary

The bridge design and the terrain chosen to construct the bridge, both play significant roles in rendering this a low impact project. The low-level crossing will be constructed mainly on bedrock, which is a stable but common habitat for this reach of the Mokolo River. The bridge structure will be constructed with culverts that will maintain longitudinal stream connectivity at different flow levels. With the construction information available, expected impacts were assessed and all were confirmed to be “Low” or mitigated to attain a “Low” risk level.

The current impact study (this report) assessed the Ecostatus as a Class B (Largely natural with few modifications). The RQO prescribe a PES of a B/C to be maintained. The REC is suggested as a Class B. Therefore, with a current Ecostatus of a B, the river is close to the RQO proposed REC, of a B. In other words, the river is currently in a very good condition and certainly in line with the B/C of the RQO requirement.

Furthermore, judging from the Impact Assessment and the mitigation proposed, the Mokolo River PES will not be affected by the bridge construction or operation. In order to protect the Mokolo River in its current condition from any degradation, a buffer of 10 m wide on both sides of the drainage line is required according to the DWS buffer tool assessment. This buffer will ensure that no riparian trees or sensitive riverine habitat will be disturbed.

The bridge culverts will maintain longitudinal stream connectivity to ensure *inter alia* proper passage for migrating aquatic species, even during very low flows. It is therefore anticipated that the design and development of the bridge and access roads will not change the PES or Ecostatus to a different ecologic category or compromise defined Resource Quality Objectives (RQOs) for this river reach in terms of water quality, quantity, habitat and biota.

By implementing all the mitigation measures and managing the system on a continuous basis as prescribed by the Risk Assessment, all the impacts will be addressed to a satisfactory level. Therefore, it is proposed that the project should be authorised with the provision that the mitigation measures prescribed in this document, where applicable, are included in the EMPr

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f. Loss or degradation of all or part of any unique or important features.

2.5.5 Impact on key ecosystems regulating and supporting services especially:

(a) Flood attenuation:
(b) Streamflow regulation:
(c) Sediment trapping
(d) Phosphate assimilation
(e) Nitrate assimilation
(f) Toxicant assimilation
(g) Erosion control
(h) Carbon storage

2.5.6 How will the proposed development impact community composition.

2.5.6 a) Need & Desirability (not listed as part of the Aquatic Biodiversity Protocol)

2.6 Estuary mouth closure (N/A)

2.7 Aquatic Biodiversity Specialist Assessment Report

2.7.1 Details of the Specialist

2.7.1.2 Field of expertise
2.7.1.3 Curriculum vitae

2.7.2 A signed statement of independence by the specialist

2.7.3 A statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment

2.7.4 Methodology

2.7.5 A description of the assumptions made and any uncertainties or gaps in knowledge or data

2.7.6 The location of areas not suitable for development, which are to be avoided during construction and operation, where relevant.

2.7.7 Additional environmental impacts expected from the proposed development.

2.7.8 Any direct, indirect and cumulative impacts of the proposed development on site.

2.7.9 The degree to which impacts and risks can be mitigated.

2.7.10 The degree to which the impacts and risks can be reversed.

2.7.11 The degree to which the impacts and risks can cause loss of irreplaceable resources.

2.7.12 A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.

2.7.13 The proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr).

2.7.14 A motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a “low” aquatic biodiversity sensitivity and that were not considered appropriate.

2.7.15 A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not.

2.7.16 Any conditions to which this statement is subjected.

References and Appendices

Abbreviations

AQV	Aquatic vegetation
ASPT	Average Score per Taxon
BA	Basic Assessment
BGIS	Biodiversity Geographic Information System
°C	Degrees Celsius
CAD	Computer-aided design
CBA	Critical Biodiversity Areas
cm	Centimetre
C-Plan	Conservation Plan
DFFE	Department of Forestry, Fisheries and the Environment
Dr	Doctor
DWA	Department of Water Affairs (post-2010)
DWAF	Department of Water Affairs and Forestry (pre-2010)
DWS	Department of Water and Sanitation (since May 2014))
E	East
e.g.	For example
EC	Ecological Category
ECO	Environmental Control Officer
Ecoclassification	Ecological classification
EcoStatus	Ecological Status
EEC	Ecoleges Environmental Consultants
EFR	Environmental Flow Requirements
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
ESA	Ecological Support Area
EWR	Environmental Water Requirements
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GPS	Global Positioning System
HCR	Habitat Cover Ratings
HQI	Habitat Quality Index
IHAS	Integrated Habitat Assessment System
IUA	Integrated Unit of Analysis
km	Kilometre
KML	Keyhole Markup Language
KMZ	Keyhole Markup language Zipped
LUDS	Land-Use Decision Support Tool
m	Meter
m^2	Square meter
m^3a	Cubic metre per year
masl	Metres above sea level
MAP	Mean annual precipitation
min	Minutes
MIRAI	Macro-invertebrate Response Assessment Index
mm	Millimetre
MPa	Megapascals
mS/m	milliSiemens per metre
MV	Marginal vegetation
N/A	Not applicable
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)

nMAR	Natural Mean Annual Runoff
NWA	National Water Act
PES	Present Ecological State
PESEIS	Present Ecological State, Ecological Importance and Ecological Sensitivity
PhD	Doctor of Philosophy
PNR	Private Nature Reserve
Pr. Sci. Nat	Natural Scientific Professionals
REC	Recommended Ecological Category
Reg. no.	Registration number
RHAM	Rapid Habitat Assessment Method
RHP	River Health Programme
RMC	Rubble masonry concrete
RQO	Resource Quality Objectives
RU	Resource Unit
S	South
SA	South Africa
SACNASP	South African Council for Natural Scientific Professions
SASS5	South African Scoring System version 5
SHI	Site Fish Habitat Integrity Index
SI	Socio-cultural Importance
SIC	Stones in current
SOOC	Stones out of current
SQ	Sub-quaternary
TOR	Terms of Reference
VEGRAI	Riparian Vegetation Response Assessment Index
Y	Yes

1. Introduction

1.1 Background to the project

The brief of the project is to undertake a Basic Assessment (BA) for the development of a low water crossing over the Mokolo River within the Kaingo Game Reserve, situated in the Waterberg, Limpopo Province, South Africa. The Kaingo project area is a declared protected area managed as the Kaingo Game Reserve.

The proposed development entails the new construction of a low water crossing/bridge to ensure year-round access to a recently acquired property (or land) on the opposite bank of the Mokolo River.

Mr Jurie Willmse, owner of Kaingo Game Reserve has recently acquired a neighbouring property on the opposite bank of the Mokolo River, called Mokolo River Private Nature Reserve (EEC, 2021). Access to the neighbouring property is required by the Management Authority to fulfil its conservation mandate during the day-to-day operations or management of both Nature Reserves.

There is currently one existing dirt and gravel crossing that is only accessible during the dry winter months of the year. For the remainder of the year, access to the neighbouring property would entail an extended round trip that requires any driver to exit Kaingo Game Reserve and then enter the Mokolo River Private Nature Reserve.

As the farms that make up the Kaingo Game Reserve are situated on either side of the Mokolo River, access and Game Reserve management and eco-tourism activities are hampered during rainy seasons as access across the Mokolo River sand bed is not possible.

The proposal therefore is to develop a low water crossing/bridge that will ensure year-round connectivity between both properties. By constructing a dedicated low-level crossing, the Game Reserve operations will be greatly improved (PG Consulting Engineers, 2021). The proposed activities (crossings) will negate the unnecessary and wasteful expenditure of time and money to access the neighbouring property by exiting Kaingo Game Reserve.

The proposed low-level crossing will be situated across the Mokolo River, between the Kaingo Private Nature Reserve and the Mokolo River Private Nature Reserve 660 KQ, in the Waterberg District of the Limpopo Province. The proposed site is approximately 48km south of Lephalale (PG Consulting Engineers, 2021).

1.2 Specialist Terms of Reference

This project proposal is prepared for a Specialist Study: A Basic Assessment for the development of a low water crossing over the Mokolo River within the Kaingo Private Nature Reserve (PNR), in the Vaalwater area, Limpopo Province, South Africa. The Environmental Evaluation concerns the wetland aspects of the delineated footprint (Regulated Zone) and the positioning of development in the terrestrial zone.

Screening Assessment

PHASE 1: Site Sensitivity Verification and Minimum Report Content Requirements

- Perform the **Site Sensitivity Verification** according to the criteria provided by the "Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity" (Appendix D: Aquatic Biodiversity Protocol (GN No. 320 dated 20th March 2020)).
- Record the outcome of the Site Sensitivity Verification in the form of a report according to the minimum report content requirements in the same protocol.
- It is your responsibility to ensure your assessment and reporting meets all the requirements of the relevant protocol.

Aquatic Biodiversity Specialist Assessment

PHASE 2: Specialist Assessment and Minimum Report Content Requirements

- Perform the Specialist Assessment according to the criteria provided by the "Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity" (Appendix D: Aquatic Biodiversity Protocol (GN No. 320 dated 20th March 2020)).
- Write up the findings of the specialist assessment in an Aquatic Biodiversity Specialist Assessment Report or Aquatic Biodiversity Compliance Statement that contains the minimum report content requirements prescribed in the same protocol.
- It is your responsibility to ensure your assessment and reporting meets all the requirements of the relevant protocol.
- Please perform a Present Ecological Study (PES) according to the "Supplementary Water Use Information Section 21(c) and (i) Water Uses (DW781suppl, DW775suppl, Edition 14 August 2009)").
- Please prepare a Wetland Delineation Report for S21(c) and (i) water uses.
- Please undertake a Risk Assessment.

Special note: The status quo of the wetland/watercourse is to be determined using established and accepted survey methods including the South African Scoring System version 5 (SASS5) and the Fish Response Assessment Index (FRAI) (Kleynhans 1999; Kleynhans et al. 2005) for aquatic invertebrates and fish communities, respectively).

The project scope requires **Water Use Authorisation** for Section 21(c), and (i) water uses (to be undertaken by Schoeman & Venotte) so the Aquatic Assessment must include all aspects in terms of the Water Use License & Appeals Regulations (2017).

Impact Assessment

- You will be required to assess the impacts for each of the proposed development alternatives including the no-go option, which will be identified throughout the process.
- The impacts must be assessed according to the Impact Assessment Criteria provided by Ecoleges at the time of appointment.
- Consider the potential negative and positive impacts that would result from the proposed alternatives and include mitigation measures to reduce those negative impacts that cannot be avoided, as well as measures to enhance the positive impacts.
- Cumulative impacts must also be described, and mitigation measures provided where possible.
- The potential impacts and recommended mitigations must be identified for the planning and design, pre-construction and construction.

Mapping

All sensitivity maps indicating, for example a delineated edge, no-go area or buffer zone, must be provided as KMZ, KML or geo-referenced CAD files

Additional Input

- You will be required to respond to all relevant comments that arise during the public participation process. After the commenting period has closed, a comments and response table will be sent to you.
- You need to take account of the process for client review and document revisions. This process is not a distinct task and shall not be billed, but allowances should be made in the price for the iterative nature of document review and client approval.

Specialist Proposal

- The specialist must supply all required safety equipment and incur all the costs associated with personnel.
- Accommodation and travelling costs are for the specialists account and should be calculated separately.
- Please indicate the anticipated timeframe to complete the entire assessment.

1.3 Legal considerations

The proposed development requires an environmental authorisation for the following listed (or specified) activities:

LN1, Listed Activity 19

The infilling or depositing of any material of more than 10 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 cubic metres from a watercourse.

LN3, Listed Activity 12

The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan.

LN3, Listed Activity 14

The development of –

(i) dams or weirs, where the dam or weir, including infrastructure and water surface area exceeds 10 square metres; or
(ii) infrastructure or structures with a physical footprint of 10 square metres or more where such development occurs -
(a) within a watercourse;
(b) in front of a development setback; or
(c) if no development setback has been adopted, within 32 metres of a watercourse, measured from the edge of a watercourse.

1.4 Aquatic Biodiversity Protocol

This section concerns the Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity (hereafter referred to as: Aquatic Biodiversity Protocol).

This protocol provides the criteria for the specialist assessment and minimum report content requirements for impacts on aquatic1 biodiversity for activities requiring environmental authorisation (Gov Gazette). In this Special Assessment Report, the corresponding numbering in the protocol will be added wherever it is relevant, for an example, this paragraph was obtained from Protocol 1 (1. Scope).

The assessment and reporting requirements of this protocol are associated with a level of environmental sensitivity identified by the national web based environmental screening tool (screening tool) (Protocol 1).

1.4.1 Screening Report for an Environmental Authorization as required by the 2014 EIA regulations – proposed site environmental sensitivity.

The National Web based Environmental Screening Tool allows for the generating of a Screening Report referred to in Regulation 16(1)(v) of the Environmental Impact Assessment Regulations 2014, as amended whereby a Screening Report is required to accompany any application for Environmental Authorisation.

During the event of formulating a technical and financial proposal to undertake a Basic Assessment (BA) for the development of a low water crossing over the Mokolo River within the Kaingo Game Reserve, Ecoleges Environmental Consultants (EEC) undertook a Screening Assessment of the crossing. By using the National web-based Environmental Screening Tool hosted by the Department (DFFE) on their website (www.environment.gov.za), the Screening Report (Ecoleges Environmental Consultants, S. Farnsworth. 2021) identified certain specialist assessments based on the selected 'application classification'.

A Screening Assessment was undertaken, and the Screening Report was generated on the 30th September 2021, using the application classification "Infrastructure Transport Services Roads Private."

Application classification “Any activities within or close to a watercourse.”

EIA Reference number: Environmental Authorisation
Project name: Proposed low-level Bridge No. 1
Project title: Basic Assessment Date screening report generated: 30/09/2021 19:17:54
Applicant: Kaingo Game Reserve
Compiler: Ecoleges Environmental Consultants - S. Farnsworth

An applicant intending to undertake an activity identified in the scope of this protocol on a site identified on the screening tool as being of “very high sensitivity” for aquatic biodiversity, must submit an Aquatic Biodiversity Specialist Assessment (**Table 1**).

Table 1: The Aquatic Biodiversity Impact Assessment identified in the Screening Report (Figure 1).

Theme	Sensitivity Rating	Reason for Sensitivity Rating		Type of Assessment	TOR
		Sensitivity	Features		
Aquatic Biodiversity	Very High	Very high	Wetlands and Estuaries	Aquatic Biodiversity Specialist Assessment	Gazetted Protocol (GN No.320)

EEC subsequently undertook a Site Sensitivity Verification (Ecoleges Environmental Consultants, 2021), which involved a desktop analysis and site inspection, to verify the land use and environmental sensitivity (rating) designated by the Screening Tool. They motivated for a Very High sensitivity at both sites and support the need for an Aquatic Biodiversity Specialist Assessment.

Table 2: The outcome of the site sensitivity verification relating to the level and/or need for specialist assessments identified in the screening tool with regards to Aquatic Biodiversity.

Environmental Theme	Environmental Sensitivity	Identified Specialist Assessments	Outcome
Aquatic Biodiversity	Very High	Aquatic Biodiversity Impact Assessment	Confirmed: Aquatic Biodiversity Specialist Assessment

1.4.2 Site Sensitivity Verification and Minimum Report Content Requirements

Prior to commencing with a specialist assessment, the current use of the land and the environmental sensitivity of the site under consideration identified by the screening tool must be confirmed by undertaking a **site sensitivity verification** (Protocol 2)**.**

The Site Sensitivity Verification was undertaken by Ecoleges Environmental Consultants (EEC) during October 2021 and written up as: "Site Sensitivity Verification Report for the Development of a low water crossing on the Mokolo River, Kaingo Game Reserve." The report will be made available as required by this protocol (Ecoleges Environmental Consultants (EEC), 2021).

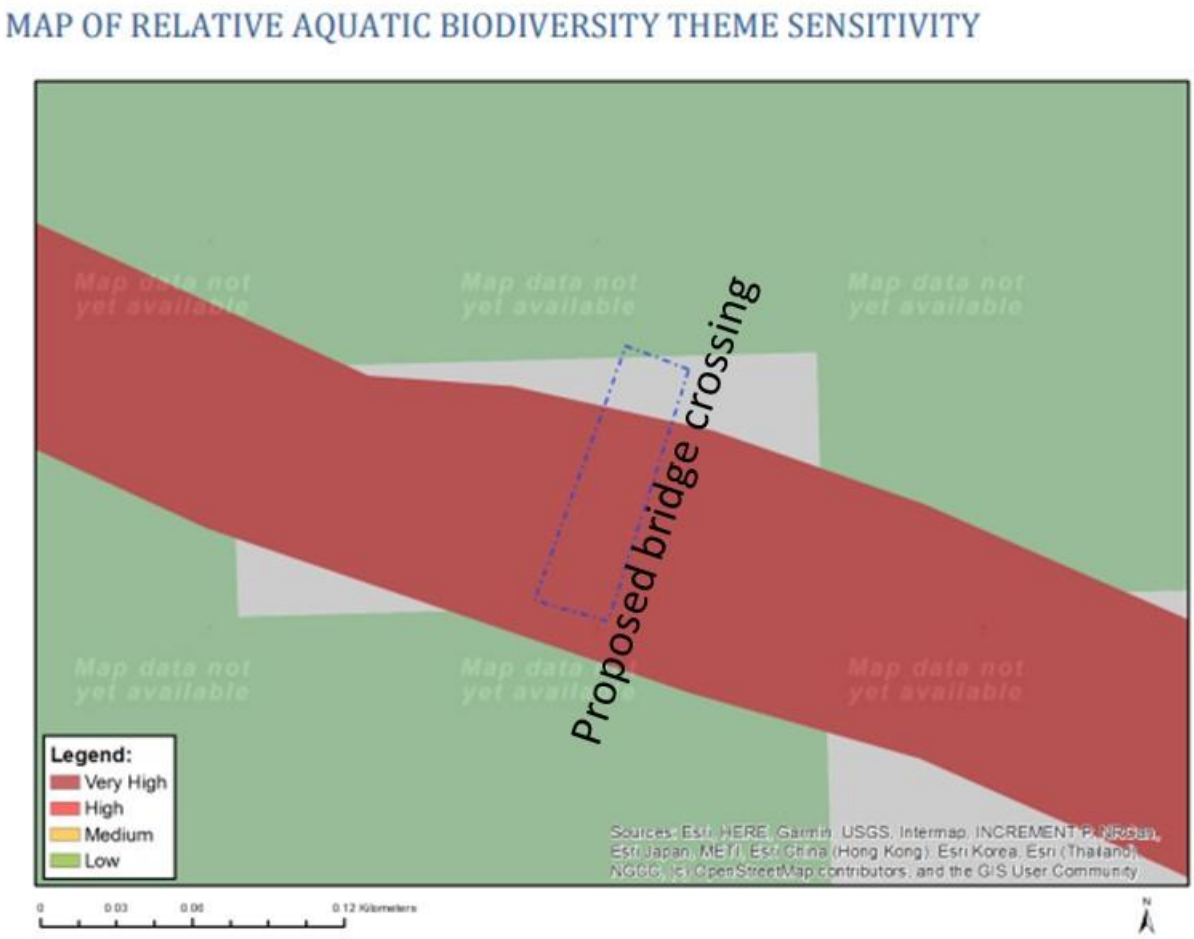


Figure 1: The proposed bridge crossing is located through the Mokolo River which is rated as "Very High" sensitivity (Environmental Screening Tool, 2021).

2. Specialist Assessment and minimum report content requirements

Assessment and reporting of impacts on aquatic biodiversity

An applicant intending to undertake an activity identified in the scope of this protocol on a site identified on the screening tool as being of "very high sensitivity" for aquatic biodiversity, must submit an **Aquatic Biodiversity Specialist Assessment** (Screening Report).

The "Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Aquatic Biodiversity" (Appendix D: Aquatic Biodiversity Protocol (GN No. 320 dated 20th March 2020)) will be the proforma used throughout this report (see Table of Contents). Tables 3 and 35 summarises the main minimum report contents requirements.

Table 3:	Specialist assessment Checklist
	Requirements for Specialist Reports: Published in Government Notice No. 320; Government Gazette 43110**;** 20 March 2020
2.1	The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.
2.2	The preferred site within the proposed development footprint.
2.3	The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:
2.3.1	A description of the aquatic biodiversity and ecosystems on the site, including; (a) aquatic ecosystem types; and
	(b) Presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns.
2.3.2	The threat status of the ecosystem and species as identified by the screening tool
2.3.3	An indication of the national and provincial priority status of the aquatic ecosystem.
2.3.4	A description of the ecological importance and sensitivity of the aquatic ecosystem including: (a) the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site.
	(b) the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat).
2.4	Identify alternative development footprints.
2.5	Assessment of the potential impacts of the proposed development:
2.5.1	Maintaining the priority aquatic ecosystem.
2.5.2	Maintaining the resource quality objectives.
2.5.3	Impact on fixed and dynamic ecological processes.
	a. Impacts on hydrological functioning.
	b. Sediment regime.
	c. Modification in relation to the overall aquatic ecosystem.
	d. Risks associated with water uses.
2.5.4	Impact on the functioning of the aquatic feature:
	a. Base flows.
	b. Quantity of water.
	c. Change in the hydrogeomorphic typing.
	d. Quality of water.

Table 3:	Specialist assessment Checklist
	e. Ecological connectivity.
	f. Loss or degradation of all or part of any unique or important features.
2.5.5	Impact on key ecosystems regulating and supporting services especially:
	(a) flood attenuation;
	(b) streamflow regulation;
	(c) sediment trapping;
	(d) phosphate assimilation;
	(e) nitrate assimilation;
	(f) toxicant assimilation;
	(g) erosion control;
	(h) carbon storage.
2.5.6	How will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator/prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?
2.6	In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered?

2.1 Registered Specialist

The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.

Dr Andrew Deacon is registered with the South African Council for Natural Scientific Professions (SACNASP). Registration number: 116951.

2.2 The preferred site within the proposed development footprint.

The preferred site, Project Site 1 (Figure 2) consists mostly of extensive bedrock and large sandy patches. There is also an extensive grassy lawn area on the right bank of the river. These habitats are all robust and not very sensitive to water level or flow changes.

However, most of the reed growth which occurs in the marginal zone at the water edge is dependent on water in the pools, and the riparian trees in the river bed and riparian zone, are dependent on a sustained inflow of subsurface water to recharge the groundwater.

Downstream of the site, bedrock is forming a control which creates natural pools. Shallower water flowing through rocky cracks, creates important flowing habitats such as riffles. Downstream of the bedrock control is an extensive reedbed marshland that is very dependent on constant flow reaching the reedy marsh.

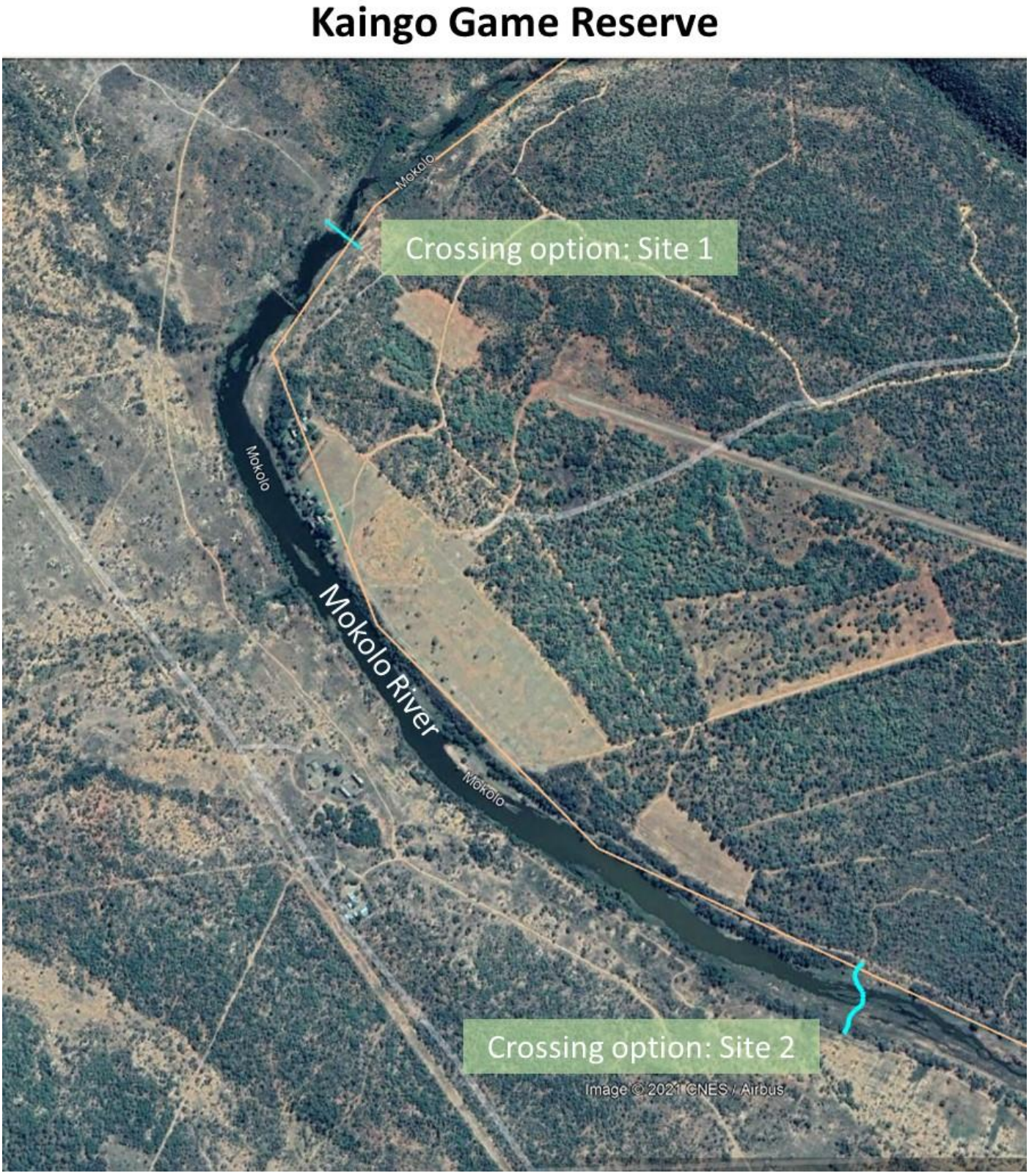


Figure 2: Locations of the two sites investigated for crossing purposes. Site1 is the preferred site (see Section 2.4).

Figure 3:

3a and b. Site 1 (Recommended site): The exposed sandstone bedrock which stretches across the riverbed.

3c. The existing DWS gauging weir.

3d. The bedrock declines a bit towards the right bank where a sand shoal was visible.

Site #2 (Alternative site): The alternative site investigated is some 2.1km upstream of the first site (Figure 4).

Although the position with regard to river alignment is suitable for a crossing only scattered bedrock was observed which is not suitable for founding conditions (Figure 4a). Another disadvantage is the topography on the left bank. The area forms a relatively large floodplain (Figure 4b; arrow) at this section causing the length of a crossing structure to be undesirably long.

The ingress of approach from the right bank is also rather steep making the approach design from the right bank a bit more complex.

The second site is also some distance away from the initially intended crossing area. In effect, this will increase travelling distances across the river making farm management a bit more difficult.

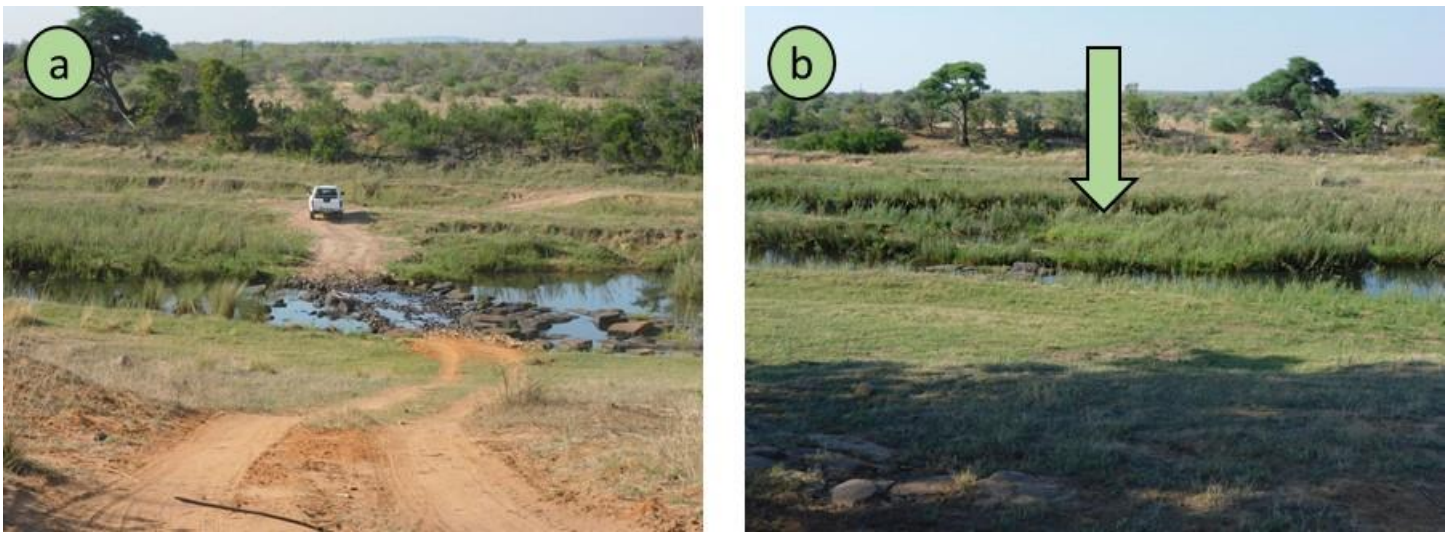


Figure 4:

4a. Site 2 (Alternative site): Only scattered bedrock was observed which is not suitable for founding conditions at this site.

4b. A relatively large floodplain (arrow) at this section, causes the length of this crossing structure to be undesirably long.

2.3 Baseline description

According to the Aquatic Biodiversity Protocol, the assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:

2.3.1 A description of the aquatic biodiversity and ecosystems on the site, including;

(a) aquatic ecosystem types; and

(b) Presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns.

2.3.1a Aquatic ecosystem types

Aquatic habitat assessment

Aquatic surveys and biomonitoring are essential components of ecological risk assessment and aim to measure present biological conditions and trends in the aquatic ecosystem. It attempts to relate the observed variation to changes in available habitat, as dictated by physical system drivers of the system such as water quality, geomorphology, and hydrology (Kleynhans & Louw, 2008).

During the monitoring survey in November 2021 the following parameters were measured - IHAS (Integrated Habitat Assessment System) and HQI (Habitat Quality Index) with the results summarized in Table 4. An area of diverse habitats was chosen for the aquatic surveys (Figure 5). The most abundant habitats were deep, slow-flowing pools with muddy bottoms; shallower edges with overhanging reeds; bedrock controls with some small riffles and rapids.

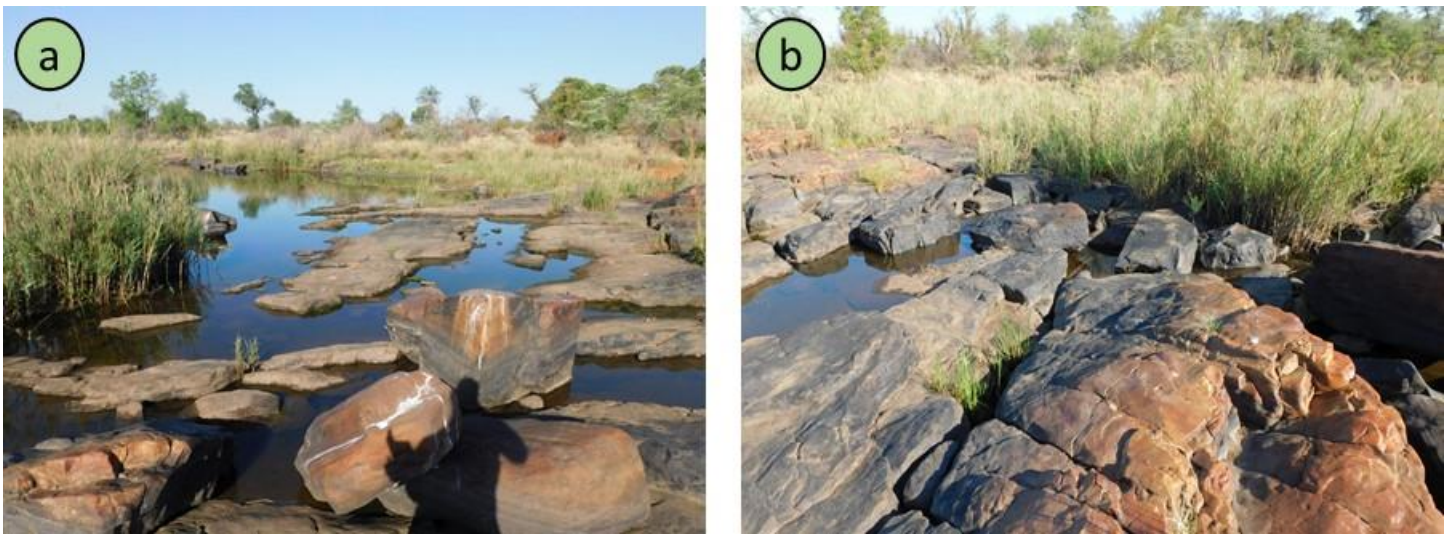


Figure 5: The aquatic survey area at Site 1 consisted of a series of pools of different depths and sizes (5a), and a flowing portion through the bedrock control (5b) with some riffles.

Table 4: The combined habitat parameters as measured at the at Site 1.

SITE	IHAS%	CATEGORY	HQI%	CATEGORY
SITE 1	71	Fair	65	Fair

During the November 2021 survey, the IHAS and HQI scores were mostly “Fair” (Table 6) due to the scarcity of fast flowing habitats (riffles and rapids).

2.3.1b Presence of aquatic species

Aquatic invertebrate assessment

The aquatic macro-invertebrates were sampled according to the SASS5 method at the proposed Site 1, and Table 5 lists the macro-invertebrates sampled at the site and reflects the SASS5 scores for the survey.

The lack of fast flowing habitats such as riffles and rapids also reflected in the macro-invertebrate scores (Table 5), resulting in “Fair” SASS scores and moderate number of families (Table 6). Most of the taxa recorded had low to moderate sensitivity scores, with the highest scores of 10 allocated to two taxa, Heptageniidae and Philopotamidae.

Table 5: SASS5 scores of the different habitat types at the sampling pool site (a complete table of this summarized version can be viewed in Appendix 1).

TAXON	Stones	Vegetation	GSM	Total
Oligochaeta 1			A	A
Leeches 3	1			1
Potamonautidae 3	A			A
Baetidae 2 spp 6	B	A	1	B
Caenidae 6			A	A
Heptageniidae 10	A	1		A
Coenagrionidae 4		B		B
Aeshnidae 8		1		1
Gomphidae 6			A	A
Corixidae 3			B	B
Gerridae 5		A	A	B
Naucoridae 7			1	1
Nepidae 3		1		1
Pleidae 4			A	A
Veliidae 5		1		1
Hydropsychidae 1= 4	A			A
Philopotamidae 10	1			1
Leptoceridae 6		A		A
Dytiscidae 5		1		1
Gyrinidae 5		B	A	B
Chironomidae 2		A	B	B
Muscidae 1		1		1
Simuliidae 5	A			A
Physidae 3		A		A
Corbiculidae 5			A	A
SASS Score	41	63	49	120
No of families	7	13	11	25
ASPT	5.8	4.8	4.4	4.8

Table 6: Categories used to classify Habitat, SASS and ASPT values:

HABITAT	SASS4	ASPT	CONDITION
>100	>140	>7	Excellent
80-100	100-140	5-7	Good
60-80	60-100	3-5	Fair
40-60	30-60	2-3	Poor
<40	<30	<2	Very poor

Macro-invertebrate Response Assessment Index: MIRAI

The survey results of the macro-invertebrates during November 2021 at Site 1 were used to run the MIRAI model and Table 7 summarises the results.

Table 7: The final MIRAI score sheet for the Mokolo River in the project area.

INVERTEBRATE EC: BASED ON WEIGHTS OF METRIC GROUPS						
INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	84,0	*0,571*	48,0201	1	100
HABITAT	H	71,1	*0,086*	6,09524	3	15
WATER QUALITY	WQ	76,5	*0,057*	4,36975	4	10
CONNECTIVITY & SEASONALITY	CS	68,1	*0,286*	19,4643	2	50
						175
INVERTEBRATE EC				77,9493		
INVERTEBRATE EC CATEGORY				C/B		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

During the current assessment, the relative MIRAI score of the Mokolo River in the project area was placed within the limits of an ecological state category Class C/B (77.9%), which means this reach is “Moderately modified” (Table 8).

The fact that the status is “Moderately modified” can mainly be attributed to the presence of the DWS Weir upstream of the survey site and upstream abstractions.

Table 8: Ratings for the macro-invertebrate integrity classes.

	MIRAI ASSESSMENT CLASSES	
Class rating	Description of generally expected conditions for integrity classes	Relative score (% of expected)
A	Unmodified, or approximate natural conditions closely	90 to 100
B	Largely natural with few modifications.	80 to 89
C	Moderately modified.	60 to 79
D	Largely modified.	40 to 59
E	Seriously modified.	20 to 39
F	Critically modified.	0 to 19

Fish Response Assessment Index (FRAI)

The purpose of the Fish Response Assessment Index (FRAI) is to provide a habitat-based cause-and-effect interpretation underpinning the deviation of the fish assemblage from the reference condition.

The application of the FRAI is based on the following:

- The FRAI is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or rivers.

- These intolerance and preference attributes are categorised into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species.

- Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually, the FRAI is based on a combination of fish sample data and fish habitat data.

- Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation.

Determine reference fish assemblage: species and frequency of occurrence

Frequency of Occurrence (FROC)

The fish reference Frequency of Occurrence (FROC) database (Kleynhans, Louw, & Moolman, 2007), which provides consistent reference frequency of occurrence for more than 700 fish sites in South Africa, was used to establish the baseline data for this report.

The list of species is based on species that are known to be present or to have been present under close to reference habitat conditions in the Mokolo River. Species that are derived to have been present under relatively recent reference habitat conditions are also identified. The resulting species reference list is a combination of both of the above approaches.

Table 9: Expected Reference and Habitat derived from the PESEIS data for fish in the Mokolo River. Observed species (HIGHLIGHTED) (Skelton, 2016).

Scientific Names (Expected species)	Common Name	Species abbreviation	Present PESEIS	Observed 2021
Anguilla bengalensis labiata	African mottled eel	ALAB	No	No
Anguilla mossambica	Longfin eel	AMOS	No	No
Amphilius uranoscopus	Mountain catfish	AURA	Yes	No
Aplocheilichthys johnstoni	Johnston's topminnow	AJOH	Yes	Yes
Enteromius bifrenatus	Hyphen barb	BBIF	Yes	No
Enteromius brevipinnis	Shortfin barb	BBRI	No	No

Scientific Names (Expected species)	Common Name	Species abbreviation	Present PESEIS	Observed 2021
Enteromius radiatus	Beira barb	BRAD	Yes	No
Labeobarbus marequensis	Largescale yellowfish	BMAR	Yes	Yes
Enteromius paludinosus	Straightfin barb	BPAU	Yes	Yes
Enteromius trimaculatus	Threespot barb	BTRI	Yes	Yes
Enteromius unitaeniatus	Longbeard barb	BUNI	Yes	Yes
Enteromius viviparus	Bowstripe barb	BVIV	Yes	Yes
Micralestes acutidens	Silver robber	MACU	Yes	No
Mesobola brevianalis	River sardine	MBRE	Yes	No
Marcusenius macrolepidotus	Bulldog	MMAC	Yes	No
Chiloglanis pretoriae	Limpopo Rock catlet	CPRE	Yes	No
Clarias gariepinus	Sharptooth catfish	CGAR	Yes	Yes
Labeo cylindricus	Redeye labeo	LCYL	Yes	Yes
Labeo molybdinus	Leaden labeo	LMOL	Yes	Yes
Petrocephalus wesselsi	Southern churchill	PCAT	Yes	No
Schilbe intermedius	Silver catfish	SINT	Yes	No
Synodontis zambezensis	Brown squeaker	SZAM	Yes	No
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	Yes	Yes
Chetia flaviventris	Canary kurper	CFLA	Yes	No
Oreochromis mossambicus	Mozambique tilapia	OMOS	Yes	Yes
Tilapia rendalli	Redbreast tilapia	TREN	Yes	No
Tilapia sparrmanii	Banded tilapia	TSPA	Yes	Yes
Alien introduced fish				
Micropterus salmoides	Largemouth bass	MSAL	No	Yes
Cyprinus carpio	Carp	CCAR	No	No

The list of species is based on species that are expected to be present under close to reference habitat conditions. This would include information from historical sites within a particular river reach.

A very high percentage of the expected fish species (90 % or 19/21) were recorded upstream of the Mokolo Dam in this region by the RHP (River Health Programme (2006). The only 2 species absent were the African mottled eel and the longfin eel (*Anguilla bengalensis* and *Anguilla mossambica*). All flow-dependent species were present upstream of the dam, confirming the near perennial status of the river in this section.

The Mokolo Dam itself has a substantial population of the two alien species of fish, the largemouth bass (*Micropterus salmoides*), and the common carp (*Cyprinus carpio*). These alien species migrated upstream into the Middle Mokolo area and are present at the Kaingo crossing site.

Execute the FRAI model

The FRAI model makes use of the fish intolerance and preference database that was compiled in 2001 (Kleynhans 2003). This information was built into the FRAI. The approach followed included the ranking, weighting and rating of metric groups. A large component of the FRAI is based on an automated calculation of ranks, weights and ratings. Table 10 indicates the FRAI results at the study site during the current surveys for fish at the Kaingo project site.

Table 10: The FRAI results at the study site during the current surveys and the resultant ecological class.

AUTOMATED	
FRAI (%)	**86,3**
EC: FRAI	**B**
ADJUSTED	
FRAI (%)	**88.3**
EC: FRAI	**A/B**

The relative FRAI score of this stretch of the Mokolo River falls within the limits of an ecological state category Class B (86.3%), which means this reach is in a “Largely natural with few modifications” state with a small change from natural. The Class ratings are explained in Table 11.

Table 11: Ratings for the fish integrity classes

	FRAI ASSESSMENT CLASSES	
Class rating	Description of generally expected conditions for integrity classes	Relative FRAI score (% of expected)
A	Unmodified, or approximate natural conditions closely	90 to 100
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification.	80 to 89
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at lower limits of this class.	60 to 79
D	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderate intolerant species. Impairment of health may become more evident at the lower limit of this class.	40 to 59
E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant	20 to 39

	and moderately intolerant species. Impairment of health may become very evident.	
F	Critically modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a loss of species at the lower limit of the class. Impairment of health generally very evident.	0 to 19

Vegetation and Landscape Features

The most recent vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006), maps the vegetation of the study area as **Central Sandy Bushveld (SVcb 12)** in the Central Bushveld Bioregion**.**

Landscape Features: Undulating terrain occurs mainly in a broad arc south of the Springbokvlakte from the Pilanesberg in the west through Groblersdal in the east. A generally narrow irregular band along the north-western edge of the Springbokvlakte (including Modimolle) extending into a series of valleys and lower-altitude areas within the Waterberg including the upper Mokolo River Valley near Vaalwater,

Vegetation: Low undulating areas, sometimes between mountains, and sandy plains and catenas supporting tall, deciduous *Terminalia sericea* and *Burkea africana* woodland on deep sandy soils (with the former often dominant on the lower slopes of sandy catenas) and low, broad- leaved *Combretum* woodland on shallow rocky or gravelly soils. Species of *Senegalia, Ziziphus* and *Euclea* are found on flats and lower slopes on eutrophic sands and some less sandy soils. *A. tortilis* may dominate some areas along valleys. Grass-dominated herbaceous layer with relatively low basal cover on dystrophic sands.

Ecoregion and River Characteristics

Ecoregions are groups of rivers within South Africa, which share similar physiography, climate, geology, soils and potential natural vegetation. For the purposes of this study, the ecoregional classification presented by Department of Water Affairs and Forestry in 1999 (DWAF, 1999), which divides the country's rivers into ecoregions, was used. The project site is located in quaternary catchment A42F with the development taken place within the catchment of the Mokolo River draining the Waterberg Ecoregion.

6.02 Waterberg Ecoregion

The Waterberg is predominantly a tableland with moderate to high relief. Bushveld types dominate the vegetation with Waterberg Moist Mountain Bushveld being the most common.

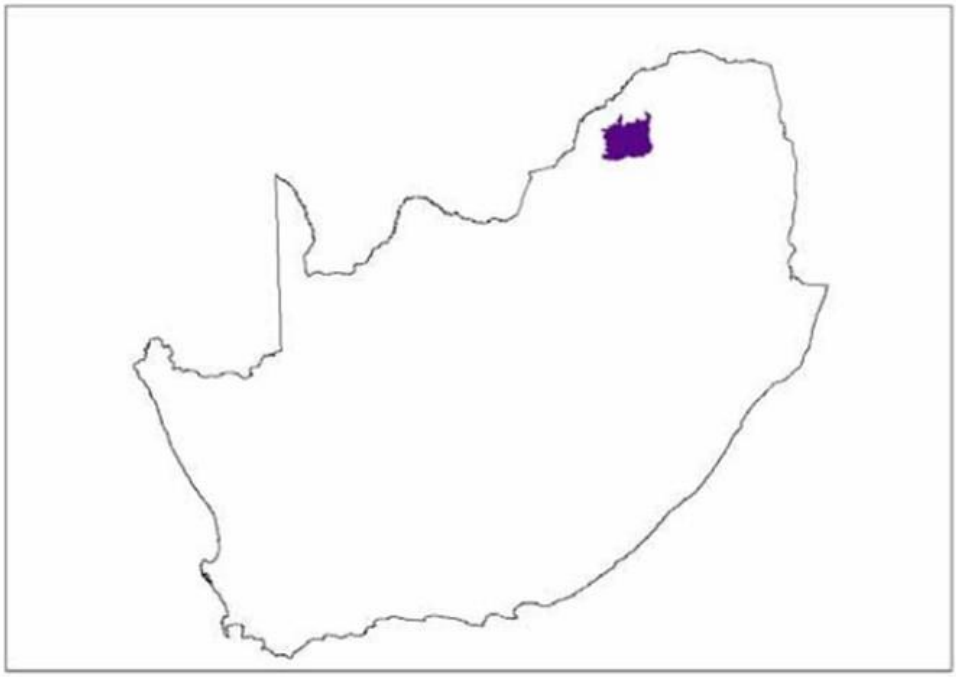


Figure 6: The Waterberg Ecoregion (6.02) according to the Preliminary Level I River Ecoregional classification System for South Africa.

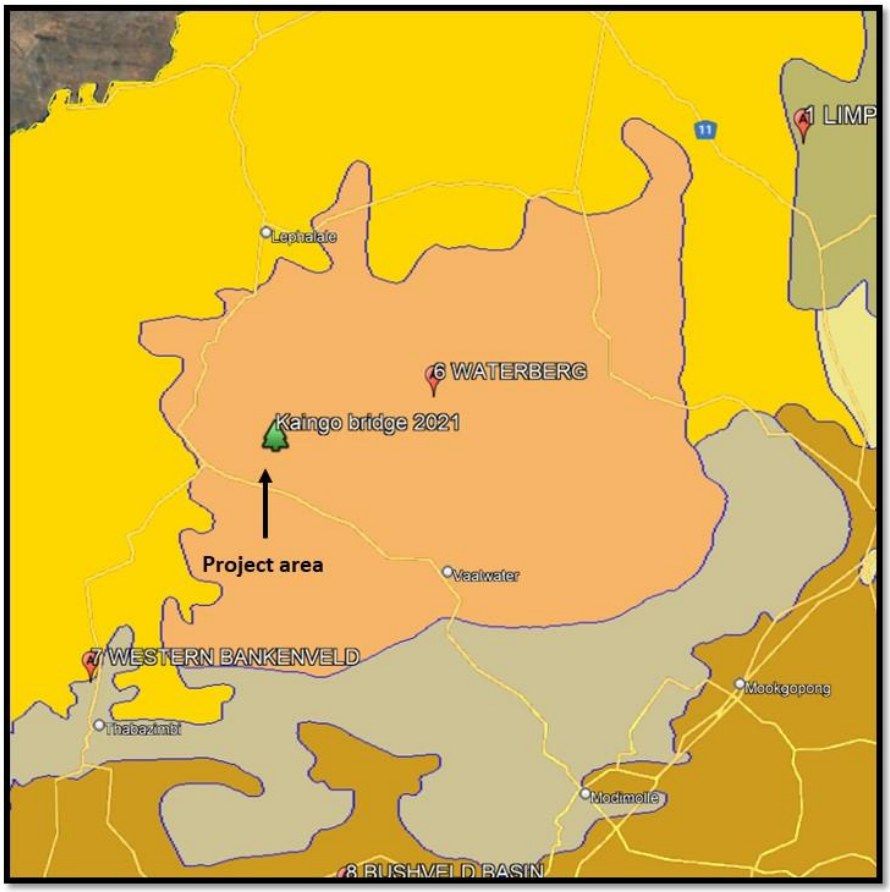


Figure 7: The Project Area is situated in the Waterberg (6.02) Ecoregion according to the Water Resource Classification System (DWS, 2005).

The sandstones on the tableland are almost flat lying and are important escarpment shapers. Perennial rivers such as the Mogalakwena and Lephalala have their sources in the Waterberg.

Table 12: Characteristics of the Waterberg Ecoregion.

Main Attributes	Description
Mean annual precipitation	Generally moderate
Drainage density	Low to medium
Stream frequency	Medium/high to low/medium
Slopes	80%
Median annual simulated runoff	Generally moderate
Mean annual temperature	Moderate to moderate/high.

Catchment and Wetland Setting

The Mokolo River is situated in the Matlabas/Mokolo Sub-Water Management Area which form part of the Limpopo drainage system. The planned project activities will take place in the Kaingo Game Reserve and the river which forms part of the assessment is the Mokolo River (A42F-00285). The project site is located in quaternary catchment A42F and the site slopes towards the Mokolo Dam to the north (Figure 8).

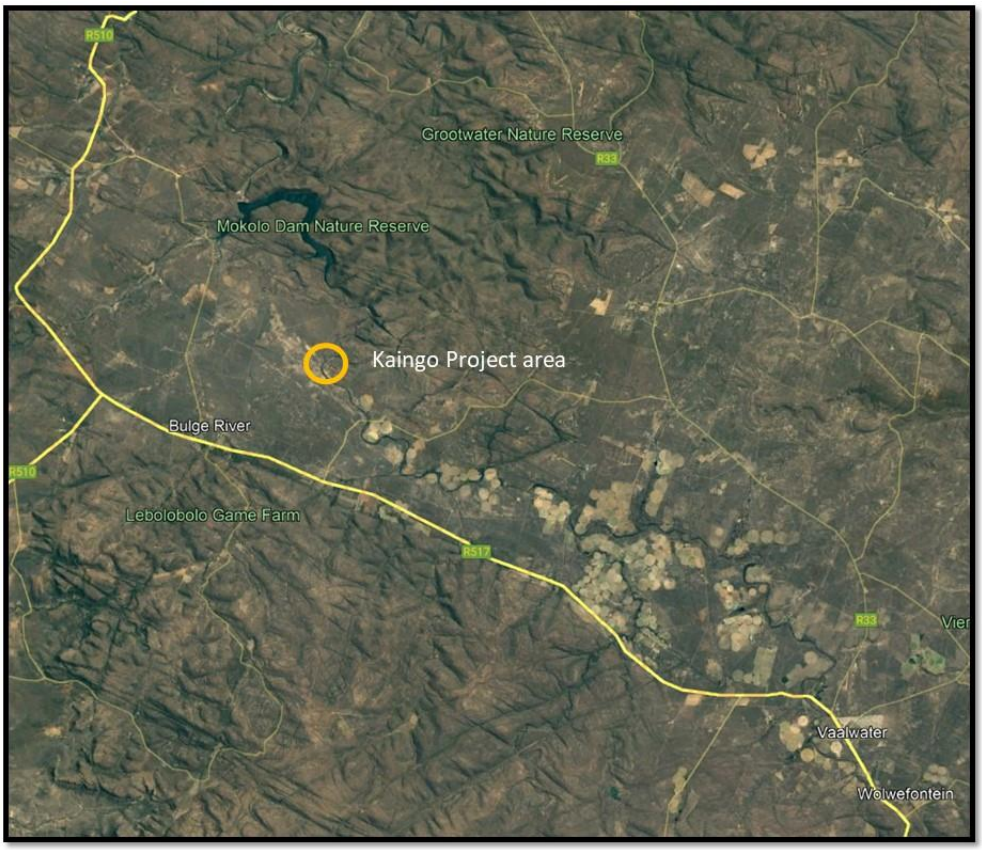


Figure 8: The study area is in the Kaingo Game Reserve, upstream of the Mokolo Dam to the north.

The ecology of the Mokolo River and associated riparian zone

Riparian vegetation is described in the Water Act (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.

The Mokolo River and its upper course tributaries rise in the southwestern part of the Waterberg, between 1200 and 1600 metres above mean sea level. The Mokolo proper originates about 1.5 km north of Alma at the confluence of the Sand River with the Grootspruit River. Shortly thereafter it flows northwards through a steep gorge emerging above the town of Vaalwater.

As it heads northwards through the northern Waterberg, river flows through an extensive rock formation that was shaped by hundreds of millions of years of river erosion. Then the river flows through the relatively flat area of the lowveld until it enters the Mokolo Dam. From there it flows through another gorge before entering the Limpopo Plain and flows through flat sandy areas until it reaches the Limpopo River.

The riverine environment of the Mokolo River can be classified as follow, using the Classification System for Wetlands and other aquatic Ecosystems in South Africa (Ollis et al, 2013) as reference: Channelled valley bottom river (active channel) with Riparian zone (Figure 9).

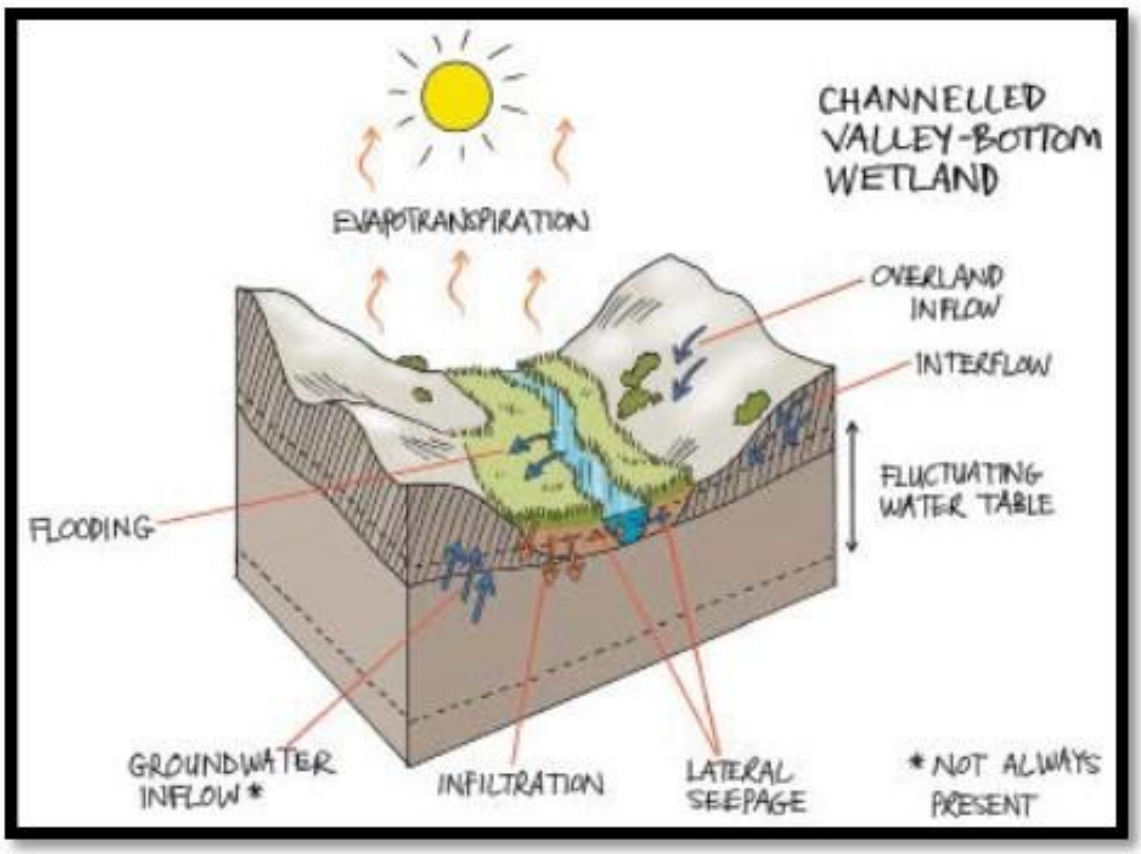


Figure 9: A diagram of a typical channelled valley bottom wetland (Ollis et al, 2013).

Ecological survey transects in the Kaingo project area.

A major component of this study is the characterisation of habitat types of the available landscape/environment. Representative survey sites were selected in all prominent vegetation types of the study area. Extensive transects (100-200m) were then surveyed for potential habitat. GPS readings provide fixed locations of these transects for future monitoring (Table 13; Figure 2).

During the survey of the Mokolo River project, the drainage line environment was surveyed by doing 5 riparian transects at two proposed sites in the project area. Figures 10 and 11 consists of map inserts which was compiled by using a Google Earth image and it indicates the survey transects on the drainage lines for the Mokolo River.

The surveys assessed the sites for the presence of all local flora which could potentially be influenced by the project activities. A transect runs from the outer edge of one riparian zone (right bank), through the drainage line to the outer edge of the other riparian zone (left bank). The results of the vegetation surveys are depicted in Figures 10 and 11 and the results for the vegetation survey for the areas are summarised in Table 14.

Apart from establishing the extent of the riparian zone, it also supplied information to assess the Present Ecological State of the areas, as well as identifying issues relating to possible impacts (current and future) in the study area. The coordinates of the transects are summarised in Table 13.

Table 13: Description of transects conducted for habitat assessments. Figures 10 and 11 consists of diagrams which was compiled by using a Google Earth image which indicates the crossing options and survey transects in the Mokolo River.

Mokolo River transects	Coordinates		Length (m)
	Start	End	
1. Crossing option: Site 1			
Transect 1	24° 4'44.38"S 27°46'25.81"E	24° 4'45.99"S 27°46'29.12"E	102
Transect 2	24° 4'45.25"S 27°46'24.79"E	24° 4'48.17"S 27°46'28.57"E	170
Transect 3	24° 4'46.31"S 27°46'24.05"E	24° 4'48.88"S 27°46'27.87"E	168
2. Crossing option: Site 2			
Transect 4	24° 5'32.17"S 27°47'2.52"E	24° 5'36.49"S 27°47'0.88"E	141
Transect 5	24° 5'31.85"S 27°46'59.95"E	24° 5'35.79"S 27°46'58.27"E	139

Vegetation communities

A total of 16 indigenous plant species were recorded during fieldwork (Table 14); no alien species were recorded. Figures 10 and 11 illustrates the basic components of the riverine setup considered during the surveys.

Table 14: Vegetation assemblages and relevant plant species in the identified morphological levels in the project footprint. Vegetation types: 1= Riverine drainage; 2= Riparian zone; 3= Adjacent terrestrial (Shaded cells indicate presence of the species).

Plant species	**1**	**2**	**3**
Trees			
African wattle (*Peltophorum africanum*)			
Bluebush (*Diospyros lycioides*)			
Blue thorn *(Senegalia erubescens)*			
Buffalo-thorn (*Ziziphus mucronata*)			
Camel thorn (*Vachellia erioloba*)			
Common wild currant (*Searsia pyroides*)			
Red bushwillow (*Combretum apiculatum*)			
River bushwillow (*Combretum erythrophyllum*)			
Round-leaved teak (*Pterocarpus rotundifolius*)			
Russet bushwillow (*Combretum hereroense*)			
Silver cluster-leaf (*Terminalia sericea*)			
Sweet thorn *(Vachellia karroo)*			
Velvet raisin *(Grewia flava)*			
Water elder (*Nuxia oppositifolia*)			
Wild seringa *(Burkea africana)*			
Grass and sedges			
Thatching reed (*Phragmites mauritianus*)			

Three of the recorded tree species are considered riparian indicator species:

- Buffalo-thorn (*Ziziphus mucronata*)
- River bushwillow (*Combretum erythrophyllum*)
- Water elder (*Nuxia oppositifolia*)

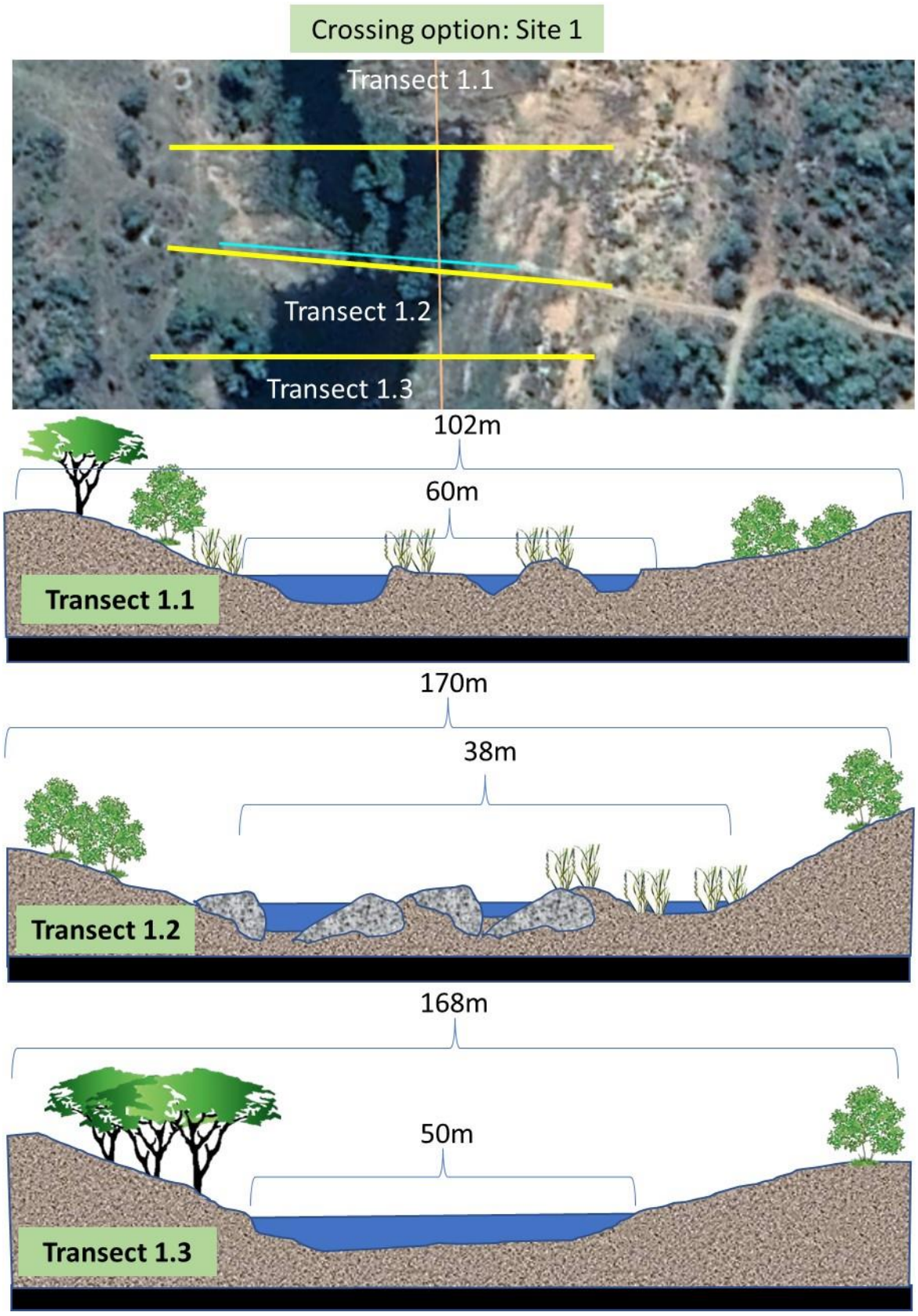


Figure 10: This figure illustrates the basic components of the riverine setup considered during the surveys. Riparian Transect 1 - Mokolo River (Coordinates: Table 13).

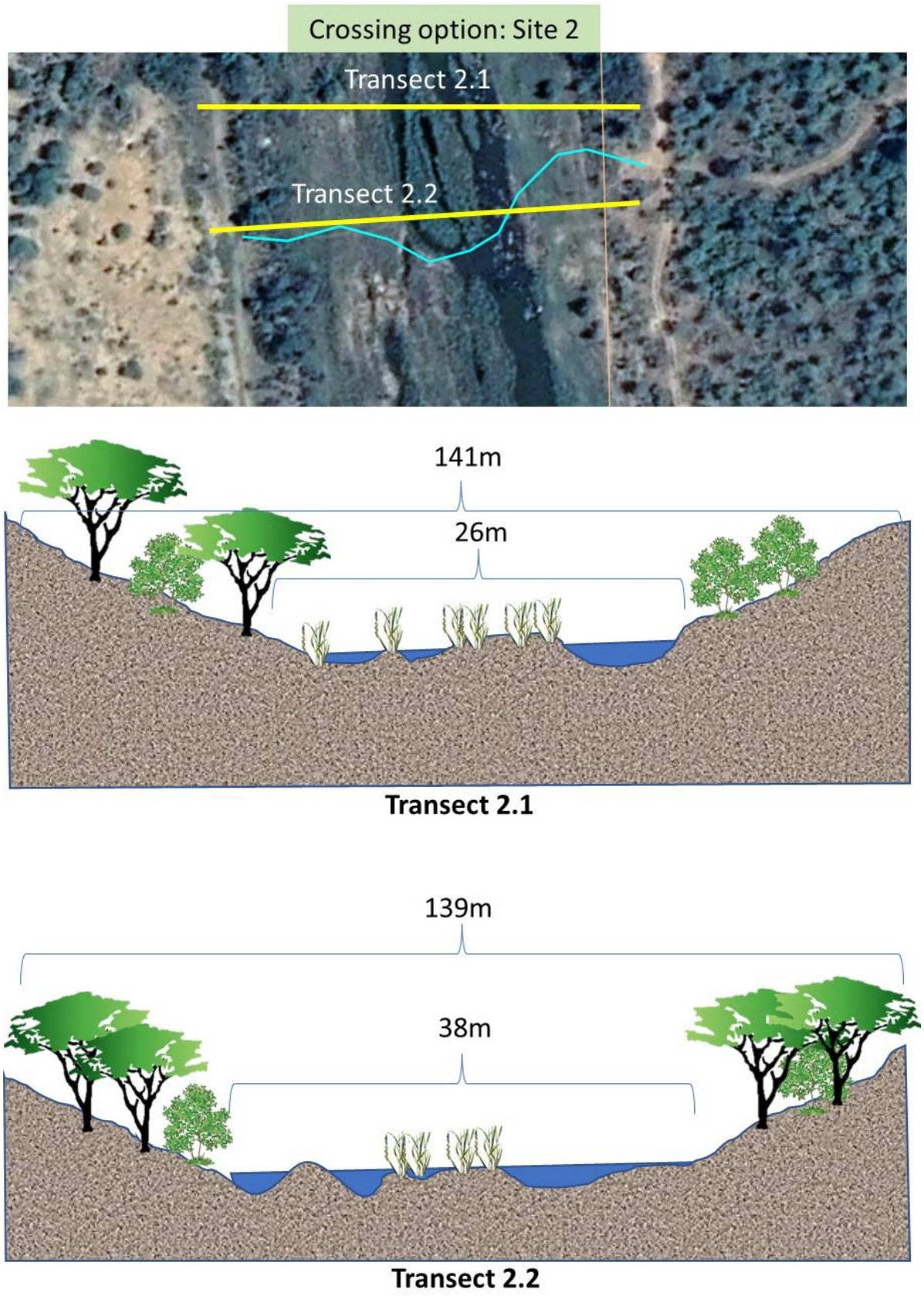


Figure 11: This figure illustrates the basic components of the riverine setup considered during the surveys. Riparian Transect 2 - Mokolo River (Coordinates: Table 13).

VEGRAI model

The VEGRAI process has a spread sheet model component that is composed of a series of metrics and metric groups each of which is rated in the field with the guidance of data collection sheets (referred to as field forms).

The purpose is to evaluate and interpret the observed impacts at a site in terms of its relative influence on the riparian vegetation according to vegetation removal, alien vegetation invasion, water quantity and quality. The approach followed is that each of these four broad causes of modification relates to and is associated with particular human-related activities that would change the riparian vegetation characteristics directly or indirectly. Some of these changes may occur rapidly while others will occur gradually and only become evident through time.

Table 15: A comparative description related to reference and present state of the riparian zone in the project area.

Zones	Impacts	Response Metrics	Description of PRESENT STATE	Description of REFERENCE STATE
Marginal	Vegetation Removal Exotic Vegetation Water Quantity Water Quality	Cover Abundance Species Composition	The surface water at the Kaingo site consist of an extensive pool system, inter connected with perennial flowing habitats such as short riffles and small rapids. There might be periods of low flow when these connections will barely flow, but during high rainfall events the stones-in-current habitats will be fully functional. The riverbed is filled with course alluvium, sand and gravel, forming sandy patches between the short-grassed lawns. Due to the slower flows in the system, more muddy patches are formed and reed expansion accelerated. The reed beds are found along the water edges, but also form large reedbed swamps downstream of bedrock controls. Water abstraction from the river results in lower flows and less scouring events, which increases sedimentation and reed encroachment.	The surface water at the Kaingo site consist of an extensive pool system, inter connected with perennial flowing habitats such as short riffles and small rapids. The riverbed is filled with course alluvium, sand and gravel, forming sandy patches between the short-grassed lawns. Reed beds are found along the water edges, but also form large reedbed patches on periodically inundated floodplains.
Non-marginal	Vegetation Removal Exotic Vegetation Water Quantity Water Quality	Cover Abundance Species Composition	Most of the riparian zone in this river reach is on the top of the macro channel bank and there are old, elevated flood plains inside the meanders. This riparian corridor in the area is relatively narrow and consists mainly of scattered riparian trees, and on the macro channel bank, denser patches of large terrestrial trees are found.	Most of the riparian zone in this river reach is on the top of the macro channel bank and there are old, elevated flood plains inside the meanders. This riparian corridor in the area is relatively narrow and consists mainly of scattered riparian trees, and on the macro channel bank, denser patches of large terrestrial trees are found.

Table 16: Evaluation of the marginal zone integrity (VEGRAI model) in the project area**.**

	MODIFICATION RATINGS						
CAUSES OF MODIFICATION	**INTENSITY**	**EXTENT**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**			
REMOVAL	0,5	5,0	4,0	Very little removal - river crossings.			
EXOTIC INVASION	0,5		4,0	Few alien forbs.			
WATER QUANTITY	2,0	2,0	3,0	Abstraction for irrigation			
WATER QUALITY	1,0	2,0	3,0	Lowered flows, less dilution.			
AVERAGE			3,5				
		RESPONSE METRIC RATINGS					
VEGETATION COMPONENTS	**RESPONSE METRIC**	**CONSIDER? (Y/N)**	**RATING**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**		
WOODY	COVER	Y	0,5	4,0	Little change.		
	ABUNDANCE	Y	0,5	3,0	Little change.		
	SPECIES COMPOSITION	Y	0,5	3,0	Little change.		
			0,5	3,3			
NON-WOODY	COVER	Y	0,5	4,0	Increase in reeds.		
	ABUNDANCE	Y	1,0	3,0	Increase in reeds.		
	SPECIES COMPOSITION	Y	0,5	3,0	Little change.		
			0,7	2,3			
VEGETATION COMPONENTS	**CONSIDER? (Y/N)**	**RANK**	**WEIGHT**	**RATING**	**WEIGHTED RATING**	**MEAN CONFIDENCE**	**NOTES: (give reasons for each assessment)**
WOODY	Y	2,0	50,0	0,5	0,25	3,3	Very little woody vegetation in the marginal zone.
NON-WOODY	Y	1,0	100,0	0,7	0,67	2,3	Reed dynamics.
CHANGE (%) IN MARGINAL ZONE CONDITION				**12.2**	0,92	2.8	

Table 17: Evaluation of the non-marginal zone integrity (VEGRAI model) in the project area.

	MODIFICATION RATINGS						
CAUSES OF MODIFICATION	**INTENSITY**	**EXTENT**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**			
REMOVAL	0,5	0,5	4,0	Very little.			
EXOTIC INVASION	0,5		4,0	Very little.			
WATER QUANTITY	0,5	0,5	3,0	Not very dependant on constant inundation			
WATER QUALITY	0,5	0,5	4,0	Water quality acceptable.			
AVERAGE			3,8				
		RESPONSE METRIC RATINGS					
VEGETATION COMPONENTS	**RESPONSE METRIC**	**CONSIDER? (Y/N)**	**RATING**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**		
WOODY	COVER	Y	0,5	4,0	Not much has been impacting the riparian zone.		
	ABUNDANCE	Y	0,5	4,0	Not much has been impacting the riparian zone.		
	SPECIES COMPOSITION	Y	0,5	4,0	Not much has been impacting the riparian zone.		
			0,5	4,0			
NON-WOODY	COVER	Y	0,5	4,0	Not much has been impacting the marginal zone.		
	ABUNDANCE	Y	0,5	4,0	Not much has been impacting the marginal zone.		
	SPECIES COMPOSITION	Y	0,5	4,0	Not much has been impacting the marginal zone.		
			0,5	2,7			
VEGETATION COMPONENTS	**CONSIDER? (Y/N)**	**RANK**	**WEIGHT**	**RATING**	**WEIGHTED RATING**	**MEAN CONFIDENCE**	**NOTES: (give reasons for each assessment)**
WOODY	Y	2,0	60,0	0,5	0,30	4,0	Scattered bush clumps.
NON-WOODY	Y	1,0	100,0	0,5	0,50	2,7	More abundant than woody.
	CHANGE (%) IN MARGINAL ZONE CONDITION	10.0	**2.3**		0,80	3,3	

Table 18: The vegetation integrity evaluation of the riparian zone in the project area.

LEVEL 3 ASSESSMENT						
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**	**NOTES: (give reasons for each assessment)**
MARGINAL	87,8	58,5	2,8	1,0	100,0	Reed beds dependant on water table.
NON-MARGINAL	90,0	30,0	3,3	2,0	50,0	Non marginal further away from aquatic zone not so much influenced by water table.
	2.0				150.0	
LEVEL 3 VEGRAI (%)				88,5		
VEGRAI EC				**A/B**		
AVERAGE CONFIDENCE				3,1		

According to the VEGRAI assessment (Table 18) for the Mokolo River, the Ecological Class is an A/B (88.5%).

The final scores of the VEGRAI assessment regarding the riparian and marginal zone integrity of the Mokolo River in the project area are presented in Table 19.

Table 19: A summary of the VEGRAI scores of the Mokolo River in the project area.

Drainage lines	Non-marginal zone condition	Marginal zone condition	Level 3 VEGRAI	VEGRAI EC
Mokolo River	87.8%	90.0%	88.5%	A/B

The vegetation integrity score is 88.5%which represents an Ecological Class A/B (80-89). This score reflects an “Largely natural with few modifications” status (Table 20).

Table 20: Generic ecological categories for EcoStatus components (modified from Kleynhans 1999).

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	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

EcoStatus and Ecological Category (EC)

EcoStatus Definition: "The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services". This ability relates directly to the capacity of the system to provide a variety of goods and services.

The driver components are assessed separately (i.e., an EC for each driver) and not integrated at a driver level to provide a driver-based indication of the EcoStatus. However, the individual metrics of all the driver components are assessed in a combined fashion that allows some comparison between metrics of all drivers. This facilitates deriving the cause-and-effect relationship that is required in the interpretation and assessment of a particular biological responses.

The biological responses are assessed separately, but the resulting fish and macro-

invertebrate ECs are integrated to provide an indication of the in-stream EC (Table 21). Logically, the integration of the riparian vegetation EC and the in-stream EC would provide the EcoStatus. The influence of the riparian vegetation on the in-stream habitat is used to interpret the biological responses and endpoints. This means that in some cases, the integrated in-stream biological responses are deemed to provide a reasonable indication of the EcoStatus.

Table 21: The table below provides the available parameters that were instrumental to establish the Ecostatus of the Mokolo River.

Parameter	Score %	Category	Description
VEGRAI	88.5	A/B	Natural
MIRAI	77.9	B/C	Small change
FRAI	86.3	B	Moderately modified
Ecostatus		B	Largely natural with few modifications

EcoClassification - the term used for the Ecological Classification process - refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The steps followed in the EcoClassification process are as follows:

- Determine reference conditions for each component.
- Determine the Present Ecological State for each component as well as for the EcoStatus. The EcoStatus refers to the integration of physical changes by the biota and as reflected by biological responses.
- Determine the trend (i.e., moving towards or away from the reference condition) for each component as well as for the EcoStatus.
- Determine causes for the PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) of the biota and habitat.

Table 22: Assessing the Ecostatus of the Mokolo River Kaingo Ste.

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	4	100		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	80		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2	50		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	30		
FISH ECOLOGICAL CATEGORY	10	260	**86,3**	**B**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	3	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	2	100		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	1	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**6**	300	**77,9**	**B/C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		560	**82,3**	**B**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proportions	Modified weights
Confidence rating for **fish** information	4	0,50	43,15
Confidence rating for **macro-invertebrate** information	4	0,50	38,95
	8	1,00	82,10
INSTREAM ECOLOGICAL CATEOGORY	EC		B

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**88,5**	**A/B**

ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	4	0,57	46,91
Confidence rating for riparian vegetation zone information	3	0,43	37,93
	7	1,00	84,84
ECOSTATUS	EC		B

According to the Instream Biota EcoClassification model, the fish component matches a Fish Ecological Category B (86.3%). The aquatic invertebrate component matches a Macro-invertebrate Ecological Category B/C (77.9%). Combined the in-stream biota (fish and aquatic invertebrate) component matches an Instream Ecological Category B (82.3%). The riparian vegetation component matches a Riparian Vegetation Ecological Category A/B (88.5%). The overall Ecostatus of the Mokolo River matches a Category B (84.8%) (Largely natural with few modifications) (Table 23). The finer scale rating (B/C and A/B to the EC finer rating table (Appendix 2).

Table 23: Generic ecological categories for EcoStatus.

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions are extensive.	20-39
F	Critical/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.	0-19

The reason for the “Category B (84.8%)” status can be ascribed to the presence of the weirs in the system. Weirs constitute obstacles for longitudinal exchanges along fluvial systems and so result in discontinuities in the river continuum;

Corridors for Connectivity

The guidelines for land-use practices or activities that impact on water quantity in freshwater CBAs includes the following: Generic buffers should be established around streams within these catchments. These buffers can be refined based on a site visit and applying the DWS's wetland delineation tool.

Due to their positioning adjacent to water bodies, buffer zones associated with streams and rivers will typically incorporate riparian habitat. Riparian habitat, as defined by the NWA, includes the physical structure and associated vegetation of the areas associated with a watercourse (Macfarlane et al, 2015). However, the riparian zone is not the only habitat type that is present in the buffer as the zone may also incorporate stream banks and terrestrial habitat, depending on the width of the aquatic impact buffer zone applied. Therefore, the riparian zone must be delineated before the buffer zone is established.

Riparian delineation

During the process of riparian delineation of Site 1, three transects were surveyed. A transect runs from the outer edge of one riparian zone (left bank), through the drainage line to the outer edge of the other riparian zone (right bank). The results of the surveys are illustrated in Figure 12 in the previous section.

Riparian delineation and habitat evaluation was undertaken according to the DWAF Guidelines (2005) and DWAF updated manual (2008) (see Methods Section 2.7.4.3.2 Aquatic biota surveys). Figure 12 illustrates the Mokolo River site with the riparian zone delineated. The delineation shapefiles are available as Appendices 3 and 4.

It is clear in Figure 12 that the 100-year floodline initially pushes out wider than the riparian zone in the upstream section of the reach, most probably due ti the presence of the weir, but then moves closer to the riparian delineation as the river continues its flow into the steeper valley reach downstream of the proposed river crossing.

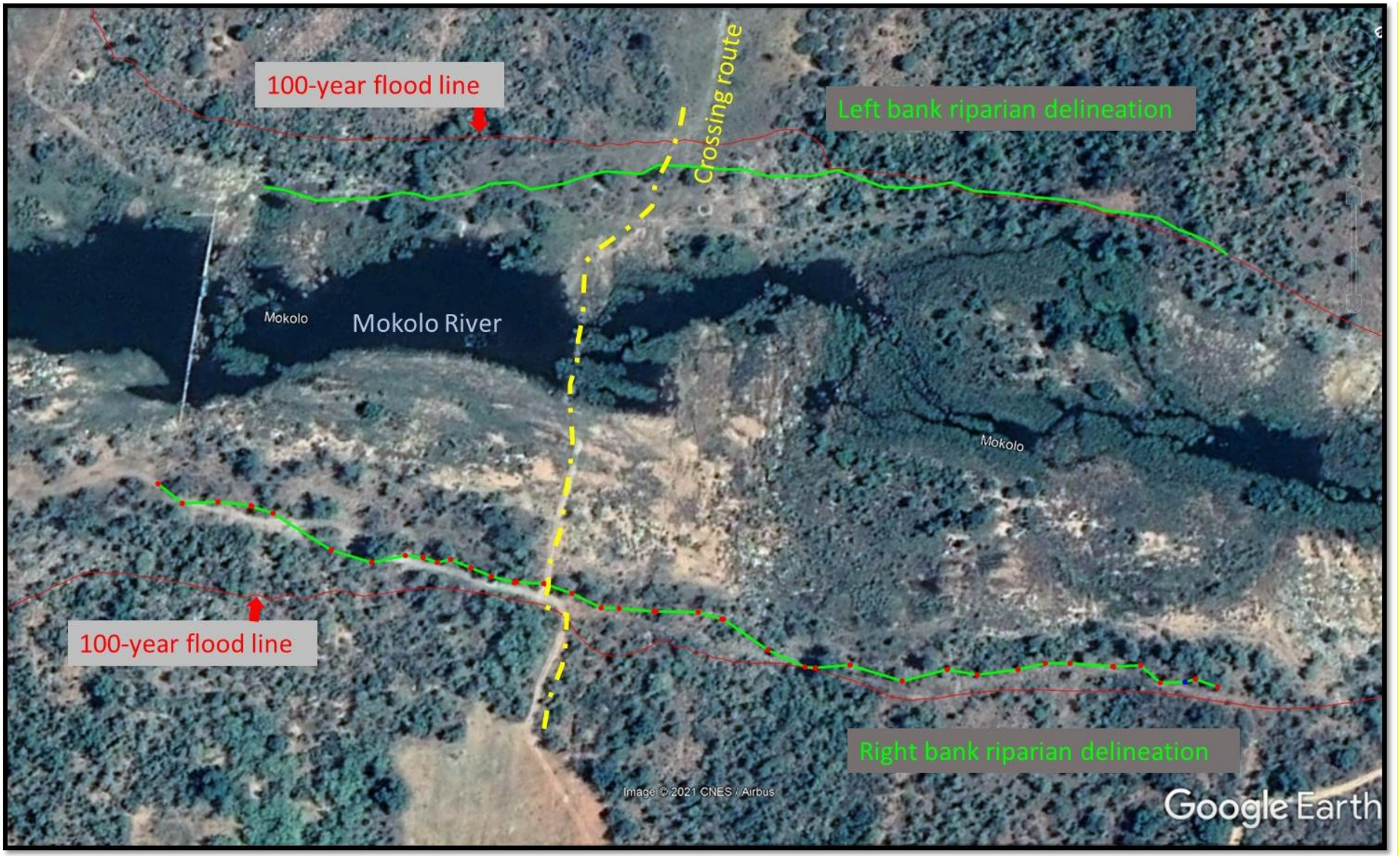


Figure 12: The delineated riparian zone (green lines) of the Mokolo River reach at Site 1 in the project area.

Buffer zones

Buffer zones have been used in land-use planning to protect natural resources and limit the impact of one land-use on another. Buffer zones will serve as a mitigating measure for impacts created by the construction and operational phases of the Kaingo river crossing project area, and the implemetation will be recapitulated in the mitigation section (Task 2.5c).

Buffer zones associated with water resources have been shown to perform a wide range of functions, and on this basis, have been proposed as a standard measure to protect water resources and associated biodiversity. These functions include:

- Maintaining basic aquatic processes;
- Reducing impacts on water resources from upstream activities and adjoining land uses;
- Providing habitat for aquatic and semi-aquatic species;
- Providing habitat for terrestrial species; and
- A range of ancillary societal benefits.

Determining the required buffer width is largely an exercise of assessing the situation and linking it to an acceptable level of risk. Determining appropriate management measures for aquatic impact buffer zones is largely dependent on the threats associated with the proposed activity adjacent to the water resource. These threats include:

- Increases in sedimentation and turbidity;
- Increased nutrient inputs;
- Increased inputs of toxic organic and heavy metal contaminants; and
- Pathogen inputs.

Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Standard management measures should be implemented to ensure that any on-going activities do not result in a decline in water resource quality. The protected riparian zone will serve as a mitigating measure for impacts created by the construction and operational phases of the proposed project.

In determining the buffer zone requirements for river ecosystems, the process involves a number of steps in order to establish the buffer around the proposed riverine site. The following aspects were addressed specifically for the Kaingo river crossing project (according to the steps suggested in Macfarlane, 2017):

Step 1: Define objectives and scope to determine the most appropriate level of the assessment.

The motivations for assessing potential impacts and establishing buffer zone requirements may be diverse. It is therefore important that the specific objective for the assessment is clearly understood before starting.

Determine the Most Appropriate Level of Assessment

Site-based assessment: This assessment is designed for detailed planning and includes a more rigorous assessment of risks as well as incorporating site-specific factors that can affect buffer requirements.

Step 2: Map and categorise water resources in the study area

After establishing the scope and appropriate level of the assessment (site-based delineation), the assessor must generate a map delineating the boundaries of the water resources potentially affected by proposed developments within the study area. The guidelines on delineating ephemeral and seasonal systems as suggested in Macfarlane (2017), were employed in the delineation exercise of the crossing drainage system.

Identify Water Resource Type: The Hydro-geomorphological (HGM) classification systems have been used to categorise the river system into the appropriate type (SANBI, 2009; Ollis et al., 2013), which is a lower footslope river type with a channelled valley bottom and associated riparian zone.

Step 3: Refer to the DWS management objectives for mapped waterresources or develop surrogate objectives.

Understanding the rationale and objective for resource protection is a key step in informing management and protection requirements for water resources. Where impacts are likely to be low, it may be appropriate to simply set a management objective to “maintain” the status quo. This ensures that existing impacts are managed to a certain level without forcing applicants to undertake extensive surveys to establish whether improvement in water resource quality is required.

Determine the PES and Anticipated Trajectory of Water Resource Change

In Section 2.3.4.1 the PES for the Mokolo River in the study area was established as a “C” (Moderately Modified) (Table 31) and the Ecological Importance and Sensitivity is rated as “Low” (DWS, 2014).

According to the Intermediate Reserve Determination Study (DWA, 2010), the PES at EWR 2 on the Kaingo Game Reserve is also rated C (Appendix 2) and the Ecological Importance and Sensitivity is rated as “High” (Figure 16). This places the river in a category assessed as Moderately Modified with a “High” EIS.

The PESEIS evaluation establish values of larger catchment sized areas, while the EWR study was for a specific reach in the Kaingo portion of the Mokolo River. Therefore the discrepancies relating to the EIS values.

Step 4: Assess the risks from proposed developments and define mitigation measures necessary to protect mapped water resources in the study area

Do a Risk Assessment for Potential Impacts of Planned Activities on Water Resources:

Apart of the Risk Assessment that was done with the Risk Matrix, the desktop buffer zone tool has also a built-in risk assessment per site.

Site-based assessment: Desktop threat ratings are used as a starting point for buffer zone determination. While desktop threat ratings provide an indication of the level of threat posed by different land uses/activities, there is likely to be some level of variability between activities occurring within a sub-sector. It is therefore important that these threat ratings be reviewed based on specialist input and that a justification for any changes is documented in the Buffer Zone Tools.

Assess the Sensitivity of Water Resources to Threats Posed by Lateral Land Use Impacts.

The sensitivity of water resources to lateral impacts is another factor affecting the level of risk posed by a development. A more risk-averse approach is therefore required when proposed

developments take place adjacent to water resources that are sensitive to lateral impacts, as opposed to the same development taking place adjacent to a water resource which is inherently less sensitive to the impacts under consideration.

The aspects utilised to establish the Mokolo River riparian buffer zone, are listed in Table 25 and the buffers obtained from these features are displayed at the end of the table as: 10 m during the construction phase, and 10 m for the operational phase.

Table 25: Site-based tool: Determination of buffer zone requirements for river systems.

Site-based tool: Determination of buffer zone requirements for river systems.	
Name of Assessor	Dr AR Deacon
Project details	Kaingo river crossing project
Date of Assessment	2021/12/15
Level of Assessment	Site-based
Approach used to delineate the riparian zone & active channel?	Site-based delineation
River type	Lower Foothills - lower footslope river type with a channelled valley bottom and associated riparian zone.
Present Ecological State	C (Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged).
Ecological importance & sensitivity (Current status)	Medium: Features that are considered to be ecologically important and sensitive at a local scale. The functioning and/or biodiversity of these features is not usually sensitive to anthropogenic disturbances. They typically play a small role in providing ecological services at the local scale.
Management Objective	Maintain
Sector	Open space: Areas defined as open space include a range of land-uses with minimal infrastructural development, such as parks, gardens and off-road trails. Includes areas set aside for preservation and conservation because they provide ecosystem services, are unique natural landscapes, viewpoints, areas of ecological, historical and/or cultural importance, biodiversity, and/or have unique, rare of endangered habitats or species.
Sub-sector	Open space
MAP Class	1001 - 1200mm
Rainfall intensity	Zone 4
Stream order	3rd order
Channel width	3-5m
Perenniality	Perennial system (>9 months)
Average slope of rivers catchment	3-5%
Inherent runoff potential of the soil in the river's catchment	Moderate Low (B)
Longitudinal river zonation	Lower Foothills
Inherent erosion potential (K factor) of catchment soils	0.25 - 0.50
Retention time	Generally slow moving
Inherent level of nutrients in the landscape	Low base status
Inherent buffering capacity	Neutral pH

Natural salinity levels	Non-saline (<200mS/m)
River depth to width ratio	Medium 0.25 – 0.75
Mean annual temperature	Zone 5 (19.5 - 24.2 Deg C)
Level of domestic, livestock and contact recreational use	Low
Buffer attributes (Current status)	
Slope of the buffer	Gentle (2.1 - 10%)
Vegetation characteristics (Construction phase)	Fair: Moderately robust vegetation with fair interception OR less robust vegetation with very good interception.
Vegetation characteristics (Rehabilitation phase)	Fair: Moderately robust vegetation with fair interception OR less robust vegetation with very good interception.
Soil permeability	Moderate: Deep moderately textured soils (e.g., sandy loam) OR shallow (<30cm) well drained soils.
Micro-topography of the buffer zone	Uniform topography: Smooth topography with no concentrated flow paths anticipated.
Aquatic impact buffer requirement	
Construction Phase	**10m**
Operational Phase	**10m**

According to the initial buffer requirement, it becomes apparent that, to protect the Mokolo River in its current condition from any degradation, a buffer of 10 m wide on both sides of the drainage line is required during the construction and operational phases. This buffer width is obtained whenever the following mitigation measures are applied to the model (Table 26).

Table 26: Mitigation measures to apply to the model in order to protect the Mokolo River.

Construction Phase

Threat Posed by the proposed land use / activity	**Justification for changes in threat ratings**
6. Inputs of toxic heavy metal contaminants.	Refrain from any activity re contaminants - be extra careful.

Operational Phase

Threat Posed by the proposed land use / activity	**Justification for changes in threat ratings**
2. Alteration of patterns of flows (increased flood peaks)	Prevent blockages by active managing the culvert flows.

Final aquatic impact buffer requirements (including practical management considerations) for both sites and all the segments:

Final aquatic impact buffer requirement: 10 m

Step 5: Assess risks posed by proposed development on biodiversity and identify management zones for biodiversity protection.

Step 6: Delineate and demarcate final buffer zone requirements.

Once protection requirements for water resources and associated biodiversity have been established, the buffer zone requirements have to be finalised and delineated on a layout plan and in-field.

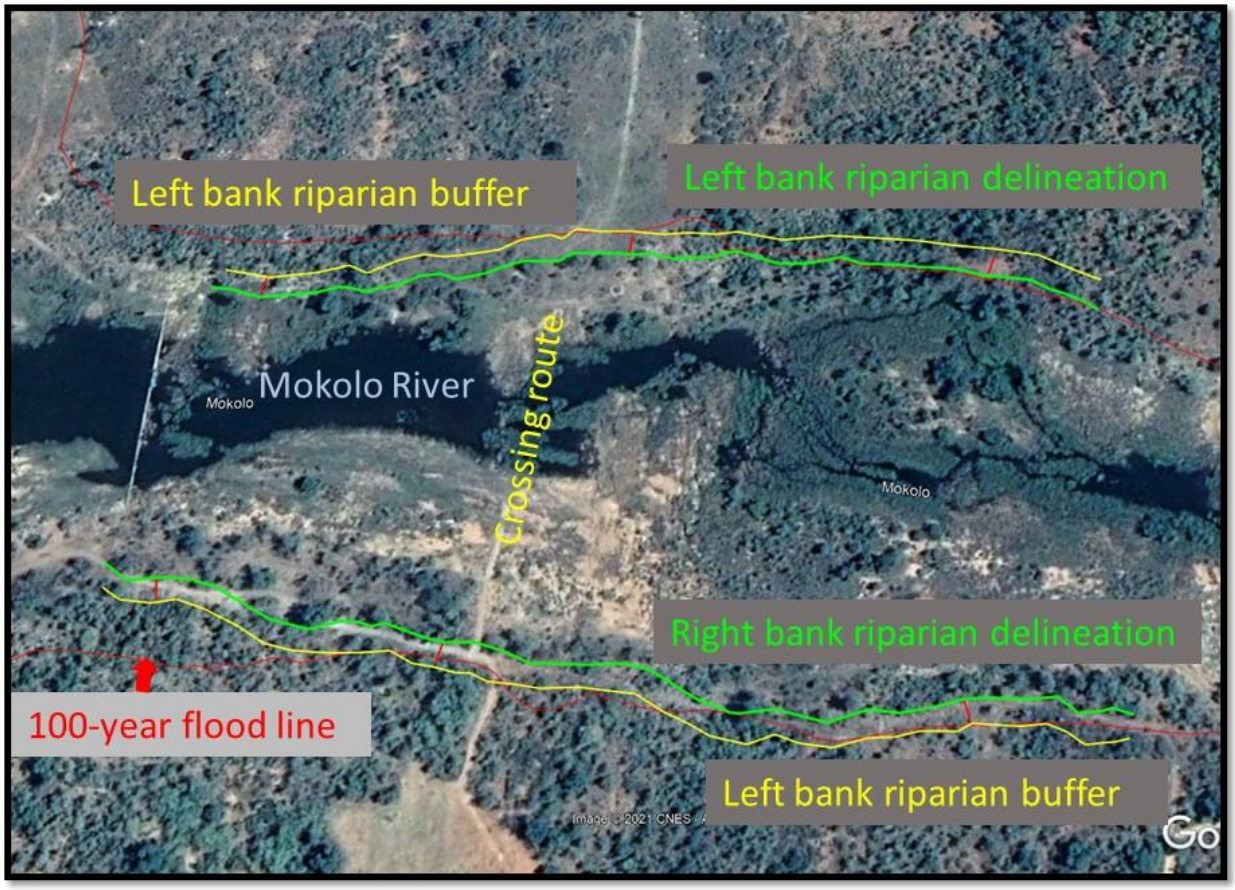


Figure 13: This figure outlines the proposed buffer of 10m (yellow line) in order to protect the riparian corridor (green line) and to protect the Mokolo River (Shape file of buffer – Appendix 5 and 6).

Step 7: Document management measures necessary to maintain the effectiveness of the final buffer zone areas.

Once a final buffer zone area has been determined, appropriate management measures need to be documented to ensure that the water quality enhancement and other buffer zone functions, including biodiversity protection, are maintained or enhanced. These measures should ideally be integrated in the environmental management plan (EMP) for the proposed development, as it includes a requirement to assign clear responsibilities for buffer zone management at both the construction and operation phases. Although management measures will be specific to each site, some guidance is provided to ensure that management measures cater adequately for key buffer zone functions.

The KML shapefile for the final buffer zone of the Mokolo River (Figure 13) is present in Appendix 5 and 6.

2.3.2 The threat status of the ecosystem and species as identified by the screening tool

Proposed Development Area Environmental Sensitivity

The following summary of the development footprint environmental sensitivities or threat status of the ecosystem and species is identified. Only the highest environmental sensitivity is indicated. The footprint environmental sensitivities for the proposed development footprint as identified, are indicative only and must be verified on site by a suitably qualified person before the specialist assessments identified below can be confirmed.

Table 27: The development footprint environmental sensitivities of the aquatic ecosystem identified by the screening tool (Figure1).

Theme	Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
Animal species		**X**		
Aquatic Biodiversity Theme	**X**			
Plant Species Theme				**X**

The following section with maps represents the results of the screening for environmental sensitivity in the proposed site for the aquatic ecosystem themes associated with the project classification.

Table 28: Sensitivity features of the project area.

Theme	Sensitivity	Feature
Aquatic biodiversity	Very High	Wetlands
Terrestrial Biodiversity Theme	Very High	Critical Biodiversity Area 1 Ka'ingo Nature Reserve Protected Areas Expansion Strategy

2.3.3 An indication of the national and provincial priority status of the aquatic ecosystem.

The use of CBA maps in Environmental Impact Assessments

Ideally, all land-users and people who make decisions about land and the use of natural resources should be aware of spatial biodiversity priorities and should know how to take these into consideration in their planning and decision-making processes. This is so that they can proactively identify the ecological opportunities and constraints within a landscape and use these to locate different land-uses appropriately (Cadman *et al.*, 2010).

Systematic biodiversity planning provides a powerful set of tools (maps and land-use guidelines) that facilitate this in a wide range of sectors, at both the policy-making and operational decision-making levels. The Limpopo Biodiversity Sector Plan represents the biodiversity sector's input to a wide range of planning and decision-making processes, frameworks and assessments in multiple land-use sectors (Desmet et al. 2009).

The Limpopo Conservation Plan (C-plan) shows that the entire site falls within an area considered to be critical for biodiversity (Figure 14) (Desmet et al. 2009). Critical biodiversity areas are required to meet the conservation targets of Limpopo C-plan. Critical Biodiversity 1: Protected Area is a category that is regarded as irreplaceable and no alternative sites are available to replace them. The key results of the Biodiversity Geographic Information System (BGIS) maps and LUDS Report are summarised in Table 29.

Table 29: The key results of the LUDS Report as extracted from the Limpopo Conservation Plan national datasets available from BGIS.

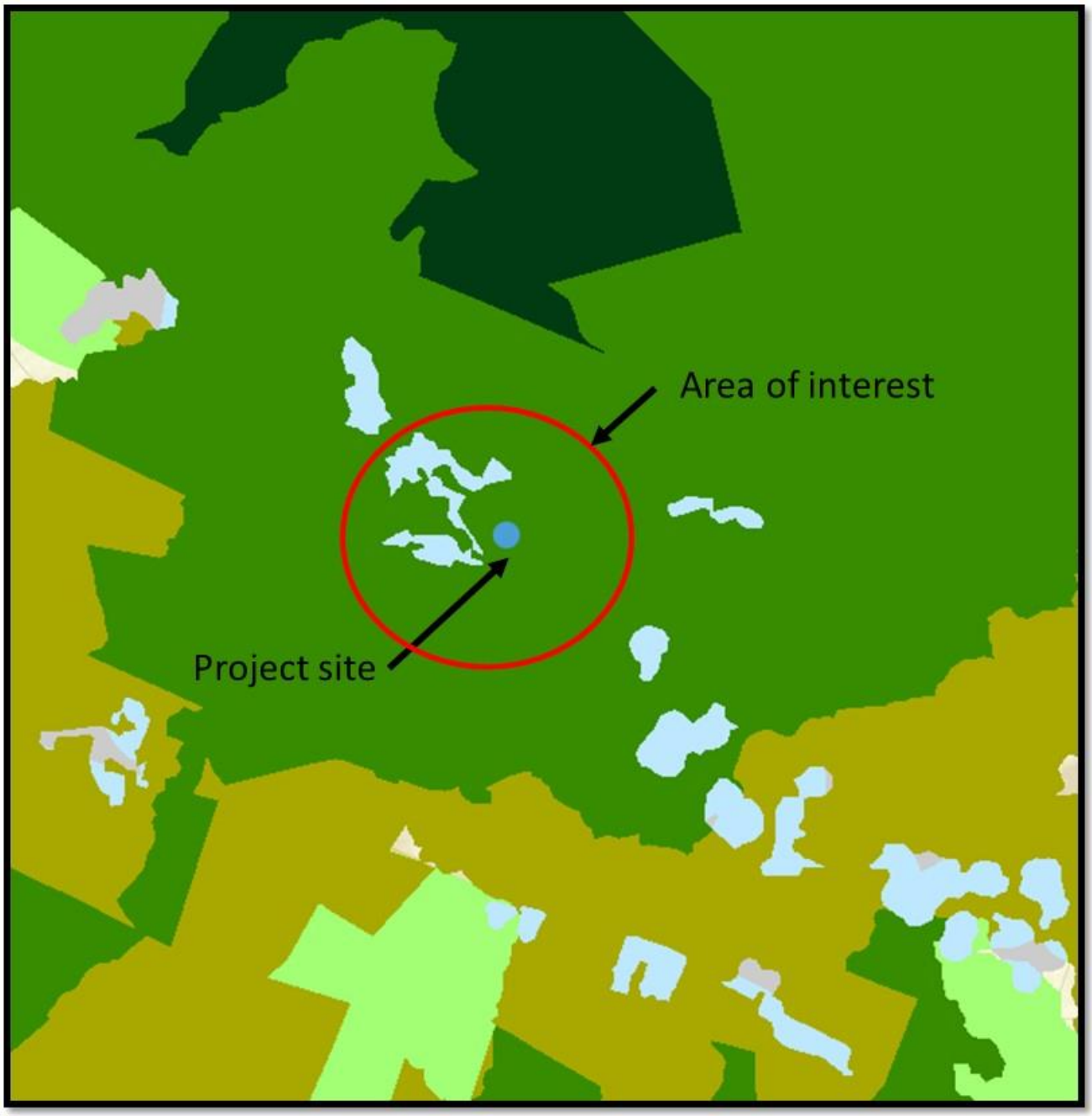
National Data Set	Aspect	Presence
National terrestrial information: Limpopo Province		
South African district boundaries	Waterberg	
South African municipal boundaries	Municipality name: Lephalale Local Municipality	LIM362
Biome	Savanna	
Bioregion	Central Bushveld Bioregion	
Vegetation type	Central Sandy Bushveld	SVcb 12
Vegetation type	Western Sandy Bushveld	SVcb 16
Terrestrial CBAs		
Limpopo Critical Biodiversity Areas (CBAs)	Critical Biodiversity Area 1	
Protected Area	Waterberg Biosphere Reserve	
Ecological Support Area	Ecological Support Area 2	ESA2
National aquatic information: Matlabas/Mokolo Catchments		
Water Management Area (WMA)	Limpopo	
Sub-WMA name	Matlabas/Mokolo	
Aquatic Ecoregion Lev I	6.02 Waterberg	Kaingo Game Reserve
Wetland ecosystem type	Central Bushveld Group 3	Channelled valley-bottom wetland
River Reach	A42F-00285	
Quaternary Catchment	A42F	
EI mean Class	High	
PES Category	C	Moderately modified
Critical Biodiversity Areas		
River FEPA	Mokolo River (perennial)	6_P_L Class C: Moderately modified

Critical Biodiversity Areas

Overlaying the BGIS Critical Biodiversity Areas map onto the Kaingo Project Area, resulted in the compilation of Figures 14 and 15 and Table 29. According to these maps and LUDS Report (Table 29) the project area falls into the following sensitive areas:

- Terrestrial:
  - Critical Biodiversity Area 1
  - Ecological Support Area 2

- Freshwater
  - FEPA river: Mokolo River



Ecological Support Area 2

Critical Biodiversity Area 1

Figure 14: The Critical Biodiversity areas for the Kaingo Project Area as illustrated by the LUDS programme (BGIS, 2015) for Limpopo Province.

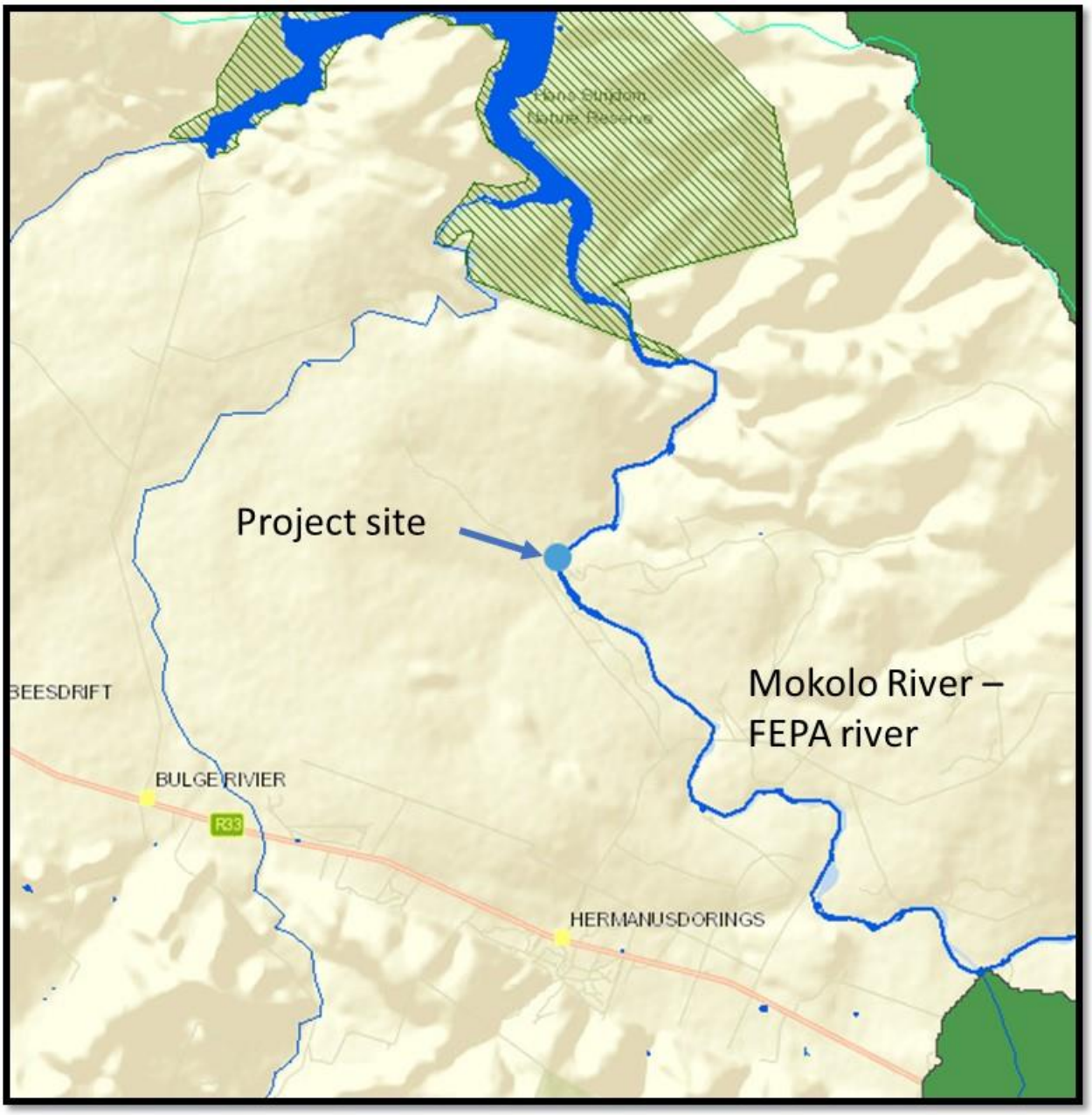


Figure 15: The conservation status of the aquatic system of the project area, as illustrated by the LUDS programme (BGIS, 2015) for Limpopo Province.

With these sensitive landscape properties, it is paramount to approach the construction and operation phases of the entire project with caution. The footprint of the entire project area is classified as Critical Biodiversity Area 1, and adjacent areas are associated with the patches of Ecological Support Area 2.

Critical Biodiversity Areas and Ecological Support Areas are areas that require safeguarding to ensure the continued existence of biodiversity, ecological processes and ecosystem services. Site 2 upstream of the DWS weir (Figure 18) is dominated by reed beds (resembling floodplains) and inter-connecting pools and backwater. Adequate water levels in these pools support recharge towards the flood plains and thus the sustained marshy habitat.

Ecological Support Areas: Figure 14 illustrates ESAs in close vicinity of both the project sites. Those areas that play a significant role in supporting ecological functioning of Critical

Biodiversity Areas and/or delivering ecosystem services, as determined in a systematic biodiversity plan.

A CBA map of the study area was compiled by using the Biodiversity Geographic Information System (BGIS) maps as illustrated in Figure 14. Every attempt should be made during all phases of the project development not to have an impact on these areas. While determining the area and distribution of a core habitat is important, it is equally important that appropriate management measures be defined to ensure the core habitat continues to function effectively.

2.3.4 A description of the ecological importance and sensitivity of the aquatic ecosystem.

This section supplies a description of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site. These include. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.

The Mokolo River downstream of Vaalwater to Mokolo Dam (Figure 15) is rated as an area of high Ecological Importance and Sensitivity (EIS). This is mostly due to the diversity and sensitivity of habitat types, species taxon richness and presence of unique species and the importance of conservation areas through which it flows (DWA, 2010).

According to the Intermediate Reserve Determination Study (DWA, 2010), the EIS at EWR 2 on the Kaingo Game Reserve is rated “Very high”. This is due to rare and endangered mammals and reptiles, unique fish and aquatic macroinvertebrate species. The fish species present in the area that are intolerant to flow and flow related water quality changes.

After the habitat assessments of the transects, detail habitat diagrams were produced to illustrate geomorphology and the setting of the proposed crossings. These diagrams are illustrated in Figures 10 and 11.

Viewing the broad-scale vegetation units and ground cover diagrams in Figures 17 and 18 the outline of the surface flow and the reed/grass-covered riverbed of the Mokolo River is visible, and the riparian fringes are also recognisable. Figures 17 and 18 also presents a layout of the different components of the riverine ecosystem at the two identified crossing sites. The main components of the Mokolo River in this river reach are a riverbed which consists mainly of some pools in a channel flanked by reeds and alluvial river beds covered with couch grass or being bare sand. The riparian corridor along Mokolo River is rather patchy on both the stream banks, and not all the tall trees in the area are part of the riparian zone.

Riparian trees line the macro-channel banks; only a small number are present in the river bed. These riparian systems are also very dependent on subsurface flows into the channel banks to survive. The rest of the habitat present in the river bed consists of short-grassed lawns (also called Grazing lawns), mainly *Cynodon* grass. Grazing lawns are a distinct grassland community type, characterised by short-stature and with their persistence and spread promoted by grazing. These habitats are less sensitive to changes in the system. The small area of shallower flowing water through rocky areas, creates riffles and shallow rapids and forms special habitat for rheophilic aquatic species.

Table 30: According to the DWS PESEIS project, the following impacts are perceived for the Mokolo River in the project area.

METRIC	IMPACT/SEVERITY
Abstraction,	Moderate
Agricultural fields,	Moderate
Algal growth,	Moderate
Bed and Channel disturbance,	Moderate
Canalization,	None
Chicken farms,	None
Low water crossings,	Small
Large dams,	Small
Small (farm) dams,	Small
Erosion,	Small
Alien aquatic macrophytes,	None
Alien vegetation,	Small
Feedlots,	None
Forestry,	None
Overgrazing/trampling,	Small
Inundation,	Moderate
Industries,	None
Inter-basin transfers,	None
Increased flows,	None
Irrigation,	Moderate
Mining,	None
Natural areas/nature reserves,	Moderate
Recreation,	Moderate
Roads,	Small
Runoff/effluent: Industries,	None
Runoff/effluent: Irrigation,	Moderate
Runoff/effluent: Mining,	None
Runoff/effluent: Urban areas,	None
Sedimentation,	None
Grazing (land-use),	Serious
Urbanization,	None
Vegetation removal,	Moderate

According to the Intermediate Reserve Determination Study (DWA, 2010), the PES at EWR 2 on the Kaingo Game Reserve is rated B/C. This is due to impacts such as abstraction, irrigation weirs, farming and catchment activities. The impacts are largely flow and non-flow related.

Project Site 1 (Figure 18) consists mostly of extensive bedrock and large sandy patches. There is also an extensive grassy lawn area on the right bank of the river. These habitats are all robust and not very sensitive to water level or flow changes.

However, most of the reed growth which occurs in the marginal zone at the water edge is dependent on water in the pools, and the riparian trees in the river bed and riparian zone, are dependent on a sustained inflow of subsurface water to recharge the groundwater.

Downstream of the site, bedrock is forming a control which creates natural pools. Shallower water flowing through rocky cracks, creates important flowing habitats such as riffles. Downstream of the bedrock control is an extensive reedbed marshland that is very dependent on constant flow reaching the reedy marsh.

The goal is to maximise connectivity in CBAs and ESAs, the retention of intact natural habitat and avoid fragmentation: Design project layouts and select locations that minimise loss and fragmentation of remaining natural habitat and maintain spatial components of ecological processes, especially in ecological corridors, buffers around wetlands, CBAs and ESAs. Activities that are proposed for CBAs must be consistent with the desired management objectives for these features and should not result in fragmentation.

The DWS weir is an example of a structure that fragments the riverine system. The dammed area upstream of the weir consists of an unnatural expanse of water inundating the original habitats, while the downstream area is changed by scouring and sediment deposition. The weir structure itself is a migration barrier for certain fish and aquatic macroinvertebrate species.

2.3.4.1 Present Ecological State of the study area

This following section supplies a description of the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).

The study area is located in Ecoregion 6.02, also known as the Waterberg. The Mokolo River enters this region through a relatively steep gorge upstream of Vaalwater and flows out of the area at the junction between the Mokolo River and the Rietspruit. The river flows through a largely flat undulating plain interspersed with steep rocky areas and gorges. This area falls mainly in the Sweet Bushveld. Altitude varies between 900 metres and 1200 metres. Rainfall varies between 300 and 700 mm per annum. Mean annual temperatures vary from 14 °C to 22 °C (River Health Programme, 2006).

Throughout this study unit, the Mokolo River has a steep gradient and passes through a inaccessible gorge. In the upstream section, the river passes through some irrigated farmlands but for the most part, the river passes through private game reserves. In the middle of the gorge, the river is impounded by the Mokolo Dam, which lies within the provincial Mokolo Dam Nature Reserve.

The Mokolo catchment is the only catchment in the Limpopo WMA with significant water resources, due to the relatively high rainfall in the upper reaches of the catchment, reaching as high as 660 mm/annum in places. The mean annual runoff of the catchment is estimated to be 292 million m^3/a.

The largest user of water in this catchment area is the irrigation sector, with an estimated demand of 68 million m^3/annum. This is located mostly upstream of the Mokolo Dam, where the main source of water supply are farm dams. The irrigation quota from the Mokolo Dam

itself is only about 10 million m^3/a. Irrigators are supplied by means of releases into the Mokolo River and the losses associated with this are thought to be large.

The other two large water allocations are 9,9 million m^3/a to the Grootgeluk mine and 7,3 million m^3/annum to the Matimba power station. Other small users are the towns of Lephelale and Vaalwater which together use approximately 2 million m^3/a. Rural water use is estimated at 2 million m^3/a, with boreholes probably being the major source of water.

Table 31: The EcoClassification results at EWR2 as summarised in the Reserve Determination Study (DWA, 2010)

IHI				Driver Components	PES Category	Trend	REC	AEC↓
INSTREAM	C / D	RIPARIAN	B / C	HYDROLOGY	C			
				WATER QUALITY	B	Stable	A/B	C
				GEOMORPHOLOGY	B/C	Stable	B	C
				Response Components	PES Category	Trend	REC	AEC↓
				FISH	C	Negative	B	D
				AQUATIC INVERTEBRATES	C	Negative	B	D
				INSTREAM	C	Negative	B	D
				RIPARIAN VEGETATION	A/B	Stable	A/B	B/C
				ECOSTATUS	B/C		B	C

It is important to note the following regarding EcoClassification of the project area:

- During the EWR study at the Kaingo site in 2010 the PES of the Mokolo River reach was a Class C (Moderately modified). The Ecostatus was a B/C.
- During the 2014 DWS Desktop Assessment, the river section also came out as a C (Moderately modified).
- The RQO prescribe a PES of a B/C to be maintained. The REC is suggested as a Class B.
- The current impact study (this report) places the Ecostatus as a B (Largely natural with few modifications).

Therefore, with a current Ecostatus of a B, the river is close to the RQO proposed REC, of a B. In other words, the river is currently in a very good condition and certainly in line with the B/C of the RQO requirement.

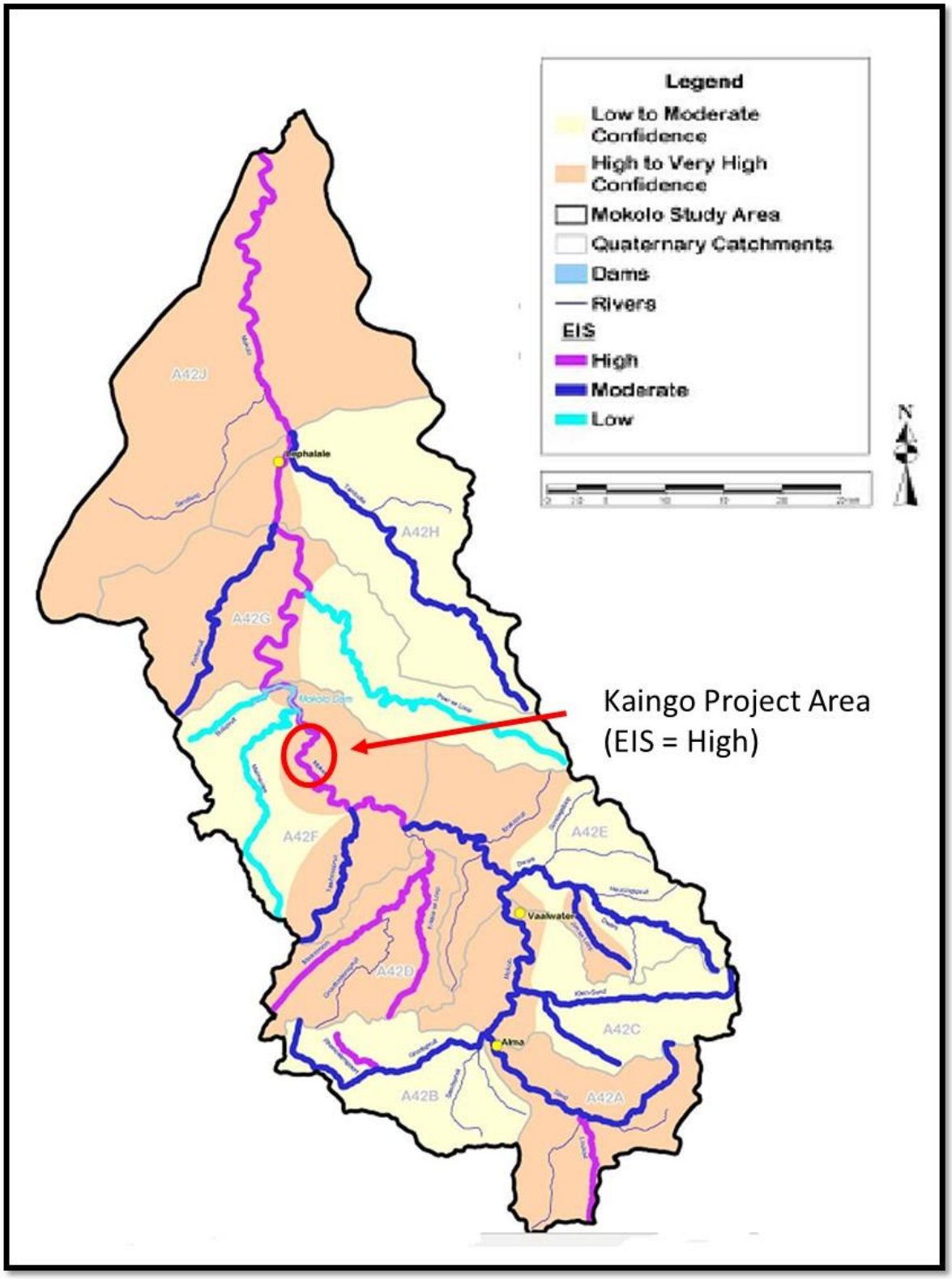


Figure 16: EIS per quaternary and sub quaternary catchment with associated confidence (DWA, 2010).

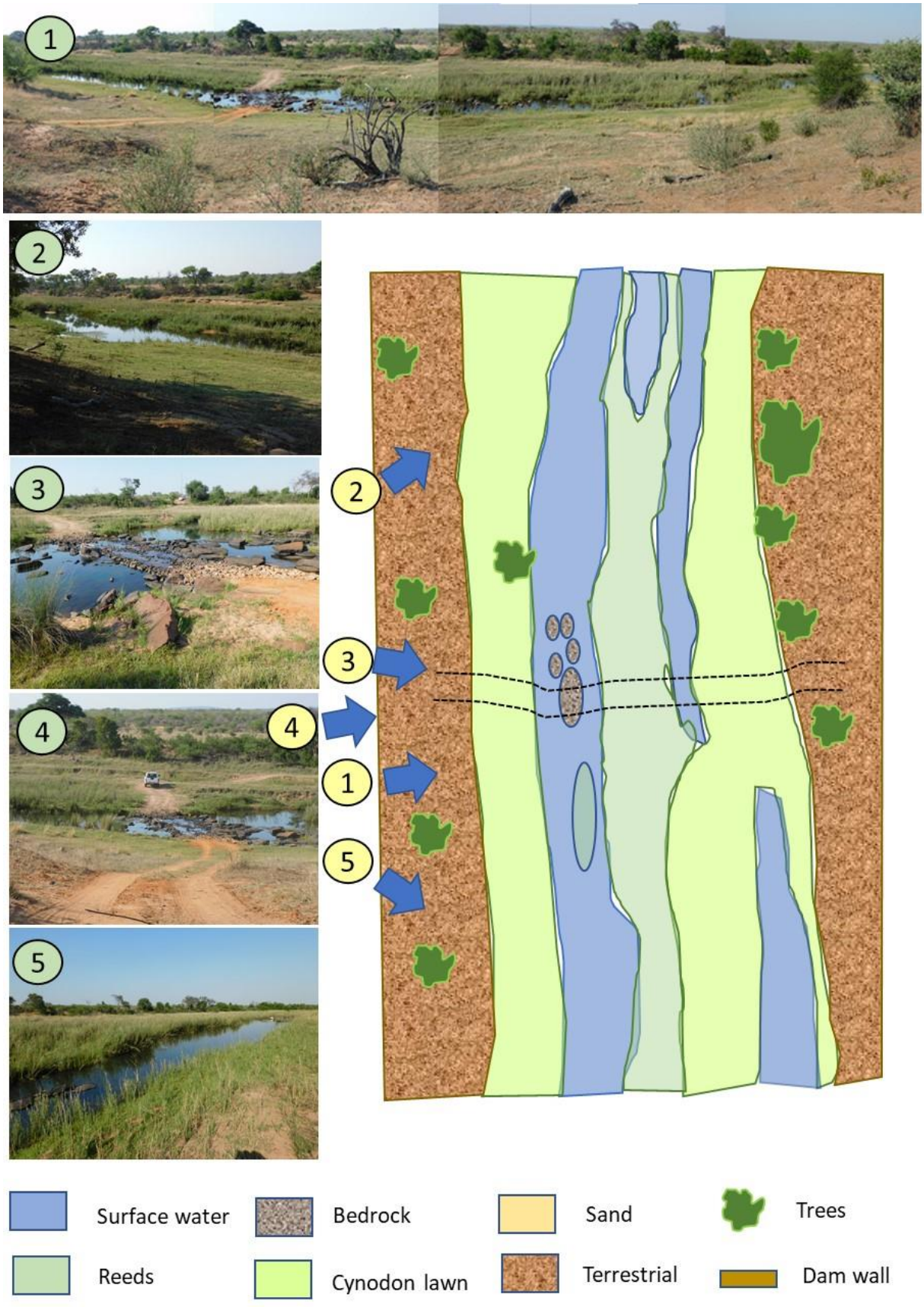


Figure 17: The broad-scale vegetation units and ground cover at Site 2 in the Kaingo project area.

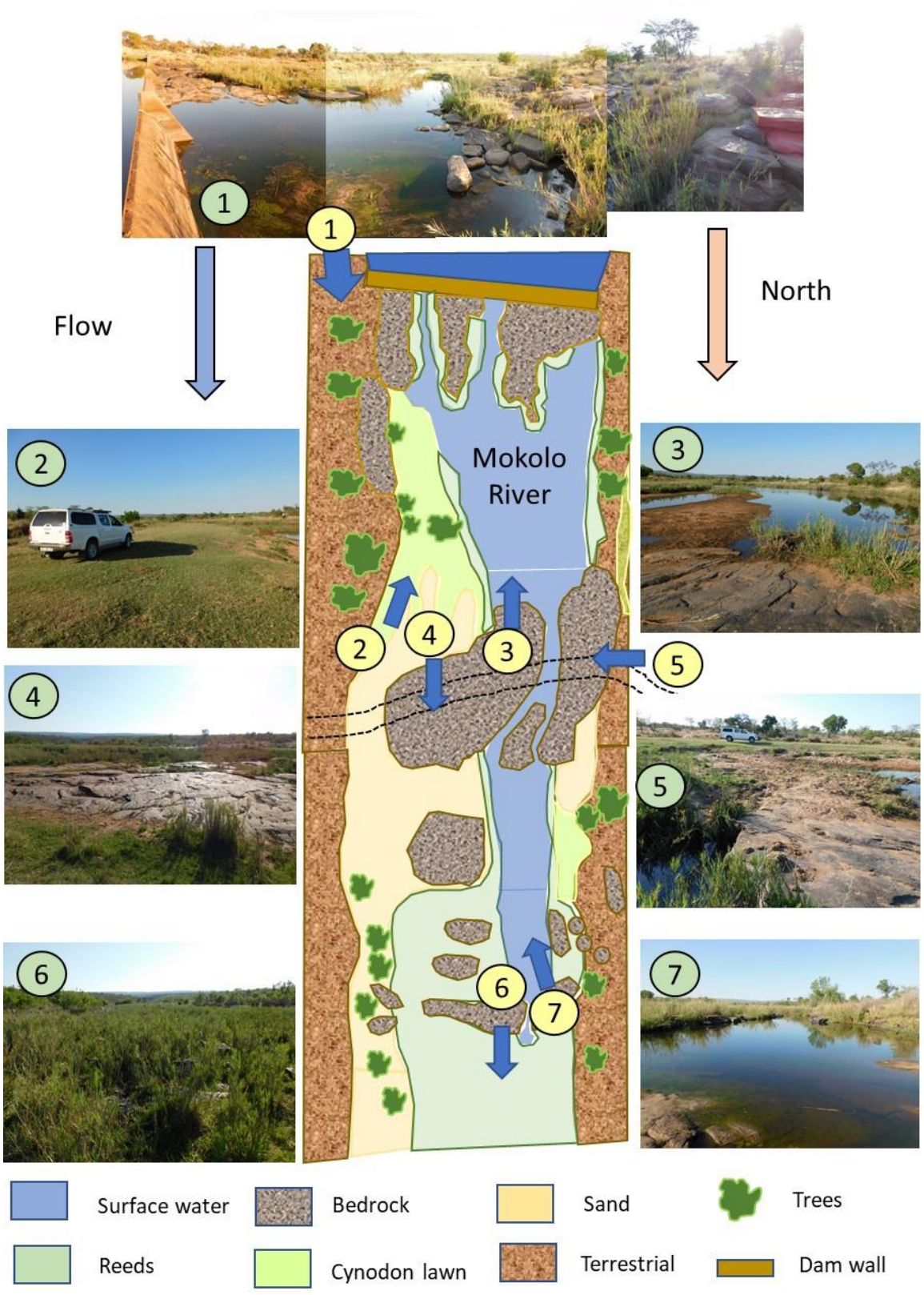


Figure 18: The broad-scale vegetation units and ground cover at Site 1 (the preferred site) in the Kaingo project area.

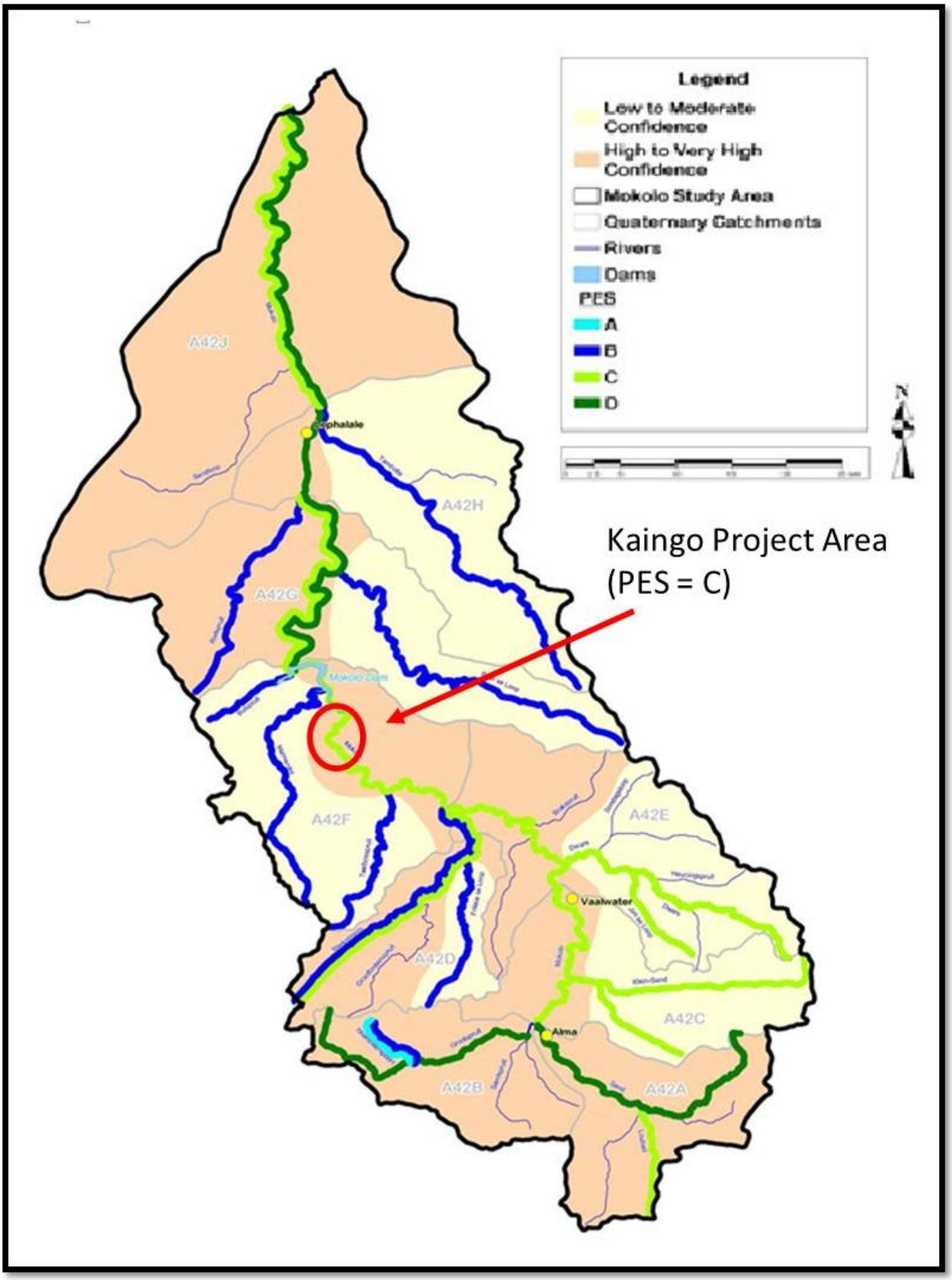


Figure 19: PES Map illustrating PES categories and confidence (DWA, 2010).

2.3.4.2 Resource quality objectives.

Since the EIS at the site is “Very High”, the REC is suggeted as a Class B which is an improvement of the PES. To reach this level the following are proposed:

- Return the functioning of the Mokolo River to a perennial system (i.e. no zero flows).
- Supply some return of freshettes and moderate floods.
- Removal of illegal dams.
- Improve nutrient levels.

DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN TERMS OF SECTION 13(1)(b) OF THE NATIONAL WATER ACT, 1998

Resource Quality Objectives (RQOs) are defined for each prioritised RU for every IUA in terms of water quantity, habitat and biota, and water quality.

Table 32: Summary of Water Resource Classes per Integrated Unit of Analysis and Ecological Categories –Mokolo catchment

Node Name	**Quaternary Catchment**	**Resource Unit**	**River Name**	**Ecological Category to be maintained**	**Mean Annual Runoff (million m3/a)**	**EWR as % of natural Mean annual runoff**
EWR Site MOK_EWR2	A42F	15_3	Mokolo River in A42F to inflow Mokolo Dam	B/C	213.99	8.65

Table 33: River: Mokolo River A42F to inflow Mokolo Dam

Component	Sub-component	Narrative RQO	Indicator	Numerical Limit RQO
Quantity	Low flows	EWR maintenance low and drought flows: Mokolo River at MOK_EWR2 in A42F nMAR = 195.69x10⁶m3 PES=B/C category. The maintenance low flows and drought flows must be attained to support the aquatic ecosystem and the downstream users.	Base Flows Maintenance flows and drought flows	
Habitat	Instream	Habitat diversity should be improved from B/C ecological category to a B category. Return flows into habitat must be controlled.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAM)	Instream Habitat Integrity EC = B ≥ 82 %
	Riparian habitat	Riparian vegetation should be improved from B/C ecological category to a B category Maintain riparian zone in cultivated areas, and control cultivation onto riparian zone.	Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%
Biota	Fish	The fish community must be maintained in a C ecological category. An assessment of the fish community should be conducted annually to monitor against the prescribed ecological category. Maintain flow velocity/depth species CPRE	Fish Response Assessment Index (FRAI)	Fish ecology category = C FRAI ≥ 62% Sample 10+ species per sample effort Sample 10 AJOH in 20min effort

		and habitat sensitive species, MMAC and AJOH		
	Semi-aquatic biota	This river reach must be maintained to serve as a habitat for aquatic bird and mammal populations through proper habitat management.	Aquatic birds/Indicator mammal species	A baseline assessment should be conducted to determine the aquatic bird community and representative mammal species along the river reach. There is a need to set a numerical RQO for density of animals/birds based on the available/collected data.
	Aquatic macroinvertebrates	Macroinvertebrate assemblage must be maintained within a C ecological category or improved upon.	Macroinvertebrate Response Assessment Index and the South African Scoring System Version 5 (SASS5)	MIRAI EC = C ≥ 62% SASS ≥ 130 ASPT ≥ 6.0 (Site MOK_EWR2)

2.4 Identify alternative development footprints.

The following extract from the PG Consulting Engineers report (2021), explains the motivation for selecting the current preferred site:

Two sites were indicated and investigated for possible river crossings (Figure 2) of which the first site shown, about 120 meters below the existing concrete weir (Figure 3c), was found to be the most favourable in terms of construction costs and geotechnical aspects. The solid rock bed across the river, as can be seen on the photos below, makes it a very lucrative site.

Site 1 (Recommended site) – Figure 3 illustrated below show the preferred site which is located some 120m downstream of an existing DWS gauging weir (Figure 3c). The weir will assist with a smooth flow regime to be expected at the crossing. The position regarding to the river's alignment at that section makes it lucrative and feasible in respect of hydraulic flow conditions.

As this site, an exposed sandstone bedrock which stretches across the riverbed (Figure 3a), is present, which allow for proper founding conditions of the proposed structure. The bedrock declines a bit towards the right bank where a sand shoal was visible (Figure 3d). The bedrock however, at this specific section is still anticipated to be shallow.

Site #2 (Alternative site) is some 2.1 km upstream of Site 1. Although the position with regard to river alignment is suitable for a crossing only scattered bedrock was observed which is not suitable for founding conditions. Another disadvantage is the topography on the left bank. The area forms a relatively large floodplain at this section causing the length of a crossing structure to be undesirably long.

The ingress of approach from the right bank is also rather steep making the approach design from the right bank a bit more complex. The second site is also some distance away from the initially intended crossing area and this will increase travelling distances across the river making farm management a bit more difficult.

For detail figures, refer to Section 2.3.4.1.

Three different crossing structure options were investigated by means of a desktop study:

1) Gabion basket structure,
2) Conventional reinforced concrete deck bridge with piers, and

3) Rubble masonry concrete culver structure (RMC).

The first two options were found to be much more expensive where structural reinforcing steel and gabion units are required. It is also more labour intensive. The stability and structural integrity of these two options were also evaluated and found to be less structurally sound and stable during high floods compared to Option 3. Thus, the latter was found to be the most practical and economical with respect to the topography and exposed bedrock at the site. This report subsequently hereafter only focuses on Option 3 (RMC).

Based on the concept design, it will be technically feasible to construct a low-level RMC culvert crossing with length of approximately 134m across the Mokolo River. Most of the structure is proposed to be constructed with RMC which will act as a gravity structure for stability purposes. The average height of the crossing structure will be 1.4m.

2.5 Assessment of the potential impacts of the proposed development.

NEMA defines “evaluation” as “the process of ascertaining the relative importance or significance of information, in the light of people’s values, preferences and judgements, to make a decision.” NEMA and the EIA Regulations call for a hierarchical approach to impact management.

According to the Specialist TOR (Section 1.2), in addition to the Impact Assessment required for the Aquatic Biodiversity Specialist Assessment, a GN509 Risk Assessment should also be completed for the study.

2.5 a) Infrastructural components to be evaluated for the impact assessment

Infrastructural components of the Kaingo bridge project need to be described and assessed according to the GN509 Risk Assessment. They need special mitigation and management measures to be determined and/or the current existing best practice management need to be described by the risk assessment report. The assessment needs to indicate if these components fall inside or outside of the regulated area (riparian habitat) and buffer zone.

2.5 b) The construction of the Kaingo dedicated low-level crossing

The bridge deck will be at CL 940.362 masl which is approximately 0.58m lower than the 1:20-year expected flood level (Figures 20 and 21). The main features of the proposed low-level crossing are summarised below:

Length of bridge deck section 134.4 m
Length of entire crossing (including approaches) 183.0 m
Crest level of bridge deck CL 940.362 masl
Lowest riverbed level CL 938.021 masl
Average bridge height to deck level 1.40m
Bridge deck width 3.66 m

The proposed RMC low-level crossing will consist of a structure with integrated concrete storm water pipes and a precast portal culvert at the critical river flow section. For the construction of a rubble or rock masonry concrete dam, the materials required are cement (and pozzolans), sand, rock and water.

Based on the recommended design, the main works to be carried out can be summarized as follows:

a) Clearing of exposed bed rock and sand shoal (bank) at the proposed crossing alignment (footprint).
b) Drill and anchor steel rebar to the exposed bed rock (to be specified during detail design).
c) Construct blinding concrete and footings at location of precast portal culvert.
d) Position and construct portal culvert sections.
e) Construct RMC sidewalls.
f) Construct concrete road deck inclusive of nominal mesh for crack prevention.
g) Excavate causeway approaches and construct concrete slabs with associated side drains to link up with bridge deck.
h) Landscaping of construction area.

The following construction material and precast components are recommended to be used for the construction of the low-level crossing. A combination of the material items described below proof to be the most economical crossing structure without compromising structural integrity.

A 3000mm x 1200mm precast concrete portal culvert is proposed for the crossing at the river's low flow section. This will assist in an unobscured flow regime at the low flow critical section in the river, thus not allowing any damming / containment of water at the crossing structure.

A blinding layer with level footings on either side will be applied and constructed to the exposed bedrock for proper founding conditions of the precast portal culvert units. Stormwater pipes in addition to the precast culvert, a set of 30 stormwater pipe barrels are proposed to cater for the required design flood as described.

The structure's sidewalls and infill between the stormwater pipes and sidewalls will be done with RMC. The sidewalls of the structure will be built up and anchored to the bedrock with Y20 rebar anchors. The rebar will be drilled into the bedrock and chemically anchored (2-part epoxy for chemically binding rebar).

After construction of the RMC structure, a bridge deck will be constructed consisting of a 150mm thick 25/19MPa concrete slab with Ref 193 mesh for crack prevention. The concrete volume of the deck slab is calculated as 82m³.

The proposed low water crossing will have limited impact on terrestrial biodiversity, considering the proposed development footprint will be restricted to the edge of the watercourse or macro-channel bank. Furthermore, there are existing roads to the ingress and egress of the proposed crossing. This road will not be widened, although a 3m working servitude on either side of the crossing will be added for traffic during construction.

According to the site sensitivity verification report, the restricted development footprint within the Mokolo River and low level of the proposed water crossing, will not alter the visual landscape in any way. None of the observed trees at the crossing (above) were within the proposed development footprint. No riparian vegetation will be affected by the ingress and egress of the proposed crossing as there are existing roads. As such the activity does not affect or impact any broader societal needs, communities or economies.

The engineer would like to, if it meets the grade, to mine the sand from within the river near the right bank for making the Rubble Masonry Concrete (RMC) structure. The structure will require 82m³ which will be sourced from the sand shoal on the right bank of the river.

Due to the construction activity, it is suggested that a wider area will be needed, therefore, a 3m working servitude on either side of the crossing, should be added for construction traffic and related activities.

Site Establishment (Layout): From previous sites, areas usually consisted of roughly 2500 to 3500 m^2 for machinery and site offices. Laydown areas for the cement, aggregates and culverts will probably take an additional 1000 m^2. This is approximately 2 areas covering 50mx50m and 30mx30m respectively.

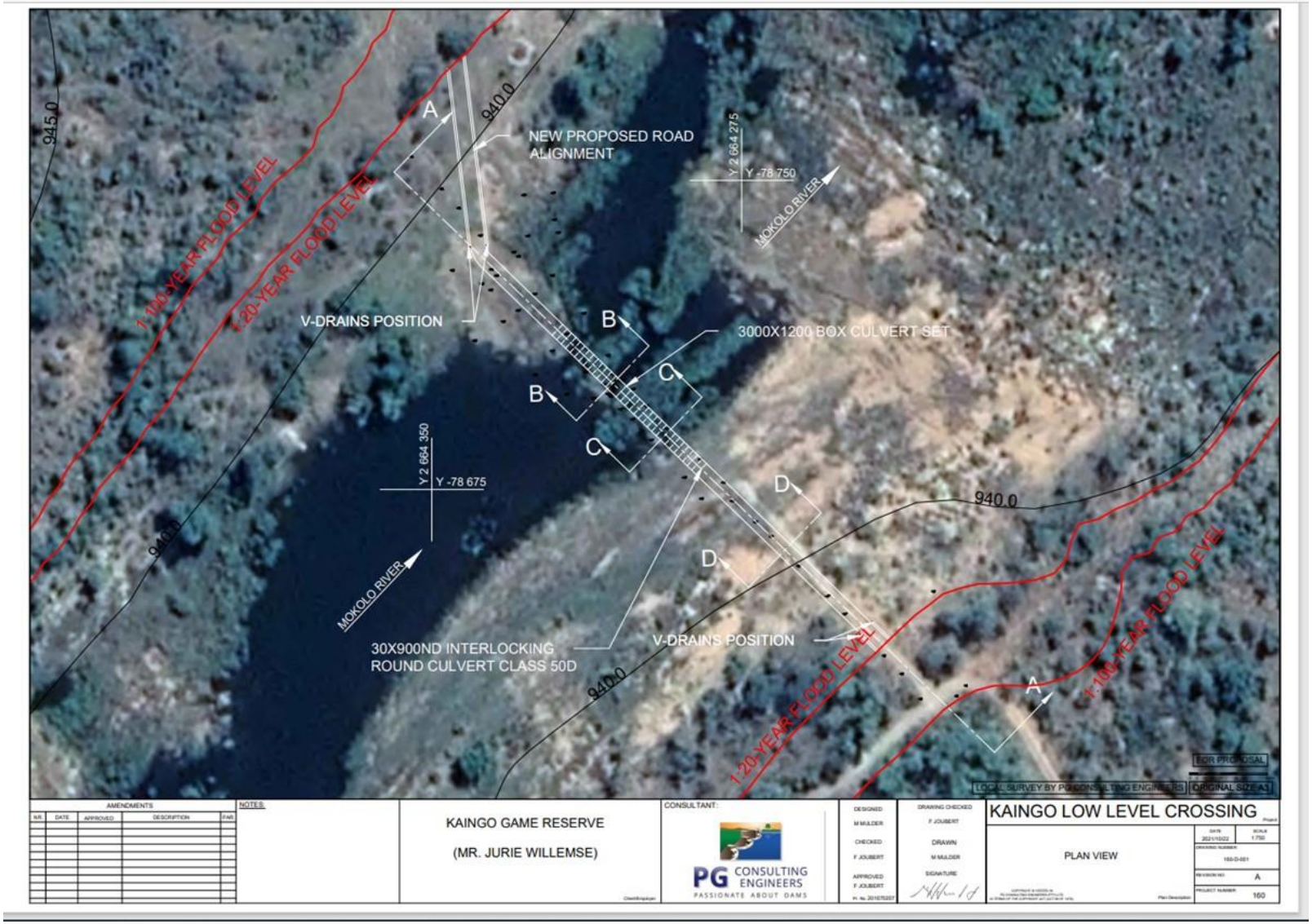


Figure 20: The proposed Kaingo low level crossing at Site 1.

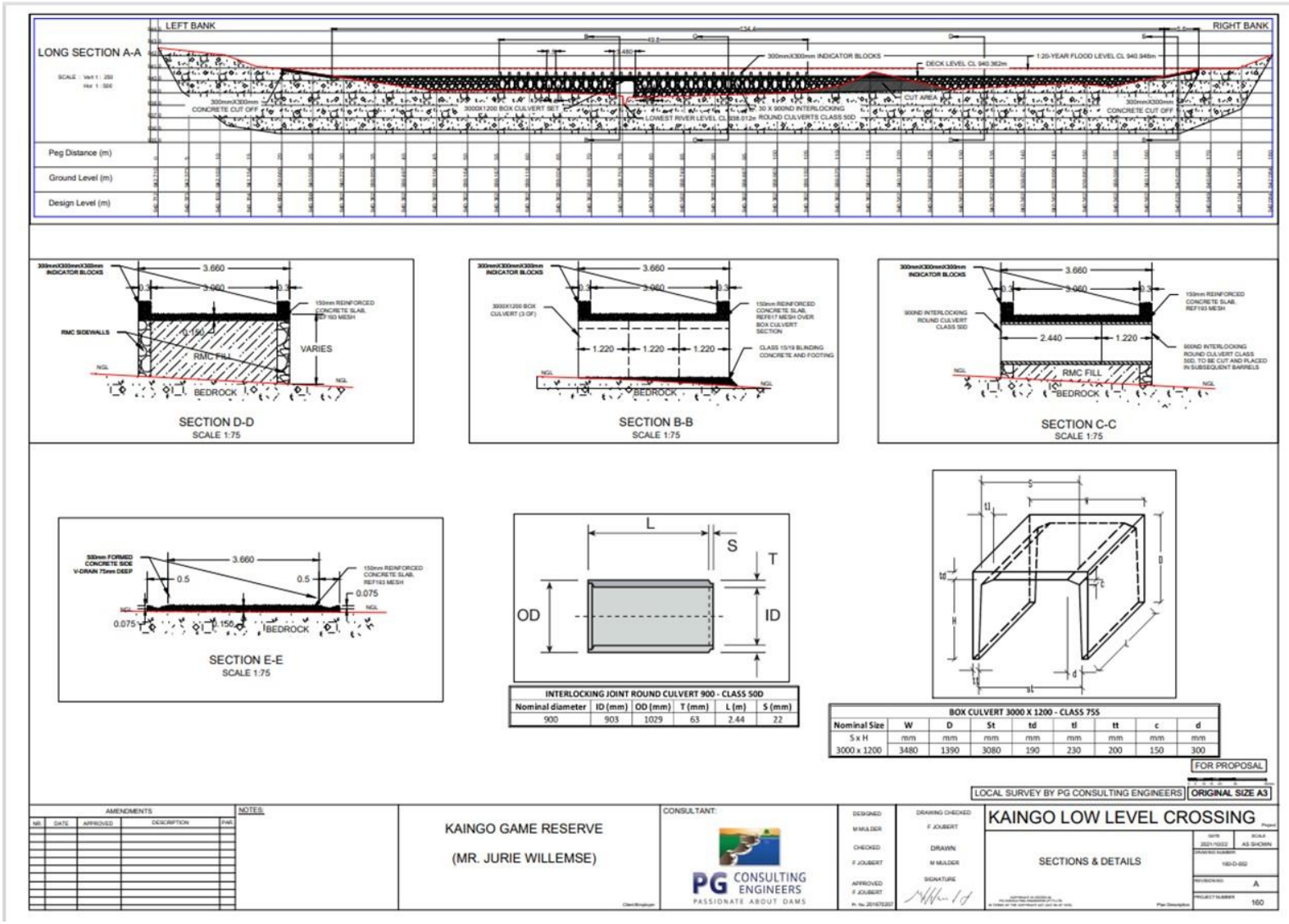


Figure 21: The sections and details of the proposed Kaingo low level crossing at Site 1.

2.5 c) Assessment of impacts – Risk Matrix (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

The risks associated with the water use/s and related activities.

The Risk Assessment was done in accordance with the Risk Matrix (Based on DWS 2015 publication: Section 21 (c) and (I) water use Risk Assessment Protocol and as contained in Appendix A in GN509 of 26 August 2016) and was carried out considering the risk rating of the project. Following is an abstract from the completed Risk Matrix to indicate the significance of the project activities on the Kaingo crossing project area:

Table 34: Following is an abstract from the Risk Assessment Matrix for the Kaingo crossing project relating to all current and expected impacts that the project had on the system, the significance of these impacts, and mitigation through control measures.

No.	Phases	Activity	Aspect	Potential Impact	Significance	Risk Rating	Confidence level	Control Measures
1	Site Establishment (Layout)	Site Establishment (Layout)	Flammable and other material stores	Potential pollution of the-instream environment.	24	Low	4	If approved, Flammable and other material stores should be established outside the riparian zone and associated ecological buffer (Figure 13).
			Bund area for fuel storage	Potential pollution of the - instream environment.	24	Low	4	If approved, Bund area for fuel storage should be established outside the riparian zone and associated ecological buffer (Figure 13). Ensure appropriate accidental spill response equipment is available on site and remediate any polluted soils immediately. It should not be necessary for the storage of any fuel on this site.
			Vehicle wash bays	Ecological disturbance (sedimentation and siltation of watercourses) and pollution (contamination of water resources) (degradation of groundwater resource)	24	Low	4	If possible, Vehicle wash bays should be established outside the riparian zone and associated ecological buffer (Figure 13).
			Sanitation/ Ablutions	The lack of nearby formal ablutions during rehabilitation can result in human excrement	24	Low	4	If approved, Sanitation/Ablutions should be established outside the riparian zone and associated ecological buffer (Figure 13). Do not locate any site toilet, sanitary convenience, septic tank or French drain within the 1:100-year flood line, or within a

				contaminating surface and groundwater.				horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland.
				Temporary ablution facilities for the construction crew have the potential to impact on surface water in the form of chemicals, pathogens and nutrients. Additional sewage requirements of construction team may have impacts on the surrounding drainage system if not managed effectively.	24	Low	4	If approved, Sanitation/Ablutions should be established outside the riparian zone and associated ecological buffer (Figure 13). The construction team can make use of a portable toilet- or mobile toilet system to quickly provide sanitation services. A major characteristic of this system is that it does not require any pre-existing services to be provided on-site, such as sewerage disposal, but are completely self-contained.
			Storage - Hazardous Substances	Potential pollution of the downstream environment.	24	Low	4	If approved, Hazardous Substances Storage should be established outside the riparian zone and associated ecological buffer (Figure 13). Hazardous substances must be stored away from the buffer areas surrounding any water bodies on site to avoid pollution. Ensure appropriate handling of hazardous substances.
			Temporary access roads	Erosion and siltation	24	Low	4	No temporary haul roads are required.
			Sand washing plant	Potential pollution and siltation of the instream environment.	24	Low	4	• Position sand washing plants on the basis of convenient location to the Work Sites as well as environmental limitations / opportunities . • Do not locate sand washing plants or associated settlement ponds within the 1:100 year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland. • Do not locate sand washing plants or associated settlement ponds within any riparian vegetation zone . • Protect the sand washing plant on the up-slope side by an earth berm or sandbag system to deflect clean surface runoff away from the plant.
			Batching plant/Cement-mixing area	Potential pollution of the instream environment.	24	Low	4	If approved, batching plant/Cement-mixing areas should be established outside the riparian zone and associated ecological buffer (Figure 13). Do not locate batching plants or associated sludge dams within the 1:100-year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland. Do not locate batching plants or associated sludge dams within any riparian vegetation zone. Protect the batching plant on the up-slope side by an

								earth berm or sandbag system to deflect clean surface runoff away from the plant. Contain the batching plant on the down-slope side by a trench and earth berm or sandbag system to control contaminated runoff and construction water emanating from within the plant.
			Laydown areas	Potential pollution of the instream environment.	24	Low	4	If approved, all laydown areas should be established outside the riparian zone and associated ecological buffer (Figure 13). Locate all storage areas and material laydown sites within predetermined zones as per the approved plan.
		Employee management	Harvesting and/or poaching	Removal of medicinal plants and/or wildlife. Incidental animal finds and deliberate acts of poaching will impact locally occurring fauna	26	Low	4	Create awareness of nature conservation designations, protected species or habitats that might be adversely affected by the works. No wild animal may under any circumstance be handled, removed or be interfered with. No wild animal may be fed on site. No wild animal may under any circumstance be hunted, snared, captured, injured or killed. This includes animals perceived to be vermin.
2	**Management**	Waste management	Handling and Collection (incl. chemical toilets)	Effluent discharges - effluent from chemical toilets	24	Low	4	If approved, Sanitation/Ablutions should be established outside the riparian zone and associated ecological buffer (Figure 13).
				Watercourse contamination	24	Low	4	If approved, all waste areas should be established outside the riparian zone and associated ecological buffer (Figure 13).
			Storage	Watercourse contamination	24	Low	4	If approved, all waste storage should be established outside the riparian zone and associated ecological buffer (Figure 13).
			Transport	Watercourse contamination	24	Low	4	If approved, all waste areas should be established outside the riparian zone and associated ecological buffer (Figure 13).
			Disposal	Watercourse contamination: Including, cement bags, epoxy packaging, food packaging, and spoil from causeway excavations, used oil from vehicle maintenance, concrete rubble, cement slurry.	24	Low	4	• Unless otherwise specified by the ECO, remove stored domestic waste to the nearest registered solid waste disposal facility. • Ensure that solid waste is transported properly, avoiding waste spills en-route. • No solid waste may be burned on site. • Where necessary, dedicate a storage area on site for the collection of construction waste.

3	**Construction**	Topsoil stripping (construction camp)	Removal of vegetation	Creating bare surfaces: Soil Erosion Vegetation removal especially down the slope, increases the probability for soil erosion.	24	Low	4	Identify and demarcate the extent of the site and associated Works Areas using danger tape with steel droppers. In sensitive environments, or where access into no-go areas takes place, then a perimeter fence must be erected around the works area, the specification of which must be adequate to address the problem. Maintain site demarcations in position until the cessation of construction works. Do not paint or mark any natural feature. Marking for surveying and other purposes must be done using pegs, beacons or rope and droppers. Identify, locate and map all plants and natural features to be protected during construction.
				Clearing vegetation can result in the loss of various plant species including those of conservation concern.	26	Low	4	Most of the area to be cleared will consist of alluvial sediment over bedrock, and in areas covered with *Cynodon* lawns. This is a common biotype in this reach of the river and is not viewed as an important biodiversity aspect. Thus, not harbouring a diversity of fauna. Any species upgraded during construction should just be released in the surrounding environment.
		Clearing/ Grubbing and Grading	Impacting riverine fauna	Loss of fauna: Small sedentary fauna can be directly affected by the disturbance footprint. Shy fauna species will be discouraged from the area by the disturbance.	26	Low	4	The construction area at site 1 has very little woody plant species present (Figure 12), the site is dominated by reeds and lawn' however, the following should be adhered to: • Minimise the area of vegetation clearance and avoid exposing soils that are vulnerable to erosion. • Identify, locate and map all plants and natural features to be protected during construction. These plants and features include, but are not limited to, Red Data Species, Protected Plants, Sensitive Communities, Riparian Vegetation, Wetlands, Drainage Lines and Aesthetically Significant Areas. • Once a site plan has been submitted and authorised by the ECO, the site layout should be clearly marked out on site by the ECO and Project manager prior to any vegetation clearing taking place in order to prevent unnecessary vegetation clearing. • Minimise the extent of the Works Site footprint as much as is possible. • The contractor will proceed with necessary vegetation clearing and/ pruning within the marked development footprint. • Demarcation is to be maintained and left in place for the duration of works. • Apart from shrubs being removed and replanted, no large tree will be removed. On the contrary, proper substrate should be placed around the roots or base of these trees to ensure their survival.
				Effects on flora/fauna biodiversity: Loss of flora: Vegetation clearance	28	Low	4	The construction area at site 1 has very little woody plant species present (Figure 12), the site is dominated by reeds and lawn' however, the following should be adhered to: • Minimise the area of vegetation clearance and avoid exposing soils

			Impacting indigenous riverine vegetation	activities can result in reduced floral diversity.			that are vulnerable to erosion. • Identify, locate and map all plants and natural features to be protected during construction. These plants and features include, but are not limited to, Red Data Species, Protected Plants, Sensitive Communities, Riparian Vegetation, Wetlands, Drainage Lines and Aesthetically Significant Areas. • Once a site plan has been submitted and authorised by the ECO, the site layout should be clearly marked out on site by the ECO and Project manager prior to any vegetation clearing taking place in order to prevent unnecessary vegetation clearing. • Minimise the extent of the Works Site footprint as much as is possible. • The contractor will proceed with necessary vegetation clearing and/ pruning within the marked development footprint. • Demarcation is to be maintained and left in place for the duration of works. • Apart from shrubs being removed and replanted, no large tree will be removed. On the contrary, proper substrate should be placed around the roots or base of these trees to ensure their survival.
				Habitat loss: Removal of vegetation and trenching can result in functional losses of the wetland.	24	Low	4	Most of the area to be cleared will consist of alluvial sediment over bedrock, and in areas covered with *Cynodon* lawns. This is a common biotype in this reach of the river and is not viewed as an important biodiversity aspect.
			Clearing of exposed bedrock and sand shoal up to 3m on both sides of the crossing alignment	Sedimentation of watercourse: Siltation: Erosion & soil export within the trench can result in siltation of the receiving watercourse and concurrent deterioration in water quality	26	Low	4	Construction should take place during the low rainfall season; then very little flow passes through the construction area. Mitigation and management measures are to be specified in order to ensure that areas susceptible to potential erosion are protected both during the construction and operational phase of the bridge and associated infrastructure. The contractor is to comply with the EMPr requirements regarding erosion prevention. Emergency erosion protection materials (sandbags, geotextile fabric, shade cloth and/or biddum) are to be kept on site to treat erosion area as soon as it appears.
			Rehabilitation.	Unrehabilitated areas will in essence jeopardise the integrity of the riverine habitat. Redundant structures and material will impact on aesthetics of the site, hazard to fauna, cover and prevent natural vegetation cover and rehabilitation.	24	Low	4	Following the completion of any works, the water user must ensure that all disturbed areas are: (i) cleared of construction debris and other blockages; (iii) reshaped to free -draining and non -erosive contours, and (iv) re-vegetated with indigenous and endemic vegetation suitable to the area.
			A 3m working servitude on either side of the crossing, will be	Approximately 804 sqm of stream bed habitat to be	28	Low	4	The working servitude should be rehabilitated on completion of the work.

			added for construction traffic and related activities.	impacted by a temporary road.				
			De-watering of excavations	Water siltation and contamination. Local erosion; impact on subsurface flows; impact on downstream habitats.	28	Low	4	Construction should take place during the dry season when very little de-watering will be necessary.
			Alien invasive plant recruitment	The removal of indigenous wetland species predisposes the disturbance footprint to alien plant invasion. Competing with indigenous plant species and further transform the natural habitat.	47,25	Low	3	Control exotics and invasive plants to be eradicated. Following the completion of any works, the water user must ensure that all disturbed areas are: (i) cleared of alien invasive vegetation; (ii) re-vegetated with indigenous and endemic vegetation suitable to the area. Control involves killing the plants present, killing the seedlings which emerge, and establishing and managing an alternative plant cover to limit re-growth and re-invasion. Dispose of the eradicated plant material at an approved solid waste disposal site. Rehabilitate all identified areas as soon as practically possible, utilising specified methods and species. Chemical eradication: Ensure that only properly trained people handle and make use of chemicals. Follow manufacturer's instruction when using chemical methods, especially in terms of quantities, time of application etc. Monitor all sites disturbed by construction activities for colonisation by exotics or invasive plants and control these as they emerge. Introducing alien fish species must be prohibited.
		River Diversion	Using construction works, e.g., RMC sidewalls	The constructing of a coffer dam. Coffer dams have the potential to permanently change the flow dynamics in a river, exacerbating scour and enhancing sedimentation. Both of these changes can impact negatively on the aquatic ecosystem.	28	Low	4	Construction should take place during the low rainfall season; then very little flow passes through the construction area. If the constructed works are not adequate for river diversion, sand bags can be used to construct a temporary working platform. Ensure that pump outfalls and outfalls from any temporary treatment do not cause or generate erosion of land, banks or beds. Removal of the cofferdam is planned and executed with the same degree of care as its installation, on a stage-by-stage basis.

			Using imported aggregate	Sedimentation of watercourse	26	Low	4	Filter fabric fence: Sediment is filtered out as runoff flows through the fabric. Such fences should be used only where there is sheet flow (i.e., no concentrated flow). Filter fabric fences have a useful life of approximately 6 to 12 months.
		Drilling	Man hand-held drilling equipment and portable generator	Noise generation - Fauna avoidance. The presence and associated noise of the rehabilitation team has the potential to cause fauna & avifauna to avoid the area.	40,5	Low	4	Noise /vibration to be mitigated by correct, modern, well serviced and silenced equipment use. For certain fish and birds, temporary works causing disturbance and stress may result in species seeking habitats elsewhere, thereby temporarily or permanently reducing the biodiversity of the reach.
				Dust generation	27	Low	4	Limit the production of dust and damage caused by dust through regular watering of the work areas.
				Causing spills	26	Low	4	Clean any accidental spills immediately, treating the spilled material and used cleaning products as hazardous waste.
			Chemically anchor steel rebar to exposed bedrock	Watercourse contamination	24	Low	4	Clean any contaminants immediately, treating the material as hazardous waste.
				Waste arisings (packaging)	24	Low	4	Unless otherwise specified by the EO / ECO, remove stored domestic waste to the nearest registered solid waste disposal facility.
		Position pre-cast portal culvert and stormwater pipe barrel sets	Driving vehicles in watercourse	Watercourse contamination: Potential sources of pollution; run-off of contaminated water from vehicle activity during construction (Fuels and oils).	24	Low	4	Vehicles used during construction must have the minimum impact on the environment or other road users. The size, height and weight of the vehicle must be kept in mind. Regularly check vehicles, machinery and equipment operating on site to ensure that none have leaks or cause spills of oil, diesel, grease or hydraulic fluid. No vehicles, machinery or equipment with leaks or causing spills may be allowed to operate on the construction site. These must be sent to the maintenance yard or workshop for repair or must be removed from site. Ensure that the maintenance of all vehicles and equipment, including oil and lubricant changes, takes place only within properly equipped, bunded maintenance areas or workshops as indicated on the ESM&R Plan. Vehicles may not leave the designated roads and tracks and turnaround points will be limited to specific sites. Only the necessary vehicles are permitted along the new route.

			Oil spill or hydraulic leaks	Poor water quality or presence of contaminants impacting on aquatic biota at the site and in the downstream reach.	24	Low	4	Sites of oiling and refuelling points to be located away from rivers, surface water sewers or other watercourses. Underlay heavy duty maintenance areas and workshops with a concrete slab, enclosed within a bund, which drains into a conservancy tank.
		Sourcing materials (aggregate)	Use of natural resources:	The collection and removal of rocks, stones, grit, sand or gravel from the riverine environment will impact on the habitat composition of the local ecosystem.	29,25	Low	4	The bulk of the RMC will be from building rubble specified by the owner, this will be transported in. The outer RMC walls will be from rock sourced on the farm, not necessarily from a single borrow pit. Do not disturb, deface, destroy or remove plants or natural features, whether fenced or not, for the duration of the Contractor's presence on site, unless otherwise specified by the EO / ECO. Refrain from removing any natural material or structures from the riverine environment, such as rocks, stones, grit, sand, gravel, dead trees or tree trunks. These components act as natural habitat for the ecosystem after the completion of the project.
			Mining sand from the riverbed	Removing sand and associated subterranean habitat. Mine sand from within the river near the right bank for making the Rubble Masonry Concrete (RMC) structure. The structure will require 82m³ which will be sourced from the sand shoal on the right bank of the river.	33,75	Low	4	An area has been identified on the right bank at the Site 1 crossing, where abundant alluvial sand has been deposited with some sand banks secured by grazing lawns for the mining of sand. The habitat consists of unstable alluvial sediments that is removed and replaced with alluvium during floods or higher flows. Should this sand be used for construction, it will be replenished with the next flood event. More stable gras covered embankment should be left as well as areas where woody vegetation (trees and shrubs) occur.
				Alter surface water hydrology	24	Low	4	Access through riparian vegetation to sand borrow areas must be constructed perpendicular to the drainage line.
				Sedimentation of watercourse	26	Low	4	During the first high flows the mined area will be inundated and there will be some siltation downstream.
		Water abstraction and use	Pumping from the river	Use of natural resources. Total expected volume of water required for mixing concrete	24	Low	4	

			Washing sand: River sand typically is clean enough to be used as is. The contractor only needs to remove any organic material (weeds, roots, etc.)	Surface water run-off	24	Low	4	Position sand washing plants on the basis of convenient location to the Work Sites as well as environmental limitations / opportunities. Do not locate sand washing plants or associated settlement ponds within the 1:100-year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland. Do not locate sand washing plants or associated settlement ponds within any riparian vegetation zone. Protect the sand washing plant on the up-slope side by an earth berm or sandbag system to deflect clean surface runoff away from the plant. Contain the sand washing plant on the down-slope side by a trench and earth berm or sandbag system to control contaminated runoff and construction water emanating from within the plant. Collect all construction water and contaminated runoff emanating from within the sand washing plant and contain within a closed settlement pond system.
			Mixing with cement	Effluent (cement slurry) discharges	24	Low	4	Do not locate batching plants or associated sludge dams within the 1:100-year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland.
				Watercourse contamination	24	Low	4	Collect all construction water and contaminated runoff emanating from within the batching plant (and associated wash bays) and contain within a sludge dam for later disposal in the appropriate manner.
		Mixing concrete	Mixing on site	Land contamination	24	Low	4	Carefully control all on-site operations that involve the use of cement and concrete (this applies to areas other than the batching plant). Implement Best Practice procedures to address all other pollution-related aspects.
				Watercourse contamination	24	Low	4	• Do not locate batching plants or associated sludge dams within the 1:100-year flood line, or within a horizontal distance of 100m (whichever is greater) of a watercourse, drainage line or identified wetland. Limit cement and concrete mixing to single sites where possible. • Use plastic trays or liners when mixing cement and concrete: Do not mix cement and concrete directly on the ground. • Dispose of all visible remains of excess cement and concrete after the completion of tasks. Dispose of in the approved manner (solid waste concrete may be treated as inert construction rubble, but wet cement and liquid slurry, as well as cement powder must be treated as hazardous waste).
			Casting flooding indicator blocks: We have made allowance for starter bars to be	Watercourse contamination	24	Low	4	• Contain water and slurry from cement and concrete mixing operations as well as from batching area wash bays. Direct such waste water into a settlement pond or sludge dam for later disposal. • Do not allow the washing of trucks delivering concrete anywhere but within

			cast with the deck slab, so that the blocks may be cast in place.					designated wash bays equipped with runoff containment. Direct such waste water into a settlement pond or sludge dam for later disposal.
			Importing Ready mix/Cleaning the cement trucks	Watercourse contamination	24	Low	4	Do not allow the washing of trucks delivering concrete anywhere but within designated wash bays equipped with runoff containment. Direct such waste water into a settlement pond or sludge dam for later disposal.
				Waste arisings (cement slurry)	24	Low	4	Spills: • Immediately clean any accidental oil or fuel spills or leakages. • Do not hose oil or fuel spills into a storm water drain or sewer, or into the surrounding natural environment.
		Placing Concrete	Placing Concrete	Watercourse contamination	24	Low	4	Carefully control all on-site operations that involve the use of cement and concrete (this applies to areas other than the batching plant). Limit cement and concrete mixing to single sites where possible. Use plastic trays or liners when mixing cement and concrete: Do not mix cement and concrete directly on the ground. Dispose of all visible remains of excess cement and concrete after the completion of tasks. Dispose of in the approved manner (solid waste concrete may be treated as inert construction rubble, but wet cement and liquid slurry, as well as cement powder must be treated as hazardous waste).
		Earthworks	Excavate causeway approaches	Fragmentation of the riparian corridor: Removing large terrestrial and riparian trees will lead to fragmentation, which impacts on riparian habitat and also affecting natural corridors and buffers.	24	Low	4	Do not remove any large tree without the permission of the EO / ECO. In all areas mark trees earmarked for removal prior to felling for approval by the EO / ECO. No open fires are permitted under trees. No material storage or laydown is permitted under trees. None of the observed trees at the crossing were within the proposed development footprint. No riparian vegetation will be affected by the ingress and egress of the proposed crossing as there are existing roads.
				Disturb borrowing animals	24	Low	4	No temporary haul roads are required.
				Alter surface water hydrology: Roads and tracks can have a significant impact on ecosystems, particularly in terms of erosion and	24	Low	4	• Make use of existing roads and tracks where feasible, rather than creating new routes. • Ensure that adequate vehicle turning areas are allowed for. • Where construction will obstruct existing access, be sure to allow for alternative temporary access routes.

				sedimentation of local drainage channels and watercourse crossings.				• In general, construction routes should not be wider that 3m in sensitive areas, with passing bays where two-way traffic is required. · Routes should not traverse slopes with gradients in excess of 8%. Where this is unavoidable, stabilise the road surface.
		Construction Plant Management - Operation and movement of vehicles & equipment on land and in the watercourse	Operating equipment	Causing spills	24	Low	4	Regularly check vehicles, machinery and equipment operating on site to ensure that none have leaks or cause spills of oil, diesel, grease or hydraulic fluid. No vehicles, machinery or equipment with leaks or causing spills may be allowed to operate on the construction site. These must be sent to the maintenance yard or workshop for repair or must be removed from site.
			Parking	Causing spills	24	Low	4	Where oil and fuel spills are expected, parking is to be on an impervious surface with adequate pollution control mechanisms in place.
			Maintenance	Watercourse contamination	24	Low	4	Ensure that the maintenance of all vehicles and equipment, including oil and lubricant changes, takes place only within properly equipped, bunded maintenance areas or workshops as indicated on the Plan.
			Washing plant	Watercourse contamination	24	Low	4	Collect all construction water and contaminated runoff emanating from within the sand washing plant and contain within a closed settlement pond system. Filtered water from the settlement pond may be liberated into the environment in an appropriate manner.
		Constructing the bridge structures	Placement of infrastructure.	Changes to natural drainage patterns may be created by the construction and placement of infrastructure. This might lead to soil erosion; loss of topsoil and deterioration of soil quality are the main potential impacts that could be caused during the construction of the bridge.	46,75	Low	3	Areas requiring erosion control mechanisms to be identified by the ECO. Instructions to be given to the contractor as required. Where access through drainage lines and riparian zones is unavoidable, only one road is permitted, constructed perpendicular to the drainage line. Avoid roads that follow drainage lines within the floodplain. • Where drifts/crossings are built through rivers, ensure that Reserve releases (i.e. for sustained downstream ecological requirements and basic human needs) are catered for and that no damming-up is experienced. • Maintain all access routes and roads adequately in order to minimise erosion and undue surface damage. Repair rutting and potholing and maintain stormwater control mechanisms. • Adequate culverts are required as to have a minimal impact on water flow patterns through the drainage line. • Ensure that causeways/crossings result in minimal disruption to flow patterns, both upstream and downstream of the crossing, and do not cause damming of the water at the crossing. • Runoff from roads must be managed to avoid erosion and pollution problems.

								• Regularly remove topsoil (and other material) accumulated in side drains of roadways to keep these open and functional. • Clear up any gravel or cement spillage on roads.
	Operation	The bridge in place	Debris and sediment accumulation	Debris and sediment accumulation at the upstream end of the structure could be impacting on the in-stream habitat and fish migrational routes.	28	Low	3	Debris should be removed by the reserve management and continue the maintenance procedure to ensure proper operation of the bridge and proper connectivity for migrating aquatic species.
			Potential flood risks.	Alterations to local flow patterns due to the structure could cause induced or accelerated bed and bank erosion, sediment deposition or increased flood risk.	42	Low	3	The bridge structure is deemed a sound structure. Regional maximum flood and recommended safety evaluation flood data was considered.
			Structure restricting flows.	Damming and flooding upstream; impact on normal hydraulic regime.	47,25	Low	3	It was agreed that the crossing will be a low-level crossing which will only accommodate low flows while still providing access across. High flows will inundate the crossing structure which will render the crossing inaccessible during major flood events, usually over a short period of time. The weir will assist with a smooth flow regime to be expected at the crossing. The position with regard to the river's alignment at that section makes it lucrative and feasible in respect of hydraulic flow conditions. the proposed low-level crossing will consist of a rubble masonry concrete (RMC) structure with integrated concrete storm water pipes and a precast portal culvert at the critical river flow section.
			Fish migration	Disruption and preventing the free passage of fish and aquatic animals.	47,25	Low	3	A 3000mm x 1200mm precast concrete portal culvert is proposed for the crossing at the river's low flow section. Refer to Photo 2 above. This will assist in an unobscured flow regime at the low flow critical section in the river, thus not allowing any damming /containment of water at the crossing structure.
			Impacts on the riverine ecology in the project area.	Degradation of core riverine habitats.	47,25	Low	3	Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Standard management measures should be implemented to ensure that any on-going activities do not result in a decline in water resource quality. Introduce a buffer zone to protect the water course. While determining the area and distribution of a core habitat is important, it is

								equally important that appropriate management measures be determined to ensure the core habitat continues to function effectively. Biodiversity conservation management measures that need to be taken into consideration when determining management measures for core habitats and corridors include: • Habitat and species management; • Alien and invasive species management; • Fire management; • Grazing management; and • The management of soil erosion and physical disturbances.
		Access roads	Run-off from roads to the river crossing	Erosion, sedimentation and siltation in the river.	24	Low	4	Access roads are to be monitored and managed for erosion prevention. No off-road driving into drainage lines or watercourses will be permitted. Cut-off drains prevent road run-off from entering the watercourse.

2.5 d) The Impact Mitigation Hierarchy

- Firstly, alternatives must be investigated to avoid negative impacts altogether.
- Secondly, after it has been found that the negative impacts cannot be avoided, alternatives must be investigated to reduce (mitigate and manage) unavoidable negative impacts to acceptable limits.
- Thirdly, alternatives must be investigated to remediate (rehabilitate and restore).
- Fourthly, unavoidable impact that remain after mitigation and remediation must be compensated for through investigating options to offset the negative impacts.
- While throughout, alternatives must be investigated to optimise positive impact.

2.5.1 to 2.5.6 Impact Assessment Aspects

Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions (2.5.1 to 2.5.6 below):

2.5.1 Maintaining the priority aquatic ecosystem.

Question: Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?

A: Yes, no significant adverse impact has been predicted during the study and impact assessment that could jeopardise the surrounding environment.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)
    - Aquatic habitat assessment (Section 2.3.1a)
    - Aquatic invertebrate assessment (Section 2.3.1b)
    - Fish Response Assessment (Section 2.3.1b)
    - Ecostatus (Section 2.3)
- Impact assessment (Section 2.5)

2.5.2 Maintaining the resource quality objectives.

Question: Is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?

A: Yes, judging from the RQO (Section 2.3.4.2) and the results of the ecological section of the report (Section 2.3), none the biological aspects will not be influenced should the mitigation proposed for the project is adhered to. Water quality and flows will also be unchanged by the construction and operational phases as supported by the Risk Assessment (Section 2.5).

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)
- Resource quality objectives (Section 2.3.4.2)

- Impact assessment (Section 2.5)

2.5.3 Impact on fixed and dynamic ecological processes.

Question: How will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include:

a. Impacts on hydrological functioning.

Impact: Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g., suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes);

A: Due to amount of water allowed to pass through the bridge structure and the low level of the structure (Figure 20), no damming behind the bridge is expected to impair any ecological processes, no matter the period of inundation.

Reference:

- Impact assessment (Section 2.5)

b. Sediment regime.

Impact: Will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g., sand movement, meandering river mouth or estuary, flooding or sedimentation patterns);

A: The bedrock control that will be used to support the bridge structure, created a damming effect that resulted in a large upstream pool (Figure 20). Scouring due to the upstream weir moved most of the sediment through the system, however alluvial habitats are abundant in the vicinity of the proposed bridge.

Sediment to be taken from the upstream area (Section 2.2; Figure 3d) will soon be replaced by new sediment, but a substantial increase is not expected.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)
- Impact assessment (Section 2.5)

c. Modification in relation to the overall aquatic ecosystem.

Impact: What will the extent of the modification in relation to the overall aquatic ecosystem be (e.g., at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.)?

A: No modification is expected. The area downstream of the proposed weir consists of bedrock channels through an extensive bedrock control, and downstream of the control, an extensive reed “swamp” covers the river for nearly 400m. Any water or sediment flowing through the rocky control will be absorbed and buffered by this inundated reedy section (Figure 12).

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

d. Risks associated with water uses.

Impact: To what extent will the risks associated with water uses and related activities change?

A: It has already been established that the development will not impact on any of the river users due to the project. The low-level bridge will be confined to a single, consolidate Private Nature Reserve for the benefit of the Management Authority during its day-to-day operations or management of the Nature Reserve. As such the activity does not affect or impact any broader societal needs, communities or economies (Ecoleges Environmental Consultants, 2021).

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

2.5.4 Impact on the functioning of the aquatic feature stated

Question: How will the proposed development impact on the functioning of the aquatic feature? This must include:

a. Base flows.

Impact: On base flows (e.g., too little or too much water in terms of characteristics and requirements of the system).

A: The possible interference of the bridge structure will not impact on base flows since all of the flows will flow through to the downstream area as prescribed by the RQO (Section 2.3.4.2). A 3000mm x 1200mm precast concrete portal culvert is proposed for the crossing at the river's low flow section. This will assist in an unobscured flow regime at the low flow critical section in the river, thus not allowing any damming / containment of water at the crossing structure.

Reference:

- Resource quality objectives (Section 2.3.4.2)
- Impact assessment (Section 2.5)

b. Quantity of water.

Impact: The quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g., seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river).

A: The possible interference of the bridge structure will not impact on the hydrological regime or hydroperiod of the aquatic ecosystem since all of the flows will flow through to the downstream area as prescribed by the RQO (Section 2.3.4.2).

Reference:

- Resource quality objectives (Section 2.3.4.2)
- Impact assessment (Section 2.5)

c. Change in the hydrogeomorphic typing.

Impact: The change in the hydrogeomorphic typing of the aquatic ecosystem (e.g., change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland).

A: The possible influence of the bridge structure will not impact on the hydrogeomorphic typing of the aquatic ecosystem since all of the flows will be channelled through to the downstream area as channelled valley-bottom wetland as expected.

Reference:

- Provincial priority status (Section 2.3.3)

d. Quality of water.

Impact: The quality of water (e.g., due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication);

A: The possible influence of the construction and operation of the bridge structure will not have an adverse impact on the quality of water in the river system as it let through the same quality of water received from the upstream area.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

e. Ecological connectivity.

Impact: The fragmentation (e.g., road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal).

A: The 3000mm x 1200mm precast concrete portal culvert and a set of 30 stormwater pipe barrels are proposed to cater for the required design flood as described in the concept design report (PG Consulting Engineers, 2021). This concept will allow any aquatic species to migrate past the bridge. No damming of water will create a habitat that will create any obstruction that will jeopardise the connectivity of the crossing area.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

f. Loss or degradation of all or part of any unique or important features.

Impact: The loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g., waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);

A: There will be no loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem since the bridge will be constructed on a bedrock control, one of many in this river reach, and which is not a sensitive or special habitat for the Mokolo River.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

2.5.5 Impact on key ecosystems regulating and supporting services especially:

Question: How will the proposed development impact on key ecosystems regulating and supporting services especially:

(a) Flood attenuation: The bridge deck will be at CL 940.362masl which is approximately 0.58m lower than the 1:20-year expected flood level. The adopted design flood has been upgraded to accommodate the same discharge capacity as the upstream district road crossing. A 3000mm x 1200mm precast concrete portal culvert is proposed for the crossing at the river's low flow section. This will assist in an unobscured flow regime at the low flow critical section in the river, thus not allowing any damming / containment of water at the crossing structure.

Reference:

- Impact assessment (Section 2.5)

(b) Streamflow regulation: No streamflow regulation will take place when the structure is in place. If the construction takes place during low flow, no coffer dam will be required, perhaps 'n few sand bags to keep water out (Table 34).

Reference:

- Impact assessment (Section 2.5)

(c) Sediment trapping: The fact that the bedrock control trapped small amounts of sediment before the construction, it is expected that the unobscured flow regime will also not create a different situation.

Reference:

- Impact assessment (Section 2.5)

(d) Phosphate assimilation: There is no reason to believe that the construction or presence of the crossing will have an impact on any water quality parameter in the river reach.

(e) Nitrate assimilation: There is no reason to believe that the construction or presence of the crossing will have an impact on any water quality parameter in the river reach.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

(f) Toxicant assimilation: There is no reason to believe that the construction or presence of the crossing will have an impact on any water quality parameter in the river reach.

Reference:

- Aquatic biodiversity and ecosystems (Section 2.3.1)

(g) Erosion control: The solid rock bed across the river with channels carving through a 90m bedrock-dominated section, and then flow in a dense reed-covered reedbed 'swamp', renders erosion of the riverbed unlikely. Any erosion originating from the causeway approaches will be managed by the reserve management that will use the bridge almost daily.

Reference:

- Impact assessment (Section 2.5)

(h) Carbon storage: By not interfering with any plant cover and not impacting on the extensive reedbed areas around the project area, will keep the carbon levels similar to before the construction. The fact that the bridge will assist in periods of higher flows to create shortcuts for vehicles when the transport does not have to take the longer route, will prevent some fuel burning.

Reference:

- Preferred site (Section 2.2)

2.5.6 How will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?

A: There is no reason to believe that the proposed development will impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site.

The low-level bridge will be constructed mostly on bedrock, no trees will be removed and the longitudinal stream connectivity will ensure proper passage for migrating aquatic species.

2.6. In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered.

A: Not applicable to this project.

2.7 Need & Desirability (not listed as part of the Aquatic Biodiversity Protocol**)**

According to Regulation 13(1)(b) and 13(1)(e) read together with Regulation 18 of the amended EIA Regulations, 2014, Specialists must have knowledge of any guidelines that have relevance to the proposed activity and have regard to the need for and desirability of the undertaking of the proposed activity.

Need and Desirability**:**

- The proposed development entails the construction of a low water bridge to ensure year-round access to a recently acquired property on the opposite bank of the Mokolo River.

- The low-level bridge will be confined to a single, consolidate Private Nature Reserve for the benefit of the Management Authority during its day-to-day operations or management of the Nature Reserve.

- Game Reserve management and eco-tourism activities are hampered during rainy seasons. There is currently one existing dirt and gravel crossing that is only accessible during the dry winter months of the year. During high flows, access across the Mokolo River sand bed is not possible.

- For the remainder of the year, access to the neighbouring property would entail an extended round trip between the reserves.

- By constructing a dedicated low-level crossing, the Game Reserve operations will be greatly improved as a low water bridge will ensure year-round connectivity between both properties.

The aim of EIA process is to find that (reasonable and feasible) alternative that will ensure sustainable development. Consistent with the aforesaid aim and purpose of EIA, the concept of "need and desirability" relates to, amongst others, the nature, scale and location of development being proposed, as well as the wise use of land.

Following is list identified as a guideline for the Need and Desirability section that is applicable to the Aquatic Biodiversity theme and which require further information.

Questions to be engaged with when considering need and desirability:

"securing ecological sustainable development and use of natural resources"

1. How will this development (and its separate elements/aspects) impact on the ecological integrity of the area?

1.1. How were the following ecological integrity considerations taken into account?:

1.1.1. Threatened Ecosystems,

1.1.2. Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure,

1.1.3. Critical Biodiversity Areas ("CBAs") and Ecological Support Areas ("ESAs"),

1.1.4. Conservation targets,

1.1.5. Ecological drivers of the ecosystem,

1.1.6. Environmental Management Framework,

1.1.7. Spatial Development Framework, and

1.1.8. Global and international responsibilities relating to the environment (e.g., RAMSAR sites, Climate Change, etc.).

Answer: The Mokolo River itself is a FEPA river with the associated sensitivities of a vulnerable riverine ecosystem. The project foot print will be the approximate 180 m linear construction that will not impact on the flow passage, riparian vegetation or river morphology in such a way that it will alter the ecological functioning of the river.

The Kaingo project area is an established protected area, thus according to the BGIS Critical Biodiversity Areas map it is a Critical Biodiversity Area 1 with patches of Ecological Support Area 2 adjacent to the river. The Mokolo River itself is a FEPA river.

Due to this sensitivity of the project area, all possible impacts were assessed and control measures have been proposed to mitigate all risks to a "Low" level.

The fact that the bridge will consolidate two Private Nature Reserves for the benefit of the Management Authority during its day-to-day operations or management of the Nature Reserve, is reason enough to acknowledge its importance as a Conservation benefit.

Minimum Requirements for Specialist Assessments (see below)

The protocol for the specialist assessment and minimum report content requirements for environmental impacts on aquatic biodiversity.

This protocol provides the criteria for the specialist assessment and minimum report content requirements for impacts on aquatic biodiversity for activities requiring environmental authorisation.

Table 35:	Specialist reports Checklist
	Requirements for Specialist Reports: Published in Government Notice No. 320; Government Gazette 43110**;** 20 March 2020
2.7	The findings of the specialist assessment must be written up in an **Aquatic Biodiversity Specialist Assessment Report** that contains, as a minimum, the following information:
2.7.1	contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;
2.7.2.	a signed statement of independence by the specialist;
2.7.3.	a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;
2.7.4.	the methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;
2.7.5.	a description of the assumptions made any uncertainties or gaps in knowledge or data;
2.7.6.	the location of areas not suitable for development, which are to be avoided during construction and operation, where relevant;
2.7.7.	additional environmental impacts expected from the proposed development;
2.7.8.	any direct, indirect and cumulative impacts of the proposed development on site;
2.7.9.	the degree to which impacts and risks can be mitigated;
2.7.10.	the degree to which the impacts and risks can be reversed;
2.7.11.	the degree to which the impacts and risks can cause loss of irreplaceable resources;
2.7.12.	a suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies;
2.7.13	. proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr);
2.7.14.	a motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a “low” aquatic biodiversity sensitivity and that were not considered appropriate;
2.7.15	. a substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not; and
2.7.16.	any conditions to which this statement is subjected.

2.7 Aquatic Biodiversity Specialist Assessment Report

The findings of the specialist assessment must be written up in an Aquatic Biodiversity Specialist Assessment Report that contains, as a minimum, the information summarised in Table 35.

The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.

For detail of the Registered Specialist, see Section 2.1.

2.7.1 Details of the Specialist

2.7.1.1 Contact details of the specialist:

Dr Andrew Deacon
Cell: 082 325 5583
Email: andrew@nethog.co.za
PO Box 784, Malalane, 1320

Registered with the South African Council for Natural Scientific Professions (SACNASP). Registration number: 116951

2.7.1.2 Field of expertise: Freshwater Ecologist

2.7.1.3 Curriculum vitae

Dr Andrew Deacon (PhD Zoology) worked as a researcher at Scientific Services, South African National Parks (SANParks, 1989 - 2012). He was initially employed as an Aquatic ecologist to coordinate the multidisciplinary KNP Rivers Research Programme, but later was tasked to manage the monitoring and research programmes for small vertebrate ecology in 15 South African National Parks (including Addo-, Kalahari- and Kruger NP).

As a recognised scientist in the fields of Ichthyology and Terrestrial Ecology, he is currently engaged as a specialist consultant regarding ecological studies. He was involved in numerous research programmes and projects and produced EIA specialist reports (aquatic or terrestrial ecology) for 82 projects. Additionally, he also participated in Aquatic ecosystem projects, Environmental Water Requirement Studies and Faunal and ecosystems monitoring projects.

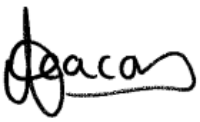
Apart from multiple environmental projects in South Africa, he has worked on assignments in the Democratic Republic of the Congo, Zambia, Mozambique, Zimbabwe, Namibia and Swaziland. He completed: Wetland Introduction and Delineation Course – Centre for Environmental Management: University of the Free State. He is a registered Professional Natural Scientist (Pr. Sci. Nat.) in the fields of Ecological Science (Reg. no. 116951).

2.7.2 A signed statement of independence by the specialist (corresponding with Item 2.7.2 in the protocol for the specialist assessment and minimum report content requirements – see Table 35)

DECLARATION

I, Andrew Richard Deacon, declare that I –

- act as an independent specialist consultant in the field of ecological science;
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.



ANDREW RICHARD DEACON

2.7.3 A statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment.

This section corresponds with Item 2.7.3 in the protocol for the specialist assessment and minimum report content requirements (see Table 35)

The field work has taken place over a period of three days from 1 to 3 November 2021 on Mokolo River in the Kaingo Private Nature Reserve. The season corresponds with early summer when the riparian zone vegetation starts to form new leaves and is in full bloom, enabling identification during riparian surveys.

Since seasonal changes do not influence the presence of aquatic fauna (fish and macro-invertebrates) significantly, aquatic surveys are not directed by seasonality. The ability to survey rivers safely when the water levels are low, is paramount for instream surveys, especially where crocodiles and hippos are present.

Apart from a few scattered rain events, the wet season has not started yet, therefore the river was still in low flow, exposing the various habitats in both the aquatic and riparian zones. This condition renders habitat in the riverine area very accessible for riparian and aquatic surveys.

2.7.4 Methodology

The methodology used to undertake the site inspection and the specialist assessment, (including equipment and modelling used, where relevant), are described in the following section.

2.7.4.1 Screening Report

The National Web based Environmental Screening Tool is a geographically based web-enabled application which allows a proponent intending to submit an application for environmental authorisation in terms of the Environmental Impact Assessment (EIA) Regulations 2014, as amended to screen their proposed site for any environmental sensitivity.

The Screening Tool also provides site specific EIA process and review information, for example, the Screening Tool may identify if an industrial development zone, minimum information requirement, Environmental Management Framework or bio-regional plan applies to a specific area.

Finally, the Screening Tool allows for the generating of a Screening Report referred to in Regulation 16(1)(v) of the Environmental Impact Assessment Regulations 2014, as amended whereby a Screening Report is required to accompany any application for Environmental Authorisation and as such the tool has been developed in a manner that is user friendly and no specific software or specialised GIS skills are required to operate this system.

A screening report was done for an environmental authorization or for a part two amendment of an environmental authorisation as required by the 2014 EIA regulations, evaluating the proposed development footprint for environmental sensitivity.

2.7.4.2 Site Sensitivity Verification Report

2.7.4.2.1 The site sensitivity verification must be undertaken by an environmental assessment practitioner or a specialist (Protocol 2.1).

2.7.4.2.2 The site sensitivity verification must be undertaken through the use of (Protocol 2.2):

(a) a desk top analysis, using satellite imagery;

(b) a preliminary on-site inspection; and

(c) any other available and relevant information.

2.7.4.2.3 The outcome of the site sensitivity verification must be recorded in the form of a report that (Protocol 2.3):

(a) confirms or disputes the current use of the land and the environmental sensitivity as identified by the screening tool, such as new developments or infrastructure, the change in vegetation cover or status etc.;

(b) contains a motivation and evidence (e.g., photographs) of either the verified or different use of the land and environmental sensitivity; and

(c) is submitted together with the relevant assessment report prepared in accordance with the requirements of the Environmental Impact Assessment Regulations.

2.7.4.3 Aquatic biodiversity and ecosystems

2.7.4.3.1 Aquatic ecosystem types

Aquatic Ecosystem Classification

Aquatic ecosystems were classified according to a hierarchical system described by Ollis *et al*. (2013).

Aquatic Habitat Assessments

Habitat assessments, according to the habitats sampled, were performed because changes in habitat can be responsible for changes in SASS5 scores. This was achieved by applying the SASS orientated habitat assessment indices. The indices used are the Integrated Habitat Assessment System (IHAS) score sheet and the Habitat Quality Index (HQI).

Applicable fish habitat assessments such as the Habitat Cover Ratings (HCR) and Site Fish Habitat Integrity Index (SHI) will be used to assess the habitat potential and condition for fish assemblages

2.7.4.3.2 Aquatic biota surveys

Macro-invertebrates and fish are good indicators of river health. By making use of established and accepted survey methods (SASS5 for invertebrates and FRAI-based surveys for fish) and incorporating the habitat aspects, a proper basis for biological diversity can be obtained.

The different components of the proposed development and its impact on the aquatic environment will be assessed for the river in the project area. The following recognised bio-parameters and methods will be used:

- Aquatic invertebrates: South African Scoring System version 5 (SASS5).
- Fish communities: Fish Response Assessment Index (FRAI).

Aquatic invertebrate assessment

Benthic macro-invertebrate communities of the selected sites were investigated according to the South African Scoring System, version 5 (SASS5) approach. An invertebrate net (30cm x 30cm square with 0.5mm mesh netting) was used for the collection of the organisms. The available biotopes at each site will be identified on arrival. Each of the biotopes was then sampled separately and by different methods. Sampling of the biotopes was done as follows:

Stones in current (SIC): Movable stones of at least cobble size (3 cm diameter) to approximately 20 cm in diameter, within the fast and slow flowing sections of the river. Kick-sampling is used to collect organisms in this biotope. This is done by placing the net on the bottom of the river, just downstream of the stones to be kicked, in a position where the current will carry the dislodged organisms into the net. The stones are then kicked over and against each other to dislodge the invertebrates (kick-sampling) for ± 2 minutes.

Stones out of current (SOOC): *Where the river is calm, such as behind a sandbank or ridge of stones or in backwaters.* Collection is again undertaken using the kick-sampling method, except in this case the net is swept across the area sampled to catch the dislodged biota. Approximately 1 m^2 is sampled in this way.

Sand: These include sandbanks within the river, small patches of sand in hollows at the side of the river or sand between the stones at the side of the river where flow was slow or no flow was recorded. This biotope is sampled by stirring the substrate, shuffling or scraping of the feet is done for half a minute, whilst the net is continuously swept over the disturbed area.

Gravel: Gravel typically consists of smaller stones (2-3 mm up to 3 cm). Sampling similar to that of sand.

Mud: *It consists of very fine particles, usually as dark-coloured sediment.* Mud usually settles to the bottom in still or slow flowing areas of the river. Sampling like that of sand.

Marginal vegetation (MV): *This represents the overhanging grasses, bushes, twigs and reeds from the riverbank.* Sampling is undertaken by holding the net perpendicular to the vegetation (half in and half out of the water) and sweeping back and forth in the vegetation (± 2m of vegetation).

Aquatic vegetation (AQV): *Rooted, submerged or floating waterweeds such as Potamogeton, Aponogeton and Nymphaea.* Sampled by pushing the net (under the water) against and amongst the vegetation in an area of approximately one square meter.

The organisms sampled in each biotope were identified and their relative abundance is also noted on the SASS5 datasheet. Habitat assessments, according to the habitats sampled, were performed due to the fact that changes in habitat can be responsible for changes in SASS5 scores. This was achieved by applying the SASS orientated habitat assessment indices. The indices used are the Integrated Habitat Assessment System (IHAS) score sheet and the Habitat Quality Index (HQI).

The SASS5 method was used to establish the macro-invertebrate integrity in all three of the main habitat assemblages: stones, vegetation and sand/mud/gravel. The associated habitats were determined with the Invertebrate Habitat Assessment System (IHAS) and the Habitat Quality Index (HQI).

Although the SASS5 method was used as prescribed by DWS, it must be kept in mind that this method was designed for water quality purposes. Therefore, the macro-invertebrate integrity scores may vary throughout the year as water quality changes, due to flow variation, as should be the case in the pre- and post-construction phases of the monitoring project.

Aquatic invertebrates were sampled using a standard SASS net and identified to at least family level according to the SASS5 sampling technique (Dickens and Graham 2002). The SASS5 results were classified into one of six Present Ecological State categories, ranging from Natural (Category A), to very Critically Modified (Category F). The limits for each category varied depending on the Level I Ecoregion and the geomorphological zone, according to the method of Dallas (2007) (Figure 22).

The quality of each instream habitat where macro-invertebrates were sampled was assessed in terms of the suitability for aquatic macro-invertebrates using a simple, five-point scale (0 = absent; 1=very poor; 5=highly suitable). Each habitat category was assigned weighted importance value that varied according to the geomorphological stream type. The weighted values were multiplied by the suitability rating (0-5), and the results were expressed as a percentage, where 100% = all habitats highly suitable. The percentage values were converted to a category (A to F), to allow easy comparison among sites or sampling events.

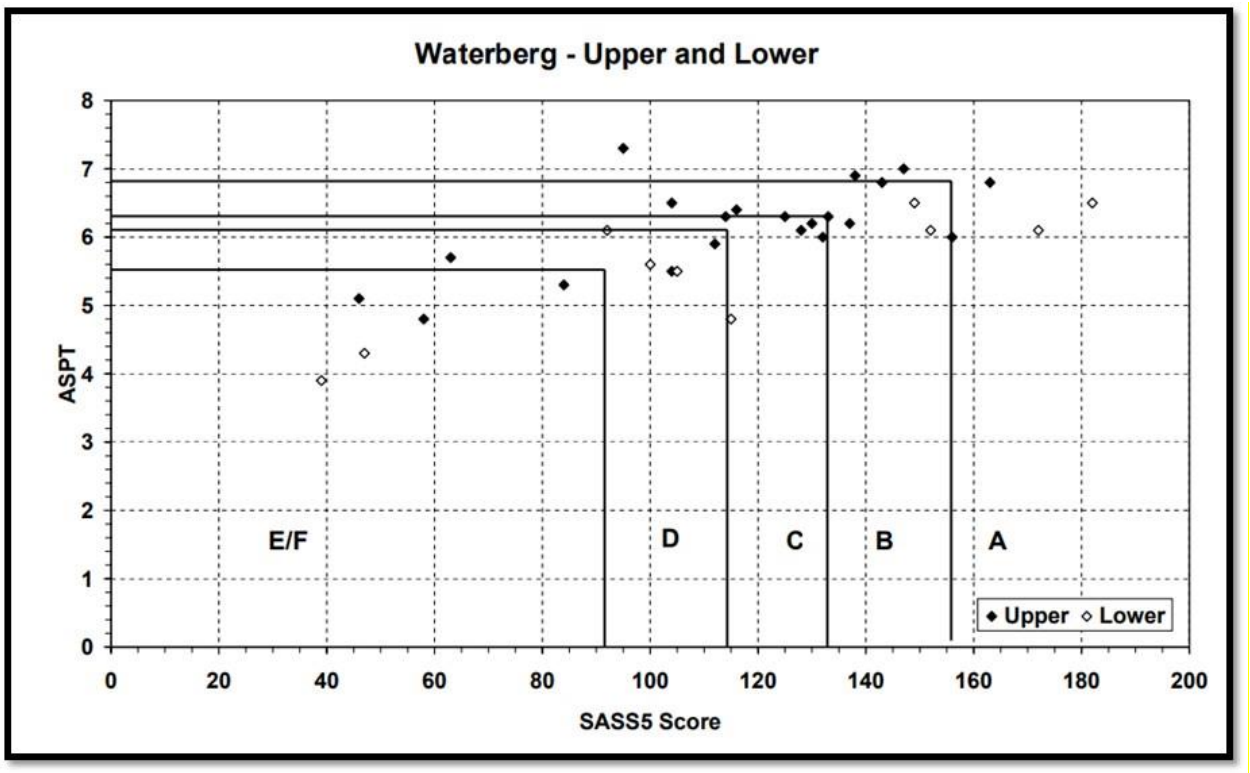


Figure 22. Guidelines used to delineate the Present Ecological State Categories in terms of SASS5 biomonitoring results in the upper portions of the Waterberg Ecoregion (Dallas 2007).

Macro-invertebrate Response Assessment Index: MIRAI

The rating approach for the MIRAI involves four different metric groups that measure the deviation of the invertebrate assemblage from the reference (expected) assemblage in terms of flow modification, habitat modification and water quality modification, as well as system connectivity and seasonality.

The first step in determining the Present Ecological State (PES) of the invertebrates is to complete the data sheets. This includes the abundance and frequency of occurrence of the different invertebrate taxa under natural (reference) conditions, as well as the abundance and frequency of occurrence of the invertebrate taxa present. For this index an increase in abundance and/or frequency of occurrence, as well as a decrease in abundance and/or

frequency of occurrence, is seen as an impact or change compared to natural. The five-point rating system works as follows:

0 = No change from reference
1 = Small change from reference
2 = Moderate change from reference
3 = Large change from reference
4 = Serious change from reference
5 = Extreme change from reference

Fish communities - Fish Response Assessment Index (FRAI)

The biotic assessment method uses a series of fish community attributes related to species composition and ecological structure to evaluate the quality of an aquatic biota. Data on distribution, richness, length frequency and abundance will be collected. The sampling methods include fish traps, seine nets, mosquito nets and electro-fishing.

Fish segment identification, species tolerance ratings, abundance ratings, frequency of occurrence and health status techniques are applied during this survey to determine the integrity of the fish communities.

On arrival at the site a basic on-site visual appraisal is made of the habitats available on that particular day at that particular flow. A site diagram is compiled indicating the different habitat types and the various components thereof. Sampling takes place in each of the different habitat types. These different habitat types are sampled separately using different methods.

a) Electro-shocking

Electro-shocking commences in the downstream component of the habitat. One person uses a backpack electro-shocker for shocking, using a scoop net to catch the stunned fish. The researcher progresses upstream, keeping the fish caught in a bucket until that particular habitat is surveyed. Each habitat shocked is timed. It is necessary to take care (as far as possible) when shocking so as not to disturb the remainder of the habitat still to be surveyed. As each habitat is completed the fish species caught, are identified, recorded and released back into their respective habitat types.

Any fish species that cannot be identified at the time is preserved in 10% formalin (in a sample bottle with label inside) for later identification by experts. The data sheet is completed for that particular habitat – recording every fish, its age class (adult, sub-adult, juvenile) and whether any fish is diseased (e.g., visible ecto-parasites). Each habitat type is recorded (e.g., shoot, riffle or pool etc.), as well as the width, depth, substrate, the extent sampled, the percentage of algae on substrate, whether there was any vegetation and the turbidity. The flow of that particular habitat is classified into one of five flow classes (no flow, slow flow, medium flow, fast and very fast flow).

The electro shocking device is used to sample certain habitats: shoots, riffles, rapids, shallow-medium depth pools in stream and off stream, runs and back waters.

b) Cast net

A cast net (a weighted circular net that is thrown into the water) is used in pool type or slower flow and deeper habitat types. As with method (a) all aspects of the habitat type are recorded

including the fish species, numbers, age class and health. The number of throws efforts per habitat is also recorded.

a) Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

The general components of the VEGRAI are specified as following:

- It is a practical and rapid approach to assess changes in riparian vegetation condition.

- It considers the condition of the different vegetation zones separately but allows the integration of zone scores to provide an overall index value for the riparian vegetation zone as a unit.

- The vegetation is assessed based on woody and non-woody components in the respective zones and according to the different vegetation characteristics which include, inter alia:

    - Cover
    - Abundance
    - Recruitment
    - Population structure
    - Species composition

- It provides an indication of the causes for riparian vegetation degradation.
- It is impact based. This means that the reference condition will only be broadly defined and based on the natural situation in the absence of impacts. Where possible, however, reference conditions should be derived based on reference sites or sections.

The index is based on the interpretation of the influence of riparian vegetation structure and function on in-stream habitat.

Although biodiversity characteristics are used in assessing the riparian vegetation condition, it is not a biodiversity assessment index *per se.*

For this study the Level 3 VEGRAI will be used as Level 3 is applied by the River Health Programme (RHP) and for rapid Ecological Reserve purposes. This level will be aimed at general aquatic ecologists.

Ecological State of the Water Course

The determination and categorisation of the Present Ecological State (PES) takes place during the process of the Ecological Classification process. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.

During the EcoClassification process, the EcoStatus is also determined. EcoStatus represents an ecologically integrated state representing the **drivers** (hydrology, geomorphology, physico-chemical) and **responses** (fish, aquatic invertebrates and riparian vegetation). The EcoStatus

refers to the integration of physical changes by the biota and as reflected by biological responses.

The development of methods to achieve the objectives of this study, focused on a two-step process –

- Devising consistent indices for the assessment of the Ecological Categories of individual biophysical components.
- Devising a consistent process whereby the Ecological Categories of individual components can be integrated at various levels to derive the EcoStatus of the river.

The following index models were developed following a Multi Criteria Decision Making Approach (MCDA):

- Fish Response Assessment Index (FRAI)
- Macro Invertebrate Response Assessment Index (MIRAI)
- Riparian Vegetation Response Assessment Index (VEGRAI)

Riparian delineation

It is important to differentiate between wetlands and riparian habitats. Riparian zones are not wetlands, however, depending on the ecosystem structure, wetlands can be also be classified as riparian zones if they are located in this zone (e.g. valley bottom wetlands). Although these distinct ecosystems will be interactive where they occur in close proximity it is important not to confuse their hydrology and eco-functions.

Riparian delineations are performed according to *"A practical field procedure for identification and delineation of wetlands and riparian areas"* as amended and published by the Department of Water Affairs and Forestry (2005); (Henceforth referred to as DWAF Guidelines (2005).

Aerial photographs and land surveys were used to determine the different features and riparian areas of the study area. Vegetation diversity and assemblages were determined by completing survey transects along all the different vegetation communities identified in the riparian areas.

Riparian areas are protected by the National Water Act (Act 36 of 1998), which defines a riparian habitat 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."*

Riparian areas include plant communities adjacent to and affected by surface and subsurface hydrologic features, such as rivers, streams, lakes, or drainage ways. Due to water availability and rich alluvial soils, riparian areas are usually very productive.

Tree growth rate is high and the vegetation is lush and includes a diverse assemblage of species. The delineation process requires that the following be taken into account:

- Topography associated with the watercourse;
- Vegetation;
- Alluvial soils and deposited material.

A typical riparian area according to the DWAF Guidelines (2005) is illustrated in Figure 23.

In addition to the DWAF Guidelines (2005) and DWAF updated manual (2008), the unpublished notes: *Draft riparian delineation methods prepared for the Department of Water Affairs and Forestry, Version 1* (Mackenzie & Rountree, 2007) were used for classifying riparian zones encountered on the property according to the occurrence of nominated riparian vegetation species.

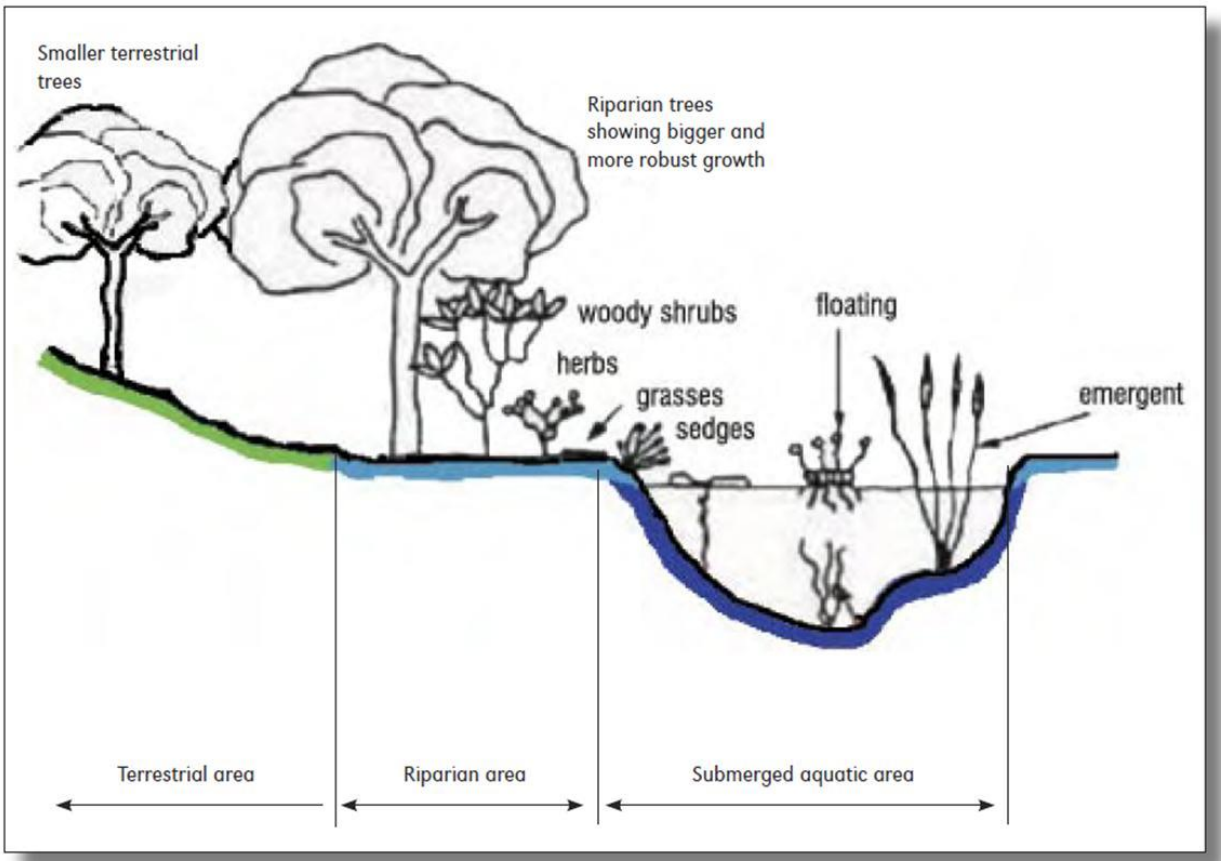


Figure 23: A cross section through a typical riparian area (DWAF Manual, 2008).

Buffers

Aquatic buffer zones are typically designed to act as a barrier between human activities and sensitive water resources thereby protecting them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions, and on this basis, have been proposed as a standard measure to protect water resources and associated biodiversity (Macfarlane et al, 2015). These functions include:

- Maintaining basic aquatic processes;
- Reducing impacts on water resources from upstream activities and adjoining land uses;
- Providing habitat for aquatic- and semi-aquatic species;
- Providing habitat for terrestrial species; and
- A range of ancillary societal benefits.

Due to their positioning adjacent to water bodies, buffer zones associated with streams and rivers will typically incorporate riparian habitat. Riparian habitat, as defined by the NWA, includes the physical structure and associated vegetation of the areas associated with a

watercourse. These areas are commonly characterised by alluvial soils (deposited by the current river system) and 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 (Macfarlane et al, 2015).

However, the riparian zone is not the only vegetation type that lies in the buffer zone as the zone may also incorporate stream banks and terrestrial habitats depending on the width of the aquatic impact buffer zone applied. A diagram indicating how riparian habitat typically relates to aquatic buffer zones defined in this guideline is provided in Figure 24.

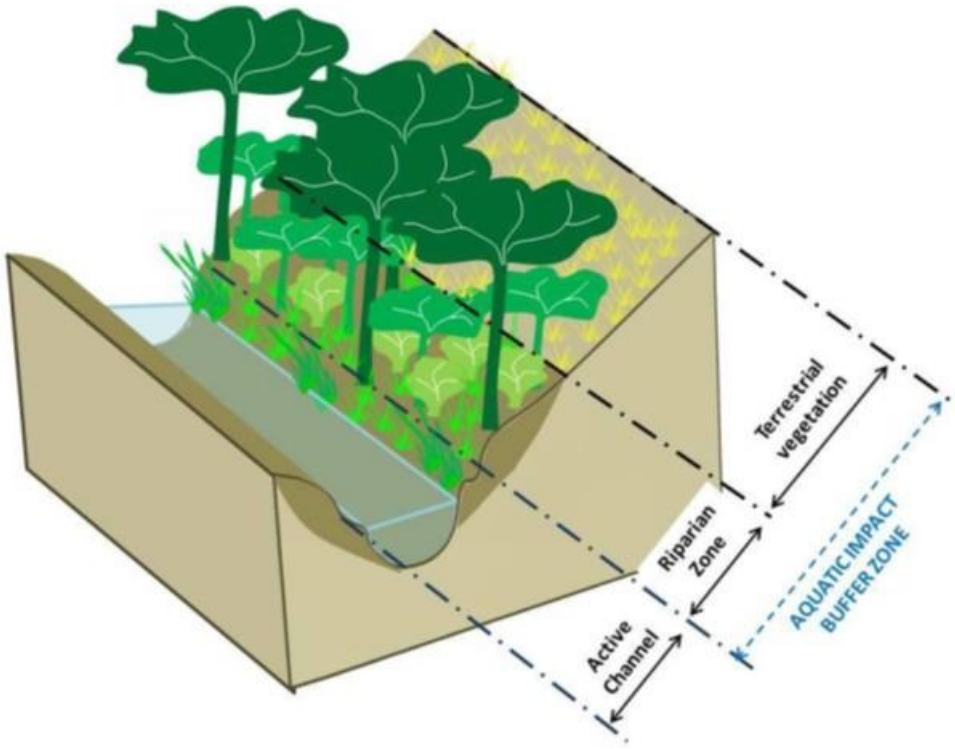


Figure 24: Schematic diagram indicating the boundary of the active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone (Macfarlane et al, 2015).

Once an aquatic impact buffer zone has been determined, management measures need to be tailored to ensure buffer zone functions are maintained for effective mitigation of relevant threat/s. Management measures must therefore be tailored to ensure that buffer zone functions are not undermined. Aspects to consider include:

- Aquatic impact buffer zone management requirements;
- Management objectives for the aquatic impact buffer zone; and
- Management actions required to maintain or enhance the aquatic impact buffer zone in line with the management objectives. Activities that should not be permitted in the aquatic impact buffer zone should also be stipulated.

Determining appropriate management and monitoring of buffer zones

A series of Excel based Buffer Zone Tools have been developed to help users determine suitable buffer zone requirements (Macfarlane and Bredin, 2017). These include a rapid desktop tool for determining potential aquatic impact buffer zone requirements together with three site-based tools for determining buffer zone requirements for rivers, wetlands and estuaries. Central to these tools is a buffer model, which is populated automatically from the data capture sheets provided. This is based on best available science and is used to generate buffer zone recommendations as part of the assessment process. The Overview of the stepwise assessment process for buffer zone determination (Macfarlane and Bredin, 2017) is illustrated if Figure 25.

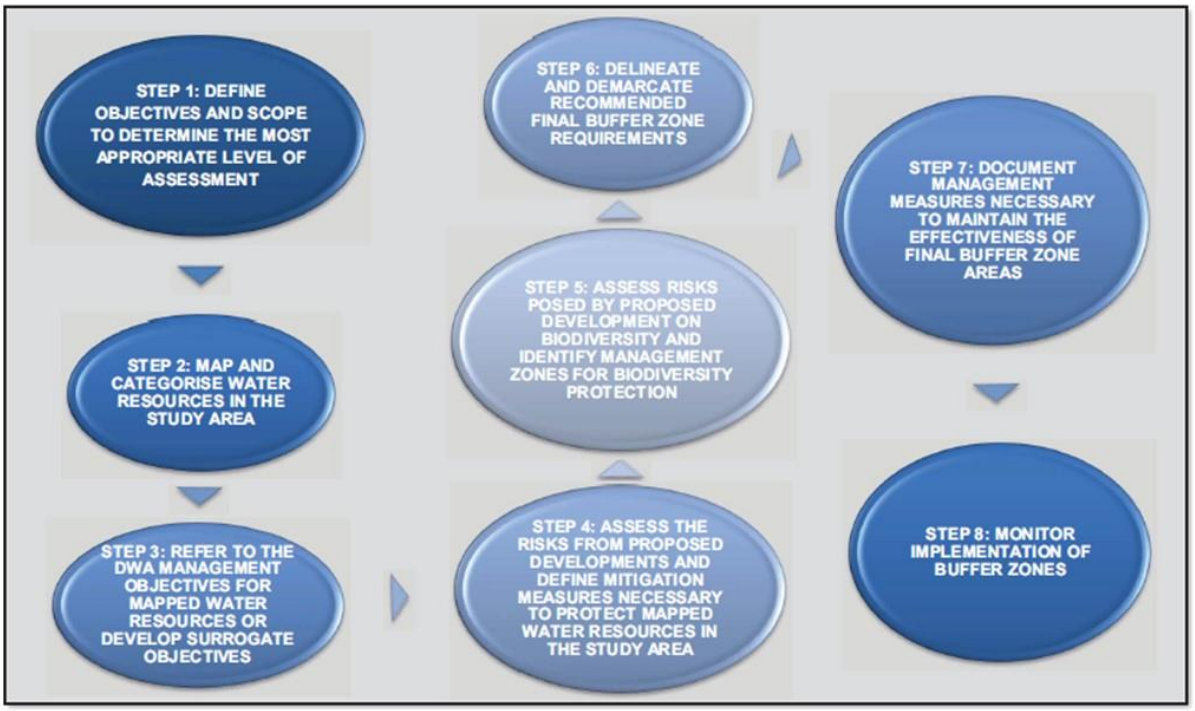


Figure 25: Overview of the step-wise assessment process for buffer zone determination (Macfarlane and Bredin, 2017).

Once a final buffer zone area has been determined, appropriate management measures should be documented to ensure that the water quality enhancement and other buffer zone functions, including biodiversity protection, are maintained or enhanced. Key aspects addressed include:

- Demarcating buffer zones.
- Defining suitable management measures to maintain buffer functions.
- Reviewing the need to integrate protection requirements with social and development imperatives.
  Monitoring to ensure that buffer zones are implemented and maintained effectively.

2.7.4.3 Spatial data sets that indicate Critical Biodiversity Areas

To establish how important the site is for meeting biodiversity targets, a number of resources and tools are used as prescribed by the Limpopo Conservation Plan (Desmet et al. 2009). Specifically, the Land-Use Decision Support Tool (LUDS) and the Limpopo Conservation Plan are extensively used to compile the LUDS Report (BGIS, 2016). LUDS was developed to facilitate and support biodiversity planning and land-use decision-making at a national and provincial level. Its primary objective is to serve as a guideline for biodiversity planning but should not replace specialist ecological assessments.

Critical Biodiversity Areas (CBAs) are areas of the landscape that need to be maintained in a natural or near-natural state in order to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. If these areas are not maintained in a natural or near-natural state then biodiversity conservation targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity-compatible land uses and resource uses.

Land-Use Decision Support Tool (LUDS)

To establish how important the site is for meeting biodiversity targets, it is necessary to answer the following three simple but fundamentally important questions:

- How important is the site for meeting biodiversity objectives (e.g., is it in a **Critical Biodiversity Areas** (CBA) or Ecological Support Area (ESA)?
- Is the proposed land-use consistent with these objectives or not (to be checked against the land-use guidelines)?
- Does the sensitivity of this area trigger the requirements for assessing and mitigating environmental impacts of developments, or in terms of the listed activities in the EIA regulations?

PES & EIS assessment brief

Since the project activities in the project area will impact on the Mokolo River, this report will determine the **Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS),** environmental sensitivity of this river, as well as other requirements necessary for the WULA and EIA processes.

Following is a summary of all the important aspects and processes that play a role in the determination of the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS), as part of the Environmental Water Requirement (EWR) process in determining the Ecological Reserve.

The **Ecological Reserve** refers to the quantity and quality of water required to (i) supply basic human needs and (ii) protect aquatic ecosystems and the detail of the Reserve is derived from the **Ecological Reserve determination**. The **EcoClassification** process is an integral part of the Ecological Reserve determination method and of any **Environmental Flow Requirement (EFR)** or **Environmental Water Requirement (EWR)** method. Reserve determination methods identify **EWRs** as continuous flows and periodic 'events' of defined magnitudes which are combined as volumes or mean monthly flows.

The term **EcoClassification** is used for the **Ecological Classification (EC)** process and refers to the determination and categorisation of the **Present Ecological State** (**PES**). The PES of the river is expressed in terms of various components i.e., drivers (physico-chemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic

invertebrates) as well as an integrated state, the **Ecological Status** or **EcoStatus** of a river. The EcoStatus refers to the integration of physical changes by the biota and as reflected by biological responses. The individual drivers and biological responses are referred to as **components** while the individual attributes within each component that are assessed, to determine deviation from the expected natural reference condition, are referred to as ***metrics***.

Ecological Categories (A→F; A = Natural, and F = critically modified) are determined as part of the **EcoClassification** process form an essential part of most of the **Reserve** steps. The **Recommended Ecological Category (REC)** can be recommended as future states depending on the **EIS** and **PES** of the river reach.

Resource Quality Objectives (**RQOs**) are defined as clear goals (numerical or descriptive statements) relating to the quality of a water resource and are set in accordance to the management class (preliminary class in the absence of the classification system) specified for the resource to ensure the water resource is protected.

Risk Assessment using the Risk Matrix

In terms of the new Government Gazette Notice, GN 509 in GG 40229 of 26 August 2016 (*General Authorisations for impeding or diverting of flow or altering the bed, banks, course or characteristics of a watercourse), Regulation 7*:

Assessment of risk and mitigation factors

It is required that the following documents and associated spread sheets be used during the assessment of risk and mitigation of risks:

(a) A Practical Field Procedure for Delineation of Wetlands and Riparian Area (2005) which is available on the Department's website http:/ /www.dws.gov.za, under water use authorization in terms of section 21 (c) or (i) of the Act;

(b) Appendix A (Excel Spreadsheet) and information regarding the method used in Appendix A is contained in the Department of Water and Sanitation 2015 publication: Section 21(c) and (i) water use Risk Assessment Protocol, which is available on the Department's website http: / /www.dws.gov.za, under section 21(c) and (i) water use authorization.

(c) Guideline: Assessment of activities /developments affecting wetlands, which is available on the Department's website http: / /www.dws.gov.za, under section 21 (c) and (i) water use authorization.

(d) Guideline for the determination of buffer zones for rivers, wetlands and estuaries, which is available on the Department's website http: / /www.dws.gov.za, under water use authorization in terms of section 21 (c) and (i) of the Act.

The DWS Risk assessment protocol was obtained from GN 509. Risk posed to "resource quality", as defined in the NWA, must be scored according to the Risk Rating Table for Severity (Table 36). A Severity score is then generated. Consequence, Likelihood and finally Significance scores are automatically calculated with the rest of parameters according to respective Risk Rating Tables (Tables 36 -40).

Risk is determined after considering all listed control/mitigation measures. Borderline LOW /MODERATE risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to a listing of additional mitigation measures considered and listed in RED font. ONLY LOW RISK ACTIVITIES located within the regulated area of the

watercourse will qualify for a General Authorisation (GA) according to GN 509 (Table 15). Medium and High risk activities will require a Section 21 (c) and (i) water use license. The risk rating is determined by combined scores from the following matrix components (Tables 8 -14):

Consequence= Severity + Spatial Scale + Duration
Likelihood = Frequency of the Activity+ Frequency of the Impact + Legal Issues + Detection
Risk = Consequence x Likelihood

Table 36: Severity - How severe do the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, and habitat)? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

Table 37: Spatial scale - How large is the area that the aspect is impacting on? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional/neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

Table 38: Duration -How long does the aspect impact on the resource quality? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

Table 39: Frequency of the activity - How often do you do the specific activity? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

Table 40: Frequency of the incident/impact - How often does the activity impact on the resource quality? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

2.7.5 A description of the assumptions made and any uncertainties or gaps in knowledge or data.

- Whilst the author has made every effort to verify that information provided in this report is reliable, accurate and relevant, this report is based on information that could reasonably have been sourced within the time period allocated to the report and is dependent on the information provided by management and/or its representatives.

- Project proponents will always strive to avoid and mitigate potentially negative project related impacts on the environment, with impact avoidance being considered the most successful approach, followed by mitigation. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.

- Due to the fact that detail mitigation procedures have been presented, it is trusted that the construction team management with the help of the ECO will ensure that these mitigatory measures be implemented where applicable.

2.7.6 to 2.7.16 Minimum information regarding:

2.7.6 The location of areas not suitable for development, which are to be avoided during construction and operation, where relevant.

Synopsis: Two sites were indicated and investigated for possible river crossings, and due to reasons explained in Section 2.4, Site 1 was chosen as the recommended site. At site 1 the following areas should be avoided during construction and operation:

- Riverine areas outside the construction footprint (3m working servitude on either side of the crossing), except when obtaining sand from the designated sand mining area,
- and riparian area inside the 10m ecological buffer on both sides of the river (except for the working servitude).

Thus, the working area should be restricted to the 3m working servitude on either side of the crossing and outside the 10m ecological buffer (Figure 13 and 26).

Figure 26: A schematic diagram illustrating the river crossing with associated working servitude and riparian buffers.

2.7.7 Additional environmental impacts expected from the proposed development.

Synopsis: All identified impacts have been addressed in detail in the impact assessment section (Section 2.5), and no additional impacts is anticipated.

2.7.8 Any direct, indirect and cumulative impacts of the proposed development on site.

Synopsis: The bridge structure of this category is an uncomplicated structure when considering ecological impacts. The main issues relating to construction and operation have been addressed and no further direct, indirect and cumulative impacts are anticipated.

2.7.9 The degree to which impacts and risks can be mitigated.

Synopsis: During the risk assessment, 66 potential impacts were identified. All were successfully mitigated to a “Low” risk rating (Table 34).

2.7.10 The degree to which the impacts and risks can be reversed.

Synopsis: For 66 potential impacts identified during the risk assessment, all were assigned mitigation measures that reversed potential impacts to “Low” risk rating posed to the resource quality of the watercourse (Table 34).

2.7.11 The degree to which the impacts and risks can cause loss of irreplaceable resources.

Synopsis: No impact was identified to cause loss of irreplaceable resources during the risk assessment. All the risk assessed were mitigated to a “Low” risk rating (Table 34).

2.7.12 A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.

Synopsis: By making use of the DWS Buffer Tool Kit, a final aquatic impact buffer of 10m on both sides of the Mokolo River were establish. The 10 m buffer is situated directly outside the riparian zone on the macro-channel bank (Figure 13 and).

2.7.13 The proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr).

Synopsis: All the proposed impact management actions listed in the Risk Matrix (Table 34) in the Environmental Management Programme will be considered and, if applicable, they will be included in the EMPr.

2.7.14 A motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a "low" aquatic biodiversity sensitivity and that were not considered appropriate.

Synopsis: The recommended development footprint identified (Site 1) is considered to be the site with the lowest aquatic biodiversity sensitivity because of the extensive bedrock structure underlying the site and low riparian vegetation cover.

2.7.15 A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not.

Synopsis: By implementing all the suggested mitigation measures and managing the system as prescribed, on a continuous basis, all the impacts will be addressed to a satisfactory level. It is the reasoned opinion that the overall project outcome mitigates all listed impacts satisfactory to a "Low" impact level.

2.7.16 Any conditions to which this statement is subjected.

Synopsis: It is proposed that the project should be authorised with the provision that the mitigation measures prescribed in this document are, where applicable, included in the EMPr.

Summary: A reasoned opinion

The bridge design and the terrain chosen to construct the bridge, both play significant roles in rendering this a low impact project. The low-level crossing will be constructed mainly on bedrock, which is a stable but common habitat for this reach of the Mokolo River. The bridge structure will be constructed with culverts that will maintain longitudinal stream connectivity at different flow levels. With the construction information available, expected impacts were assessed and all were confirmed to be "Low" or mitigated to attain a "Low" risk level.

The current impact study (this report) assessed the Ecostatus as a Class B (Largely natural with few modifications). The RQO prescribe a PES of a B/C to be maintained. The REC is suggested as a Class B. Therefore, with a current Ecostatus of a B, the river is close to the RQO proposed REC, of a B. In other words, the river is currently in a very good condition and certainly in line with the B/C of the RQO requirement.

Furthermore, judging from the Impact Assessment and the mitigation proposed, the Mokolo River PES will not be affected by the bridge construction or operation. In order to protect the Mokolo River in its current condition from any degradation, a buffer of 10 m wide on both sides of the drainage line is required according to the DWS buffer tool assessment. This buffer will ensure that no riparian trees or sensitive riverine habitat will be disturbed.

The bridge culverts will maintain longitudinal stream connectivity to ensure *inter alia* proper passage for migrating aquatic species, even during very low flows. It is therefore anticipated that the design and development of the bridge and access roads will not change the PES or Ecostatus to a different ecologic category or compromise defined Resource Quality Objectives (RQOs) for this river reach in terms of water quality, quantity, habitat and biota.

By implementing all the mitigation measures and managing the system on a continuous basis as prescribed by the Risk Assessment, all the impacts will be addressed to a satisfactory level. Therefore, it is proposed that the project should be authorised with the provision that the mitigation measures prescribed in this document, where applicable, are included in the EMPr

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Appendices

Appendix 1: The complete SASS 5 form.

TAXON	Stones	Vegetation	GSM	Total
Porifera 5				
Coelenterata 3				
Turbellaria 3				
Oligochaeta 1				
Leeches 3				
Amphipoda 15				
Potamonautidae 3				
Atyidae (Shrimp) 8				
Palaemonidae 10				
Hydracarinae 8				
Notonemouridae 14				
Perlidae 12				
Baetidae 1 spp 4				
2 spp 6				
>2 spp 12				
Caenidae 6				
Ephemeridae 15				
Heptageniidae 10				
Leptophlebiidae 13				
Oligoneuridae 15				
Polymitarcyidae 10				
Prosopistomatidae 15				
Teloganodidae 12				
Tricorythidae 9				
Calopterydidae 10				
Chlorocyphidae 10				
Chlorolestidae 8				
Coenagrionidae 4				
Lestidae 8				
Platycnemidae 10				
Protoneuridae 8				
Zygoptera 6				
Aeshnidae 8				
Cordulidae 8				
Gomphidae 6				
Libellulidae 4				
Belostomatidae 3				
Corixidae 3				
Gerridae 5				
Hydrometridae 6				
Naucoridae 7				
Nepidae 3				
Notonectidae 3				
Pleidae 4				
Veliidae 5				
Corydalidae 8				
Sialidae 6				
Dipseudopsidae 10				
Ecnomidae 8				
Hydropsychidae 1= 4				
2spp = 6				
>2spp =12				
Philopotamidae 10				

Polycentropodidae 12				
Psychomyiidae/Xip. 8				
Barbarochthonidae 13				
Calamoceratidae 11				
Glossosomatidae 11				
Hydroptilidae 6				
Hydrosalpingidae 15				
Lepidostomatidae 10				
Leptoceridae 6				
Petrothrincidae 11				
Pisuliidae 10				
Sericostomatidae 13				
Dytiscidae 5				
Elmidae/Dryopidae 8				
Gyrinidae 5				
Haliplidae 5				
Helodidae 12				
Hydraenidae 8				
Hydrophilidae 5				
Limnichidae 8				
Psephenidae 10				
Athericidae 13				
Blepharoceridae 15				
Ceratopogonidae 5				
Chironomidae 2				
Culicidae 1				
Dixidae 13				
Emphididae 6				
Ephydridae 3				
Muscidae 1				
Psychodidae 1				
Simuliidae 5				
Syrphidae 1				
Tabanidae 5				
Tipulidae 5				
Ancylidae 6				
Bulininae 3				
Hydrobidae 3				
Lymnaeidae 3				
Physidae 3				
Planorbidae 3				
Thiaridae 3				
Viviparidae 5				
Corbiculidae 5				
Spaeridae 3				
Uniondae 6				
SASS Score				
No of families				
ASPT				

Estimated abundance: 1=1; A=2-10; B=11-100; C=101-1000; D=>1000

Appendix 2: Finer detail EC rating table.

Rating	Deviation from reference conditions	A- F Categories	Natural – Poor categories	Score
0	No change	A	Natural	≥ 92.01
		A/B		>87.4 and <92.01
1	Small change	B	Good	82.01 – 87.4
		B/C		>77.4 and <82.01
2	Moderate change	C	Fair	62.01 – 77.4
		C/D		>57.4 and <62.01
3	Large change	D		42.01 – 57.4
		D/E		>37.4 and <42.01
4	Serious change	E	Poor	22.01 – 37.4
		E/F		>17.4 and <22.01
5	Extreme change	F		0 - 17.4