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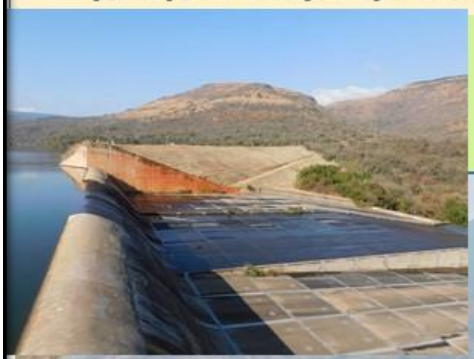
DR ANDREW DEACON

August 2020



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The Present Ecological State of the water courses in the proposed project area: Ecological Risk Assessment Process

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August 2020

Executive Summary

Ecoleges Environmental Consultants have been appointed to undertake an application for Environmental (via Basic Assessment) and Water Use (via General Authorisation) Authorisation for remedial work required on the SAPPI Ngodwana Dam on the Farms Roodewal 470 JT and Grootgeluk 477 JT, directly South of the N4, West of Nelspruit.

This project proposal was prepared for a Specialist Study: An ecological assessment regarding the Environmental and Water Use Authorisation for remedial work required on the SAPPI Ngodwana Dam. The Environmental Evaluation concerns the riverine aspects of the delineated footprint (Regulated Zone) and the positioning of site camps in the terrestrial zone.

The farms the SAPPI Ngodwana project area is situated in, is located in the Crocodile River Sub-Water Management Area which form part of the Inkomati drainage system. The project site is located in quaternary catchment X21H and the Ngodwana River (X21H-01060) runs through the project area.

Riparian- and In-stream Habitat

The outcome of the in-stream and riparian IHI evaluated for the Ngodwana River in the study area, resulted in an in-stream IHI of 69.2% (C) which classifies as “Moderately modified” according to the Habitat Integrity Categories. The riparian IHI of 61.6 (C/D) falls in the “Moderate change” category. The finer scale rating (C/D) of the riparian IHI relates to the EC rating table where C/D matches a score of >57.4 and <62.01, which puts it in the “Fair” category.

Vegetation communities

The final vegetation integrity score of the VEGRAI assessment, which is incorporating the riparian and marginal zone integrity of the Ngodwana River in the project area, is 64.1% which represents an Ecological Class C (60-79). This score reflects a “Moderately modified” status.

Riparian delineation

During the study the Ngondwana River and its associated riparian zone was delineated. Most of the area below the Ngodwana dam wall (314m wide) consists of wetlands, both natural and created by the dam environment. According to the National Wetland Classification System, the source zone at the upper end of a river would typically be classified as one of the wetland types (e.g. a seep, an unchannelled valley bottom wetland, depression or wetland flat) and not as part of a river. In the peoject area, two wetland seeps originates on the slope of the mountain and drain down into the area below, one becomes a valley bottom wetland which joins the Ngodwana River just before the Ngodwana Water Works, while the other shorter seepage joins the original drainage line of the Ngodwana River below the dam.

Buffer Zone

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 proposed Ngodwana Dam project. Final aquatic impact buffer requirements (including practical management considerations) for all the identified systems, are:

Wetland system	Construction Phase	Operational Phase	Final aquatic impact buffer requirement
Ngodwana River	18 m	19 m	19 m
Ngodwana catchment valley bottom wetland	21 m	22 m	19 m
Ngodwana catchment seep wetland	24 m	24 m	24 m

Aquatic Invertebrates and Fish

Aquatic habitat assessment.

During the July 2020 survey, the IHAS (Integrated Habitat Assessment System) and HQI (Habitat Quality Index) scores were "Fair" to "Good" at Site 1, while at Site 2, all habitat scores are "Fair". The lack of running water habitats, such as riffles and rapids, reflected in the macro-invertebrate scores at Site 2, resulting in the "Fair" SASS scores, while the favourable stones-in-current habitats at Site 1, resulted in HQI score of 80% ("Good").

Aquatic invertebrate assessment

The better habitat quality at Site 1 also reflected in the macro-invertebrate scores, where the ASPT score at Site 1 is 6.9 ("Good" very close to "Excellent"), while the ASPT score at Site 2 is 5.0 (borderline between "Fair" and "Good"). Although Site 1 had a lower number of Families, these were mostly more sensitive taxa.

During the current assessment, the relative MIRAI score of the Ngodwana River in the project area was placed within the limits of an ecological state category Class C (68.9%), which means this reach is "Moderately modified". The fact that the status is "Moderately modified" can mainly be attributed to the presence of the Ngodwana Dam upstream of the survey sites, which intercept most flow events and seriously affects the natural hydrology of the river.

Fish Response Assessment Index (FRAI)

The relative FRAI score at this reach in the Ngodwana River was placed within the limits of an ecological state category Class D (54.9%), which means this reach is "Largely modified".

According to the FRAI model, the "Flow Modification" metric carries the most weight due to the impact of the Ngodwana Dam wall on the system. This is followed by "Velocity-depth" and "Cover" metrics, caused by lack of surface flows certain times of the year due to the presence of the dam. Stagnant pools during no-flow situations and poor water quality in the Elands River explain the Physico-chemical metric, while both the dam wall and poor water quality obstacles impact on fish migration. The Rainbow trout in the upper Ngodwana River flags the "Impact of Introduced" metric.

EcoClassification

PES of the Project Area:

The table below provides the available parameters that were instrumental to establish the PES of the Project Area:

Parameter	Score %	Category	Description
In-stream IHI	69.2	C	Moderately modified
Riparian IHI	61.6	C/D	Moderate change.
VEGRAI	64.1	C	Moderately modified
MIRAI	68.9	C	Moderately modified
FRAI	54.9	D	Largely modified
Mean EI Class			Moderate
Ecological Sensitivity			Very high
EcoStatus		C	Moderately modified
PES		C	Moderately modified

The table lists the parameters that were instrumental in providing the project area with a very favourable PES Category of a "C", which equates to a "Moderately modified" status.

The use of CBA maps

A CBA map of the study area was compiled by using the Biodiversity Geographic Information System (BGIS) maps. The key results of the Biodiversity Geographic Information System (BGIS) maps and LUDS Report are summarised below:

National terrestrial information: Ngodwana 638 and 1030 (Mpumalanga).

- Savanna Biome (Lowveld): SVI 9 Legogote Sour Bushveld- Threatened ecosystem status: Vulnerable

Aquatic Critical Biodiversity Areas

- Water Management Area (WMA): Inkomati WMA - Freshwater Ecosystem Priority Areas (FEPA) WMA;
- Ecological Support Areas: Ecological Support Area (ESA): Important subcatchments and ESA: FEPA subcatchments;
- Freshwater **Critical Biodiversity Areas (**CBA) and Ecological Support Area (ESA): FEPA rivers; Fish support area.

The Ngodwana River is a river FEPA, which means it is a river reach that is required for meeting biodiversity targets for river ecosystems and threatened fish species. The Desired Management Objectives of a river in the Critical Biodiversity Area category, are to maintain the river in a natural state with no loss of ecosystems, functionality or species; no flexibility in land-use options.

Since the river is also situated in a Ecological Support Area, the Desired Management Objectives are to minimise habitat and species loss through judicious planning and maintain basic ecosystem functionality

Risk Assessment

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

The Risk Assessment for this project 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 Risk Assessment Matrix for the Ngodwana Dam project area relating to all current and expected impacts that the development will have on the system and the significance of these impacts.

PHASE: CONSTRUCTION

Activity 1. Stabilizing the berm and toe drain.

Aspect 1.1 Vegetation clearing.

Impact 1. Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.

Impact 2. Damage to riparian large trees or shrubs.

Impact 3. Fragmenting the riparian corridor by removing riparian bushes or river bank vegetation and compromise the function of riparian continuity.

Activity 2. Raising of the right flank embankment

Aspect 2.2: Topping soil on the embankment

Impact 4. The covering of indigenous riverine vegetation will be associated with the

construction of the berm and toe drain.
Impact 5. Covering the marginal vegetation on the embankment will lead to loss of potential habitat and biodiversity.
Impact **6.** Erosion of cleared areas will lead to siltation of the downstream aquatic habitat.

Aspect 1.3: Disturbance - Noise and movement
Impact **7.** Vehicle and human movement and sounds will disturb riparian fauna in the vicinity of the construction activities.

Aspect 1.4: Impacting the Ngodwana catchment seep on the western slope.
Impact 8. Impacting the flow and water quality of this near-pristine mountain stream due to construction activities.

Activity 2. Raising of the right flank embankment

Aspect 2.1: Vegetation clearing
Impact 9. Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.
Impact 10. Erosion of dumped soil will lead to siltation of the downstream aquatic habitat.

Activity 3. Haul route – both sides of the river

Aspect 3.1: Vegetation clearing.
Impact 11. Removal of indigenous riparian vegetation, considering coves of White Stinkwood along the western haul route.

Aspect 3.2: Fragmentation or riparian corridor
Impact 12. Removal of indigenous riparian vegetation, considering coves of White Stinkwood along the western haul route.

Aspect 3.3: Impacting stream flow of the Ngodwana catchment seep on the western slope.
Impact 13: Impacting the flow and water quality of this near-pristine mountain stream due to construction activities.

Aspect 3.4: Erosion and siltation.
Impact 14**:** Disturbing the soil during the construction of roads, clearing areas and create bare patches, channelling storm water and road run-off, etc. will cause erosion and siltation of the river.

Activity 4. Site establishment area and footbridge.

Aspect 4.1: Vegetation clearing.
Impact 15: Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.
Impact 16: Damage to large trees or shrubs.
Impact 17: Fragmenting the riparian corridor by removing riparian bushes or river bank vegetation and compromise the function of riparian continuity.

Aspect 4.2: Erosion and siltation
Impact 18: Clearing of site establishment areas will create bare areas, channelling storm water and surface run-off, etc. which will cause erosion of sediment and resulting in the siltation of the river.

Activity 5. Alien invading vegetation

Aspect 5.1: Introduction of alien vegetation
Impact 19: Competition with indigenous vegetation - would impact adjacent plant communities and promote the invasion of alien species into the intact vegetation.

PHASE: OPERATION

Activity 6: Haul route – both sides of the river

Aspect 6.1: Dust

Impact 20: Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants.

Activity 7: Alien invading vegetation.

Aspect 7.1: Spreading of alien vegetation

Impact 21: Alien species are already present in the valley and will colonise any area of disturbance should they not be actively controlled.

Risk rating after mitigation: Impact 1 to 21 - all “Low” (4 confidence).

Summary

All the risk ratings have been classified as “Low”. This rating indicates that the impacts of the proposed project on the ecology of all the project area drainage lines, will not be significant. The identified risk will thus not alter the PES of these reaches or the downstream ecology in any way should the prescribed control measures be adhered to.

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Abbreviations

AQV	Aquatic vegetation
ASPT	Average Score per Taxon
BGIS	Biodiversity Geographic Information System
^{0}C	Degrees Celsius
CBA	**Critical Biodiversity Areas**
cm	Centimetre
DP	Dissolving pulp
DWAF	Department of Water Affairs (pre-2010)
DWS	Department of Water and Sanitation
E	East
EC	Ecological Category
Ecoclassification	Ecological classification
EcoStatus	Ecological Status
EFR	Environmental Flow Requirements
EI	Ecological Importance
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
ELU	Existing lawful use
ES	Ecological Sensitivity
ESA	Ecological Support Area
EWR	Environmental Water Requirements
FEPA	Freshwater Ecosystem Priority Areas
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GAI	Geomorphological Driver Assessment Index
ha	Hectare
HAI	Hydrological Driver Assessment Index
HCR	Habitat Cover Ratings
HQI	Habitat Quality Index
IHAS	Integrated Habitat Assessment System
IHI	Index of Habitat Integrity
IIHI	Instream Index of Habitat Integrity
km	Kilometre
km^2	Kilometre square
LUDS	Land-Use Decision Support Tool
mamsl	Metres above sea level
m	Meter
m^3	Cubic meter
m^3s	Cubic meter per second
mm	Millimetre
MBCP	Mpumalanga Biodiversity Conservation Plan
MIRAI	Macro-invertebrate Response Assessment Index
MRU	Management Resource Unit
MTPA	Mpumalanga Tourism and Parks Agency
MV	Marginal vegetation
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NFEPA	National Freshwater Ecosystem Priority Areas
NSBA	National Spatial Biodiversity Assessment
NWA	National Water Act
PAI	Physico Chemical Driver Assessment Index
PES	Present Ecological State
PESEIS	Present Ecological State, Ecological Importance and Ecological Sensitivity

RDM	Resource Directed Measures
REC	Recommended Ecological Category
RHP	River Health Programme
RIHI	Riparian Index of Habitat Integrity
RL	Reduced level
RQO	Resource Quality Objectives
S	South
SAPPI	South African Pulp and Paper Industries
SASS5	South African Scoring System version 5
SI	Socio-cultural Importance
SIC	Stones in current
SHI	Site Fish Habitat Integrity Index
SOOC	Stones out of current
SQ	Sub-quaternary
Sqkm	Square kilometer
SQR	Sub-quaternary reach
VEGRAI	Riparian Vegetation Response Assessment Index
WTW	Water Treatment Works
WULA	Water Use License Applications
ZAR	South African Rands

1. Introduction

1.1 Background to the Project

Ecoleges Environmental Consultants have been appointed to undertake an application for Environmental (via Basic Assessment) and Water Use (via General Authorisation) Authorisation for remedial work required on the SAPPI Ngodwana Dam on the Farms Roodewal 470 JT and Grootgeluk 477 JT, directly South of the N4, West of Nelspruit.

The dam facility is regarded as a water reservoir facility which has a primary function of the storage of water for SAPPI's Ngodwana factory, requiring no additional land-use approvals. .

Project description

Ngodwana Dam is a 41 m high zoned earthfill Category III Dam. The dam is located on a tributary of the Elands River, Mpumalanga Province, directly upstream from the N4 highway and the Ngodwana Paper Mill, 40 km from Mbombela. The layout of the dam is shown in Figure 1.

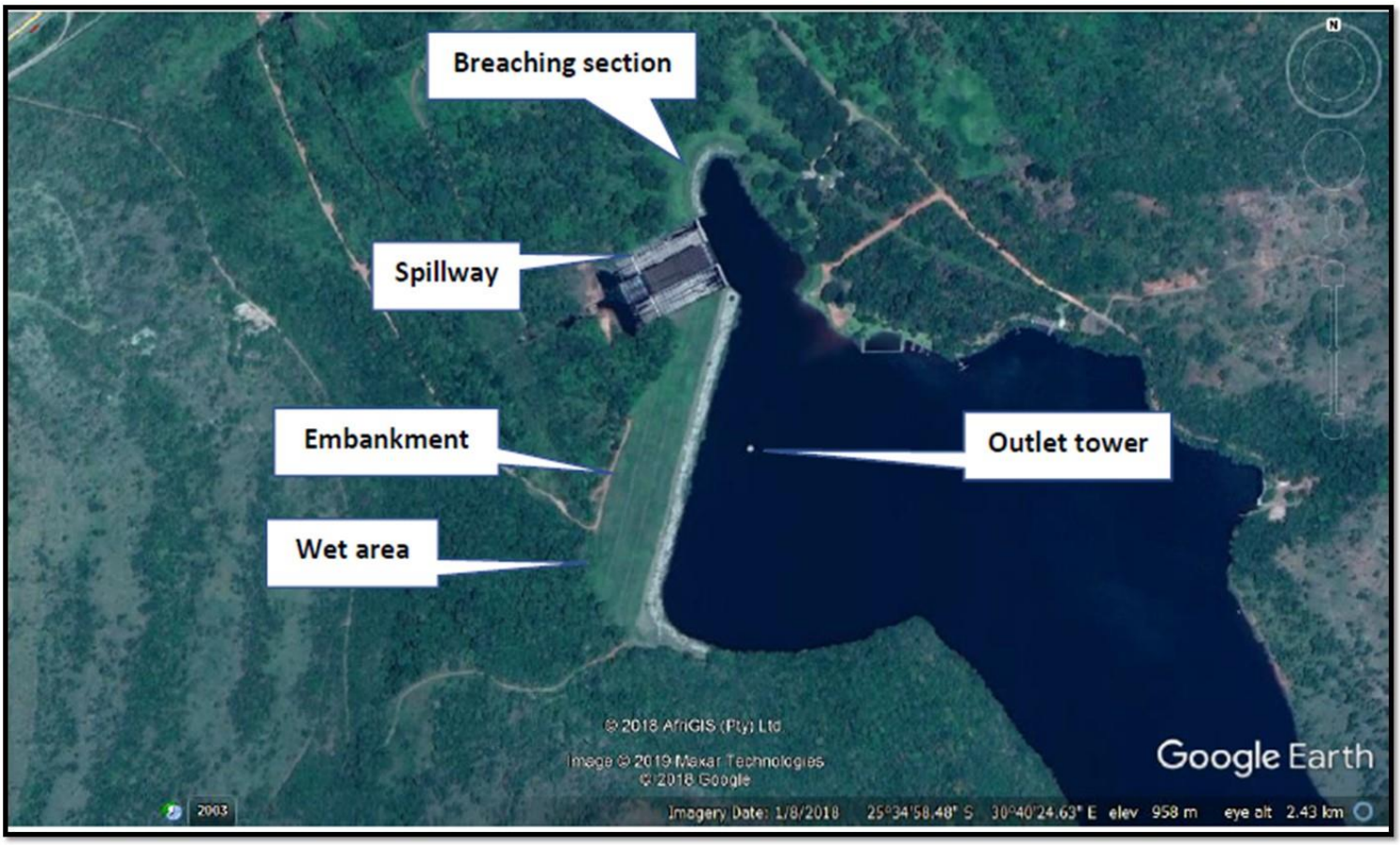

Figure 1: The existing Ngodwana Dam and associated elements (Hagen, 2019).

The Hagen letter 20191203 (2019) by Professional Engineer DJ Hagen, reports the following in his review of the Dam Safety Risk and proposed remedial work associated with Category 3 Ngodwana Dam:

“Since 1987, six dam safety evaluations of the dam have been completed with the last one in September 2016. Annual dam safety reports are also presently conducted with the last one completed in September 2019 by Altus de Beer Consulting Engineer, who is also presently the Approved Professional Person responsible for the dam.

The 2016 dam safety evaluation report recommended further analyses and monitoring of the suspect downstream slope stability of the dam. These investigations were concluded in the 2019 dam safety report. The main conclusion from this report is quoted below for ease of reference:

“The principal safety risk for Ngodwana Dam is the precarious stability conditions of the downstream slope, as was determined as part and parcel of the 2018 dam safety report.”

In this review report it is concluded that a downstream slope failure of the dam is a very likely potential failure mode, but that internal erosion of the poorly protected embankment core, internal erosion of the complex embankment foundation, specifically the embankment left flank, or internal erosion along the outlet conduit are other potential failure modes to be considered.

Observations, analyses, original design shortfalls and instrumentation monitoring have identified likely potential failure modes of Ngodwana Dam. The present probability of failure of this Category III is considered too high. A dam break analysis conducted in 1987 indicated that the dam break flood peak could be as much as 11 000 m^3/s compared to the 1 in 200 year flood of the catchment of the dam of 832 m^3/s. A dam failure will cause significant damage to the N4 and SAPPI Mill immediately downstream of the dam, and also further downstream of the dam.

The dam remediation is to ensure the continued safe operation of this Category III dam and the stability of the main and right flank embankments and its foundations (Ecoleges, 2020).

The scope of construction works to be included in the rehabilitation and to be authorised is:

1. Stabilizing berm (Figure 2) on the downstream face of the main embankment to RL 941.3 m, including approximately 30 000 m^3 of earthworks, a new internal drainage system (sand & gravel filters, rock toe and drain pipes with inspection concrete manholes) and gabion retaining walls.

2. Subsoil pipe drains above the berm of 133 m length with inspection concrete manholes.

3. Raising of the right flank embankment to prevent overtopping and failure during large floods and to improve the stability of the embankment (earthworks to be confirmed).

Proposed remedial works

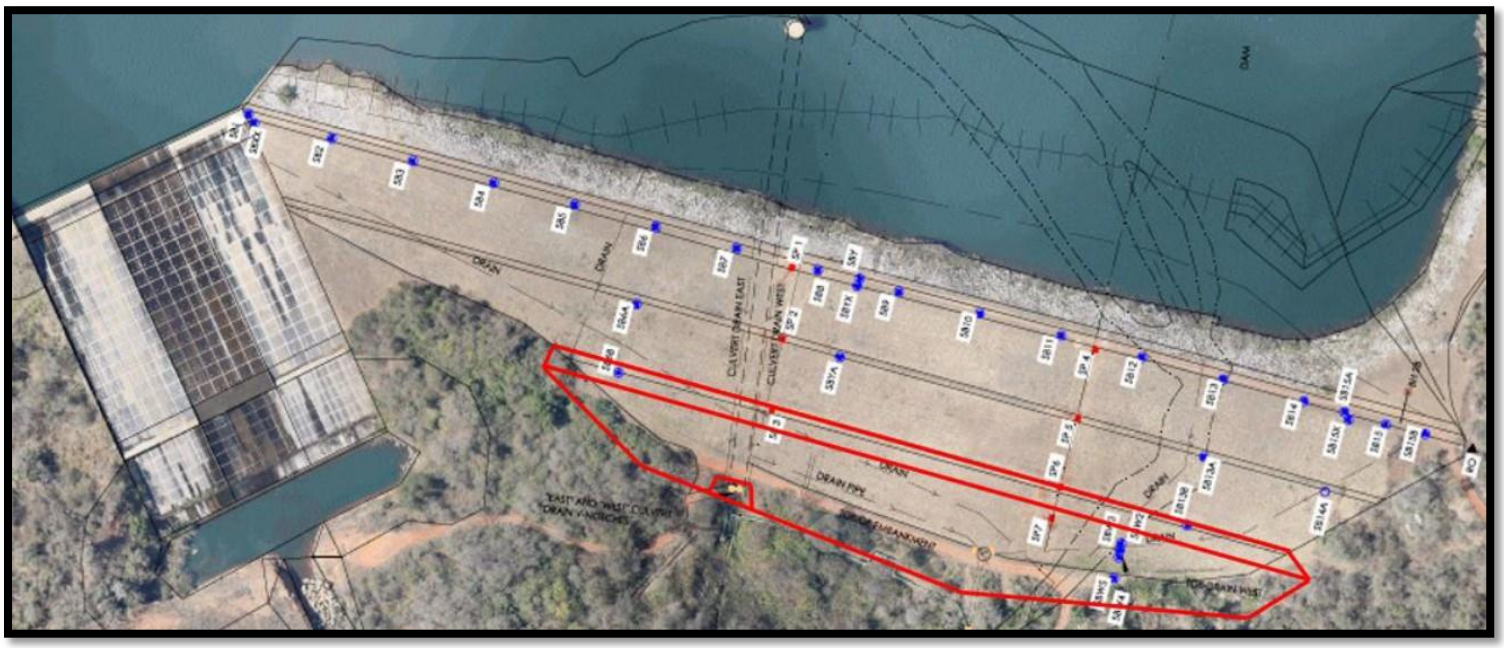

Figure 2: The proposed stabilising berm (red polygon) on downstream face of the Ngodwana Dam wall (Hagen, 2019).

The proposed remedial work to construct a downstream stabilizing berm with an adequate internal drainage filter system and toe drain is supported. The proposed layout of the berm is shown in Figure 2. The extent and size of the berm should be optimized by further slope stability analyses. A new toe drain for the embankment flanks above the berm should also be considered. The berm toe drain should have manholes at regular intervals for maintenance and monitoring.

As part of this review investigation the following other items were identified and could be included in the remedial work scope of works (Hagen, 2019):

- Remedial work to the breaching section downstream face local slip and possible raising of the breaching section as it is no longer considered a necessary emergency spillway.
- Repair of outlet conduit joints where water with muddy material is leaking out.
- Spillway joint sealant replacement.
- Removal of trees along spillway discharge channel training walls and repair of joint.
- Provide safety handrails alongside the spillway retaining walls.
- Reservoir rim stability assessment.

Figure 3: Outlet conduit exit at embankment toe (20 November 2019). Seepage was noted emanating from sides of conduit monitored at v-notch weirs.

Figure 4: Spillway right training wall joint movement likely caused by tree roots (19 November 2019).

Figure 5: Downstream toe on lower left flank (19 November 2019). Note wet conditions which could be attributed to high phreatic surface within embankment.

Figure 6: Downstream face of breaching section (fuseplug embankment) on right flank showing local slip (19 November 2019).

Figure 7: The proposed alterations in the Ngodwana Dam wall project area (Hagen, 2019).

Figure 8: Infrastructure setup involved in the proposed Ngodwana Dam rehabilitation project.

Haul roads for the Ngodwana Dam rehabilitation

Figure 9 supply an aerial view of the layout of the catchment area, proposed haul routes, construction areas, possible stockpile areas, conflicting infrastructure and proposed new infrastructure as described in DMV Nelspruit Incorporated (2020).

Most of the information following is sourced from the document: DMV Nelspruit Incorporated (2020). Preliminary assessment of haul roads for SAPPI, Ngodwana Dam Rehabilitation. Project 20828.

The proposed Ngodwana Dam rehabilitation process will require approximately 41,000m³ of material. It will be upgraded with a raised right flank to the North of the dam spillway and a rock toe berm on the main sections south of the spillway, which includes the left flank of the dam.

The material for the haul road upgrading and right flank (± 29,000m³) will be hauled from the stockpiles at the SAPPI dumpsite area to the South-West of SAPPI (Route 1) and the rock toe material (22,500m³) will come from commercial sources to the East of Ngodwana (Route 2). The balance of material (7,500m³) for this section will also come from SAPPI stockpiles at the dumpsite area and is included in the figures above.

Route 1: This route (indicated in green road arrows on Figure 9) starts at the SAPPI dumpsite stockpile, continue on N4 and to the Kaapsehoop road to the existing fishing club access (#1). A material stockpile area is located approximately 600m along this road (#2) from where material will be hauled to the point of placement on the north flank (#3). An access route to the contractors' site office turns off to the stockpile towards the spillway area (road indicated in yellow on Figure 9). This access route will also serve as a haul road for the ± 7,500m³ material from the SAPPI stockpiles reserved for the main section of the embankment, as well as the ± 10,200m³ material required for the upgrading of haul roads. A link from this road to the Northern spillway retaining wall is required for the clearing of trees along this retaining wall (#4).

Route 2: The material for the rock toe berm (± 22,500m³) will be hauled from commercial sources situated at Alkmaar or Karino via the N4 in 18m³ tipper trucks (normal road haulers). These trucks will use the road which provides access to SAPPI's Water Treatment Works (WTW) (#5). Material will be stockpiled on a stockpile area opposite the WTW (#6). Material will be hauled from the WTW stockpile area to the rock toe berm on the main section of the dam on an existing route. It runs along the SAPPI bulk water supply line to the West of the Ngodwana River (#7) to the embankment of the central section (road indicated in green on Figure 9). A new route (road indicated in blue on Figure 9) up the embankment (#8) up to the point of placement of the rock toe berm on the main section of the dam will be required due to material delivery requirements and restricted space between the toe and the bulk water pipeline. A foot bridge (#9) below the spillway will link the site office area (#10) with the contractor's laydown area (#11).

A pedestrian walkway and pedestrian bridge below the spillway will provide access to the construction site from here. This must be done in a way to conserve the area and to serve as an eco-recreation area after construction.

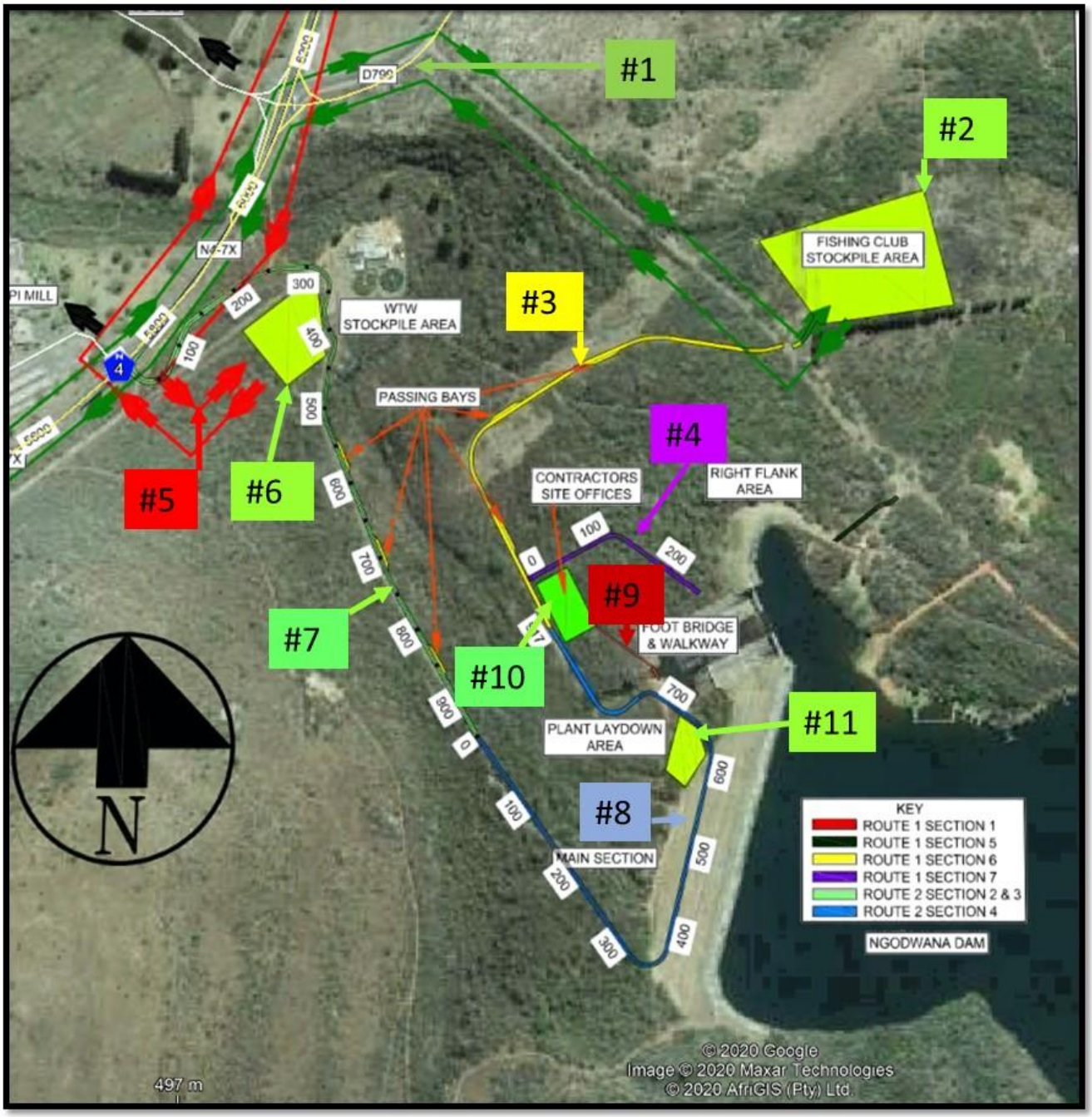

Figure 9: The proposed Ngodwana Dam rehabilitation infrastructure setup, highlighting haul road routes to areas.

1.2 Project brief

This project proposal was prepared for a Specialist Study: An ecological assessment regarding the Environmental and Water Use Authorisation for remedial work required on the SAPPI Ngodwana Dam. The Environmental Evaluation concerns the riverine aspects of the delineated footprint (Regulated Zone) and the positioning of site camps in the terrestrial zone.

Task 1: PES study for the WULA

1. Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

1.1 Riparian and In-stream Habitat.

1.1.1 Morphology (physical structure): water courses, riparian habitat (as per DWAF methodology), and ecologically valued features.

1.1.2 Vegetation: Identification and delineation of wetlands and riparian areas. The delineation process requires that the following be taken into account:

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

1.1.3 A Wetland Delineation report for the riparian corridor and other wetlands (according to methodology prescribed by DWAF), with their scientific determined buffers in place. All these features need GPS boundaries, so that they could be overlain on a plan.

Riparian habitat surveys will incorporate the Riparian Vegetation Index (VEGRAI).

2. Biota

Aquatic biota and associated habitats

Fish and macro-invertebrates are good indicators of river health. By making use of established and accepted survey methods and incorporate the habitat aspects, a proper basis for biological diversity could be obtained. Should there be any surface water present in the river reach affected by the project, this will be evaluated according to the accepted survey methods.

3. General reporting

- Discuss existing land and water use impacts (and threats) on the characteristics of the watercourse.
- List and map locality-sensitive environments in proximity of the project.
- Suggest and discuss mitigation measures relating to the proposed project.

Task 2: Ecological risk assessment

An ecological risk assessment is required according to the GN509 guidelines for the project. The risk assessment will finally be rated as having a low, medium or high

ecological impact. This impact refers to impeding or diverting the flow of water and altering of the bed (Notice 509 of 2016, 26 August 2016).

3. General reporting

- **Master Layout Plan:** Planned infrastructure will be included (supplied by the developers), and flood lines will be supplied (requested from the Engineer). All these features need GPS boundaries, so that they could be overlain on a plan.
- **Monitoring and Compliance**: Provide a detailed Biomonitoring programme for the Project.

1.3 Legal considerations

Applicable Legislation (Ecoleges, 2020)

Water Use

A General Authorisation registration is required for the construction-related remedial work on the SAPPI Ngodwana Dam, for the following water uses:

DWS Section 21 (c) & (i) Supplementary information Requirements

- **Section 21(c):** impeding or diverting the flow of water in a watercourse;
- **Section 21(i):** altering the bed, banks, course or characteristics of a watercourse

This assessment takes into consideration specific requirements of the DWS document DW775/781, titled: *"Supplementary Water Use Information (Section 21 (c) and (i) Water Uses; Section 21(c) - impeding of diverting the flow of water in a watercourse; Section 21 (i) - altering the bed, banks, course or characteristics of a watercourse)."*

The following tasks list certain activities required to determine the PES & EIS and are based on this DWS document referred to above. Throughout this report reference is made to the below list of **tasks and is included as headings to the relevant sections in this report.**

1.1 Locality

*1.1.1. Provide a description of the **location** of the watercourse at which the water use/s is to take place*
*1.1.2 Provide a **locality map/s** indicating the relevant catchment, surrounding land use, towns, infrastructure etc.*
*1.1.3 Provide the **catchment reference number**.*

1.2 Description

*1.2.1 Provide the name and/or **description** of the affected watercourse.*
*1.2.2 Provide a **map** indicating the segment and affected reach/es of the watercourse in which the water use/s is to take place and which indicates/delineates the regulated area, including:*
1.2.2.1 The extent of the riparian habitat.

1.2.3 Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

1.2.3.1 ***Flow*** *and* ***sediment regimes*** *at appropriate flows*

1.2.3.2 ***Water quality*** *(including the* ***physical, chemical and biological characteristics*** *of the water) in relation to the flow regime*

1.2.3.3 Riparian and In-stream ***Habitat****.*

1.2.3.3.1 ***Morphology*** *(physical structure)*

1.2.3.3.2 ***Vegetation***

1.2.3.4 ***Biota***

*1.2.4 Describe the ecological importance and sensitivity (****EIS****) as well as the* ***Socio-cultural Importance (SI)*** *of the affected reach/es of the watercourse including the functions*

1.2.5 Discuss existing ***land and water use impacts*** *(and threats) on the characteristics of the watercourse*

1.2.6 ***List and map sensitive environments*** *in proximity of the project locality-sensitive environments include wetlands, nature reserves, protected areas, etc.*

3.2 **Risk Assessment:**

3.2.1 Provide an assessment of the risks associated with the water use/s and related activities.

Task 3.6 **Monitoring and Compliance:** Provide a detailed Biomonitoring programme for the Project.

Background studies and Fieldwork:

Section 21 (c) & (i) Supplementary Requirements	**Specialist Comments**
1.2.3.1. Flow and sediment regimes at appropriate flows:	To be obtained from existing DWS data base and other relevant studies.
1.2.3.2. Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime:	To be obtained from existing DWS data base (PES of the Sabie River catchment) and other relevant studies.
1.2.3.3 Riparian and In-stream Habitat. 1.2.3.3.1 Morphology (physical structure): 1.2.3.3.2 Vegetation:	Identification and **delineation of wetlands and riparian areas**. The delineation process requires that the following be taken into account: • **Topography** associated with the watercourse; • Vegetation; • **Alluvial soils** and deposited material. Riparian habitat surveys will incorporate the Riparian Vegetation Index (**VEGRAI**).
1.2.3.4 Biota	**Aquatic biota and associated habitats**

	Fish and macro-invertebrates are good indicators of river health. By making use of established and accepted survey methods and incorporate the habitat aspects, a proper basis for biological diversity could be obtained. The following recognized bio-parameters and methods will be used: • General **habitat assessment** to assess the general physical habitat condition of the rivers and identify potential sources and impacts responsible for deterioration of the aquatic ecosystem. The general habitat assessment and biota specific habitat assessments also evaluated the condition and availability of habitats for specific biotic groups. • **Fish communities**: All applicable non-destructive fish sampling methods will be applied at sites along the relevant rivers in an attempt to gain a representation of the fish assemblage per river. All fish was identified to species level and returned unharmed back into the aquatic ecosystem. The fish results will be interpreted using existing fish indices such as the Fish Response Assessment Index (FRAI). • Aquatic macro-invertebrates by the application of the SASS5 (South African Scoring System) protocol. The Integrated Habitat Assessment System (IHAS) method will be used to assess the invertebrate specific habitats.

1.4 PES & EIS assessment brief

This specialist study, relating to the SAPPI Dam project activities in the Ngodwana River catchment, forms part of the process to compile the Water Use License Application (WULA), which will be reviewed by the relevant competent authorities, mainly the Department of Water & Sanitation (DWS).

The purpose of this assessment process is to investigate the impact of implementing the proposed activities (project specifics are included in Section 4.3) within the project footprint of the SAPPI Ngodwana project area.

Since the project activities in the project area will impact on the Ngodwana 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 process.

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.

Indices to determine **Ecological Categories** for each component are:

- Hydrological Driver Assessment Index (HAI)
- Geomorphological Driver Assessment Index (GAI)
- Physico-chemical Driver Assessment Index (PAI)
- Fish Response Assessment Index (FRAI)
- Macro-Invertebrate Response Assessment Index (MIRAI)
- Riparian vegetation Response Assessment Index (VEGRAI)

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.

2. Biophysical Background of the Catchment

The most recent vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006), maps the vegetation of the study area as **Legogote Sour Bushveld** (**SVI 9**) in the Lowveld Bioregion**.**

Distribution

Mpumalanga and Limpopo Provinces: Lower eastern slopes and hills of the northeastern escarpment from Mariepskop in the north through White River to the Nelspruit area extending westwards up the valleys of the Crocodile, Elands and Houtbosloop Rivers and terminating in the south in the Barberton area. Altitude 600–1 000 m and higher in places.

Vegetation & Landscape Features: Gently to moderate. Sloping upper pediment slopes with dense woodland including many medium to large shrubs often dominated by *Parinari curatellifolia* and *Bauhinia galpinii* with *Hyperthelia dissoluta* and *Panicum maximum* in the undergrowth. Short thicket dominated by *Vachellia ataxacantha* occurs on less rocky sites. Exposed granite outcrops have low vegetation cover.

Geology & Soils: Most of the area is underlain by gneiss and migmatite of the Nelspruit Suite, but the southern part occurs on the potassium-poor rocks of the Kaap Valley Tonalite (both Swazian Erathem). The westernmost parts of the distribution are found in Pretoria Group shale and quartzite (Vaalian). Archaean granite plains with granite inselbergs and large granite boulders also occur. Soils are of Mispah, Glenrosa and Hutton forms, shallow to deep, sandy or gravelly and well drained. Diabase intrusions are common, giving rise to Hutton soils.

Climate: Summer rainfall with dry winters. MAP from about 700 mm on the footslopes of the escarpment in the east to about 1 150 mm where it borders on grassland at higher altitude to the west. Frost infrequent to occasional at higher altitudes. Mean monthly maximum and minimum temperatures for Nelspruit 35.7°C and 1.6°C for October and July, respectively. Corresponding values for Barberton-Agr 36.0°C and 0.8°C for October and June, respectively. Both weather stations lie at the eastern edge of the unit at lower altitude.

Conservation: Endangered. Target 19%. About 2% statutorily conserved mainly in the Bosbokrand and Barberton Nature Reserves; at least a further 2% is conserved in private reserves including the Mbesan and Kaapsehoop Reserves and Mondi Cycad Reserve. It has been greatly transformed (50%), mainly by plantations and also by cultivated areas and urban development. Scattered alien plants include *Lantana camara, Psidium guajava* and *Solarium mauritianum.* Erosion is very low to moderate.

Remark: At places on the footslopes this vegetation becomes very dense and is transitional to forest in kloofs on the eastern slopes of the escarpment.

Table 1: SVI 9 Legogote Sour Bushveld – status.

Name of vegetation type	Legogote Sour Bushveld
Code as used in the Book - contains space	SVI9
Conservation Target (percent of area) from NSBA	19%
Protected (percent of area) from NSBA	1.6% (+2.3%)

Remaining (percent of area) from NSBA	50.4%
Description of conservation status from NSBA	Endangered
Description of the Protection Status from NSBA	Poorly protected
Area (sqkm) of the full extent of the Vegetation Type	3538.14 (354 000 ha)
Name of the Biome	Savanna Biome
Name of Group (only differs from Bioregion in Fynbos)	Lowveld Bioregion
Name of Bioregion (only differs from Group in Fynbos)	Lowveld Bioregion

Catchment and Wetland Setting

The farms the SAPPI Ngodwana project area is situated in, is located in the Crocodile River Sub-Water Management Area which form part of the Inkomati drainage system. The project site is located in quaternary catchment X21H and the Ngodwana River (X21H-01060) runs through the project area (Figure 10).

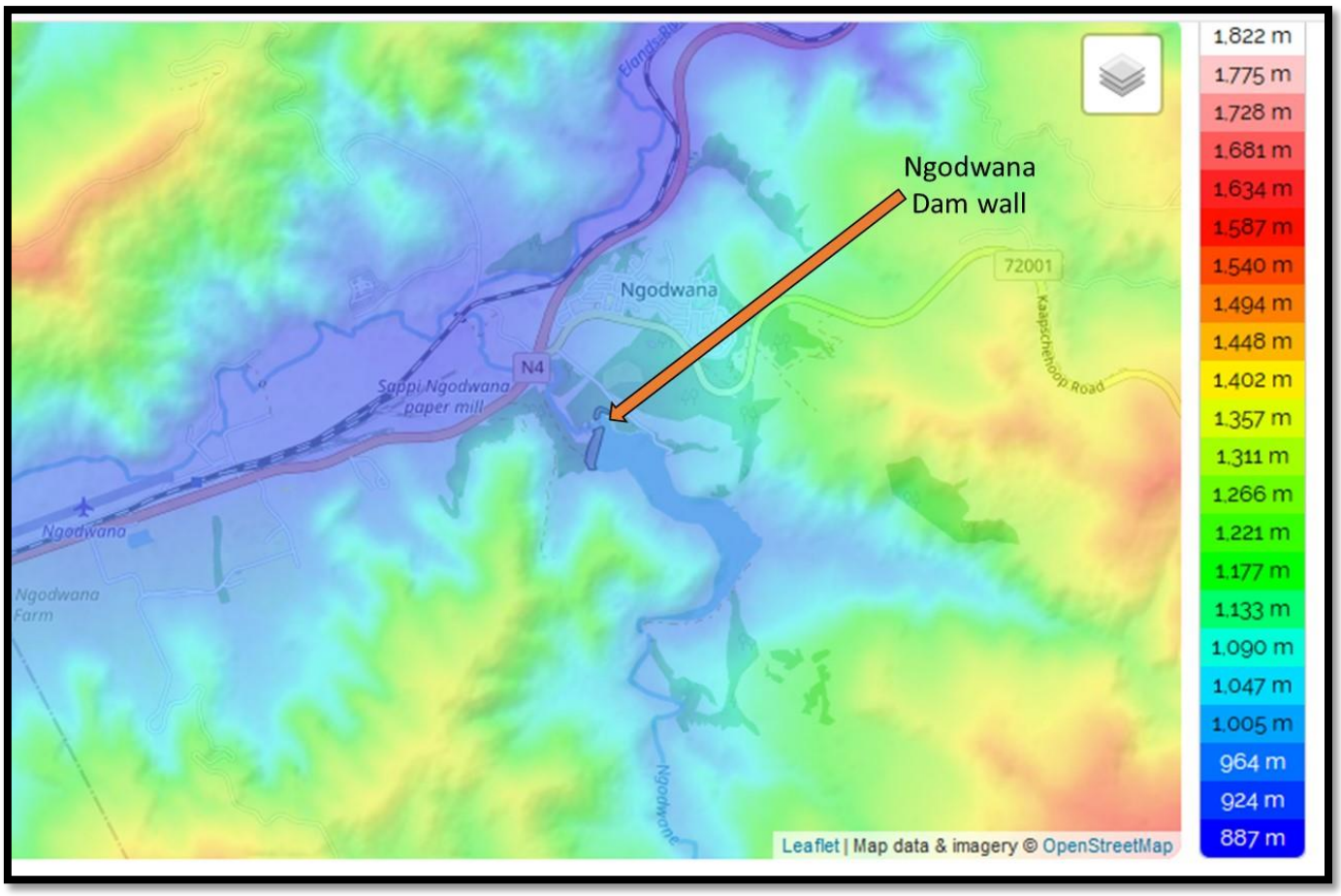

Figure 10: Most of the project area is situated in the valleys of the Crocodile and Ngodwana rivers and the altitude of these areas varies from *c*. 1090 to 1005 mamsl.

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 X21H with the development taken place within the catchment of the Ngodwana River in the Northern Escarpment Mountains (10.02) Ecoregion.

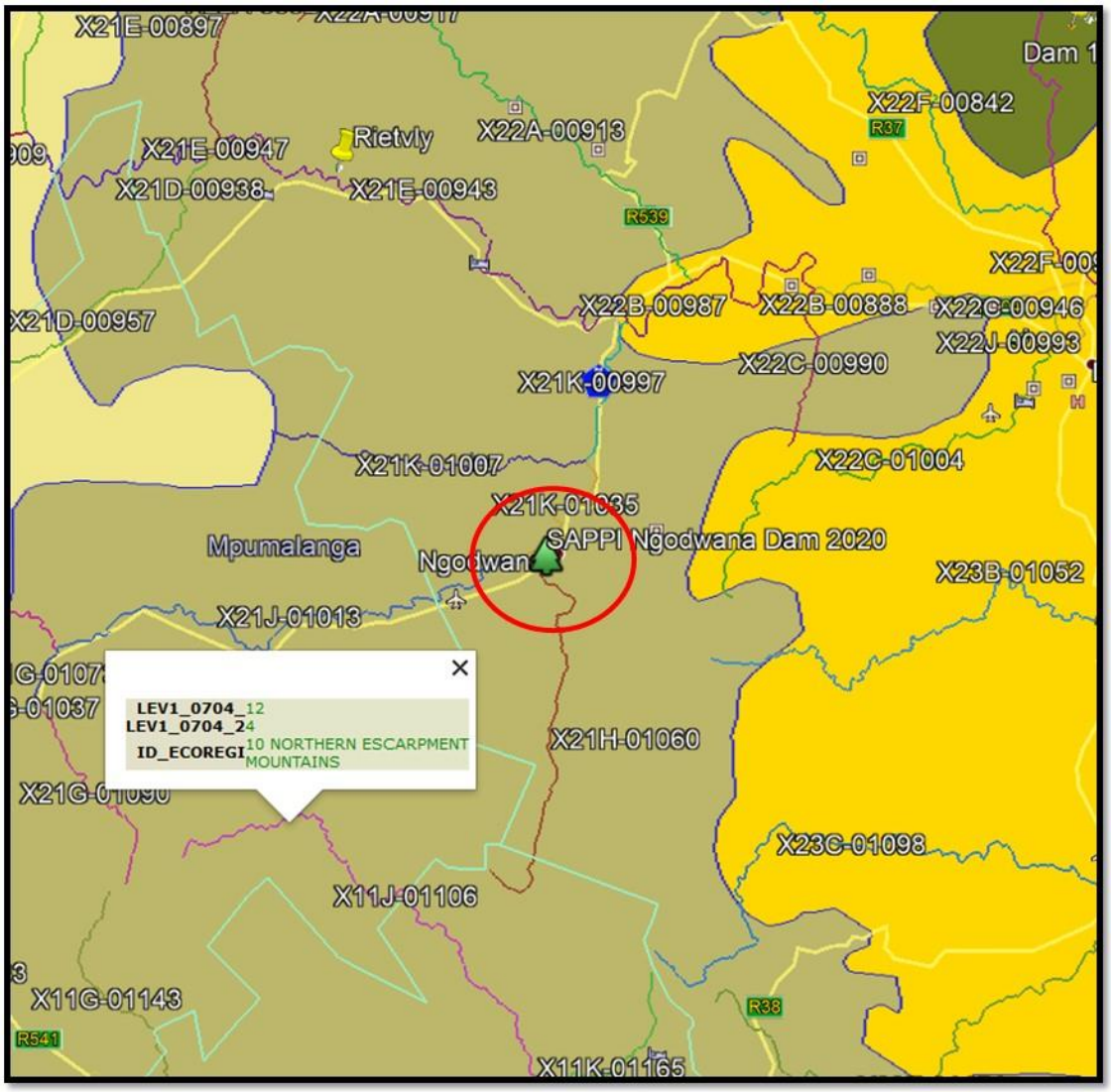

Figure 11: The Project Area is situated in the Northern Escarpment Mountains (10.02) Ecoregion according to the Water Resource Classification System (DWS, 2014).

This is a mountainous area characterised by closed hills and mountains with moderate to high relief and vegetation comprising North-Eastern Highveld Grassland and Lowveld Bushveld types. Patches with Afromontane Forest are scattered throughout the region (Kleynhans et al., 2005).

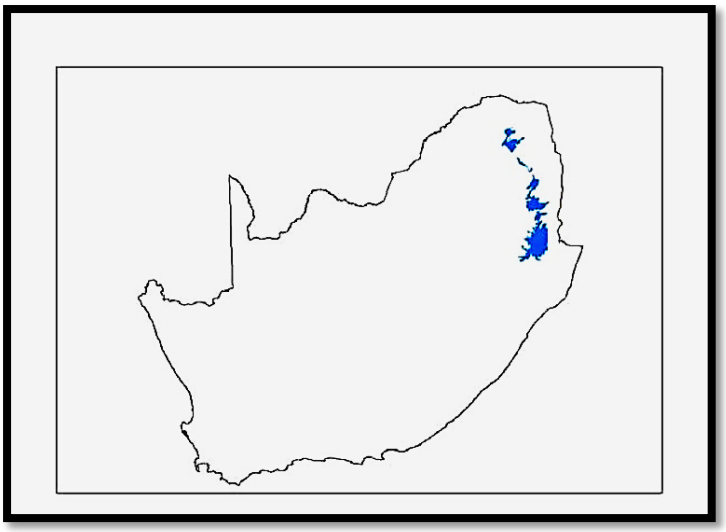

Figure 12: The Northern Escarpment Mountains (10.02) Ecoregion according to the Preliminary Level I River Ecoregional classification System for South Africa.

Generally, this ecoregion can be regarded as transitional between the Lowveld and the Northern Escarpment. Towards the south, larger rivers such as the Great Usutu and Pongolo have some of their sources here, while perennial tributaries commonly contribute to the flow of larger rivers along the length of the region.

- Mean annual precipitation: Moderate to high.
- Coefficient of variation of annual precipitation: Moderate to very low.
- Drainage density: Generally medium
- Stream frequency: Low/medium to medium high
- Slopes <5%: Varies from <20% to 25 – 50%.
- Median annual simulated runoff: Moderate/high to high.
- Mean annual temperature: Cool to moderate

Size = 16140.3 km^2

Table 2: Main attributes of the North Eastern Highlands Ecoregion.

MAIN ATTRIBUTES	**NORTH EASTERN HIGHLANDS**
Terrain Morphology: Broad division (dominant types in bold) (Primary)	**Plains; Moderate Relief** Open Hills, Lowlands, Mountains; Moderate to High Relief Closed Hills, Mountains; Moderate and High Relief
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld; Mixed Lowveld Bushveld; **Sour Lowveld Bushveld;** Natal Lowveld Bushveld (limited) **North Eastern Mountain Grassland;** Patches Afromontane Forest
Altitude (m a.m.s.l) (primary)	300-1300 (1300-1500 limited)
MAP (mm) (modifying)	400 to 1000
Coefficient of Variation (% of annual precipitation)	<20 to 30
Rainfall concentration index	50 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp. (°C)	16 to 22
Mean daily max. temp. (°C): February	24 to 32

Mean daily max. temp. (°C): July	18 to>22
Mean daily min. temp. (°C): February	14 to 20
Mean daily min temp. (°C): July	2 to 10
Median annual simulated runoff (mm) for quaternary catchment	20 to >250

3. Standard Methods proposed for the DWS authorisation process

As partial requirement for the DWS licensing requirements protocol, specific biodiversity surveys were recommended by the environmental consultant. The terms included for this investigation are as follow:

- Assess the ecological status, importance and sensitivity of the site as required for section 21 (c) and (i) water uses by the Department of Water and Sanitation (DWS),

- Aquatic and riparian surveys are proposed in the riverine habitats in the vicinity of the proposed development. The objective of this survey is to provide information on the aquatic environment of the proposed development regarding the fish and macro-invertebrate integrity, integrity of the aquatic habitat and possible impacts and mitigation.

For the purposes of this report, the site was assessed during 5 -10 July 2020.

Tasks undertaken during this study are listed below and indicated according to the task numbering in the Section 21 (c) & (i) Supplementary Water Use Information directive (DW775/781. Edition 7 July 2009).

1.1 Locality

Task 1.1.1. Provide a description of the location of the watercourse at which the water use/s is to take place

This information was obtained during the field study survey.

Task 1.1.2 Provide a locality map/s indicating the relevant catchment, surrounding land use, towns, infrastructure etc.

Make use of existing information.

Task 1.1.3 Provide the catchment reference number.

Obtain the catchment reference number from the DWS documents.

1.2 Description

Task 1.2.1 Provide the name and/or description of the affected watercourse.

Obtain the name from the DWS documents (if the stream course is named) and the description of the affected watercourse was obtained during the field study survey.

Task 1.2.2 Provide a map indicating the segment and affected reach/es of the watercourse in which the water use/s is to take place and which indicates/delineates the regulated area.

Obtain the map from of existing resources.

Task 1.2.2.1 The extent of the riparian habitat.

Riparian delineation and habitat evaluation was done according to the DWAF Guidelines (2005) and DWAF updated manual (2008).

Task 1.2.3 Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

3.1 PES and EIS of watercourse

For the Risk Assessment, a PES and EIS for the watercourse must be supplied:

Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

- Flow and sediment regimes at appropriate flows
- Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime
- Riparian and Instream Habitat.

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 required 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, focussed 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.

Following are additional aspects and processes that play a role in the determination of the current state (Present Ecological State or PES) of the affected reach/es of the watercourse.

a) **EcoClassification**

EcoClassification refers to the determination and categorisation of the Present Ecological State (PES) (health or integrity) of various biophysical attributes of rivers compared to the natural (or close to natural) reference condition. The purpose of EcoClassification is to gain insight 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.

The state of the river is expressed in terms of biophysical components:

- Drivers (physico-chemical, geomorphology, hydrology), which provide a particular habitat template; and
- Biological responses (fish, riparian vegetation, riverine fauna (other than fish) and aquatic invertebrates).

During recent years DWS has published the *River EcoClassification* series of methods used to determine the health of rivers and streams in South Africa. As part of this series the methods for ecological status determination and the classification of riparian and aquatic systems, is published in Module A: *EcoClassification and EcoStatus Determination* (Kleynhans *et al*, 2009). The following sections are extracted and modified (where appropriate) from the last mentioned authors.

b) **Present Ecological State (PES)**

The PES of the river is expressed in terms of various components: That is, **drivers** (physico-chemical, geomorphology, hydrology) and **biological responses** (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus. A rule-based procedure is followed to assign each component an Ecological Category for the PES (on a scale of A to F) using the following information:

- Biophysical surveys conducted during the project.
- Information and data from historical surveys, databases and reports.
- Aerial photographs and videos.
- Land-cover data.
- Internal Strategic Perspective (ISP) reports of DWS.
- Expert knowledge is regularly used to estimate the degree of change to a particular component.

Different processes are followed for each component to assign a category from A→F (where A is natural, and F is critically modified) (Table 3) (DWS, September 2013).

Table 3: Ecological Categories (ECs) and descriptions (see also Appendix 2)

EC	Description of EC
A	Unmodified, natural.
A/B	Boundary category between A and B.
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.
B/C	Boundary category between B and C.

C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
C/D	Boundary category between C and D.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
D/E	Boundary category between D and E.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
E/F	Boundary category between E and F.
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

It must be emphasised that the A→F scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum. For practical purposes, these situations are referred to as boundary categories and are denoted as B/C, C/D etc. The B/C boundary category, for example, is indicated as the light green to dark-blue area in Figure 13.

Figure 13: The continuum on an A to F scale for rating Ecological Category

The models for each component all use a swing ranking system in which key ecological components are ranked and weighted to provide consistent results (Appendix 2 - finer scale).

c) **Trend**

Trend is viewed as a directional change in the attributes of the drivers and biota (as a response to drivers) at the time of the PES assessment. A trend can be absent (close to natural or in a hanged state but stable), negative (moving away from reference conditions) or positive (moving back towards natural - when alien vegetation is cleared, for instance). The ultimate objective is to determine if the biota have adapted to the current habitat template or are still in a state of flux. Generally such an assessment can be approached from a driver perspective. This means that there can be a positive or negative trend response from the biota if the drivers (specifically geomorphology and water quality) are still in a directional state of change (+ or -).

It must be emphasised that the A→F scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum. For practical purposes, these situations are referred to as boundary categories and are denoted as B/C, C/D etc. The B/C boundary category, for example, is indicated as the light green to dark-blue area in Figure 13.

Task 1.2.3.1 Flow and sediment regimes at appropriate flows.

Flow and sediment regimes at appropriate flows will be obtained from existing DWS data base and other relevant studies.

PES supporting information

The PESEIS data from the Department of Water and Sanitation Desktop PESEIS assessment (DWS, 2014), supplies most of the current status information of the relevant sub-quaternary river reaches (SQRs) for South Africa. The objective of the PESEIS is to provide desktop level information on ecological issues as it relates to the protection and management of SQRs.

Task 1.2.3.2 Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime.

Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime will be obtained from existing DWS data base and other relevant studies.

Task 1.2.3.3 Riparian and In-stream Habitat.

Aquatic habitat assessments

Habitat assessments have been carried out to identify situations in which changes in habitat are responsible for changes in faunal populations. The nature and diversity of habitats available at the sampling point are factors of overwhelming influences on the biota present. The diversity of available biotopes itself is often incorporated in information on the conservation status of the river.

The habitat indices to be used in this survey are the Invertebrate Habitat Assessment System (IHAS) and the Habitat Quality Index (HQI).

a) IHAS (Integrated Habitat Assessment System)

b) HQI (Habitat Quality Index)

- **IHAS** (Integrated Habitat Assessment System, version 2) habitat assessments were performed in conjunction with the SASS5 assessment to determine the role of habitat in the observed biotic integrity based on the macro-invertebrates.

- General habitat assessment (including photographic assessment) was done to assess the general physical habitat condition of the sites and identify potential sources and impacts responsible for deterioration of the aquatic ecosystem.

Task 1.2.3.3.1 Morphology (physical structure).

Surveys were done at two sites in the Ngodwana River. The transects in and around the sites were surveyed for the different parameters (habitat, vegetation and fauna). At each of these sites, one complete transect was surveyed: from the terrestrial habitat, through the riparian and aquatic habitats, to a predetermined area in the

terrestrial habitat on the opposite side of each site. All the sites were evaluated according to the Instream Index of Habitat Integrity (IIHI) and the Riparian Index of Habitat Integrity (RIHI).

Task 1.2.3.3.2 Vegetation.

a) 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 characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent 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 projected in Figure 14.

In addition to the DWA&F Guidelines (2005) and DWA&F 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.

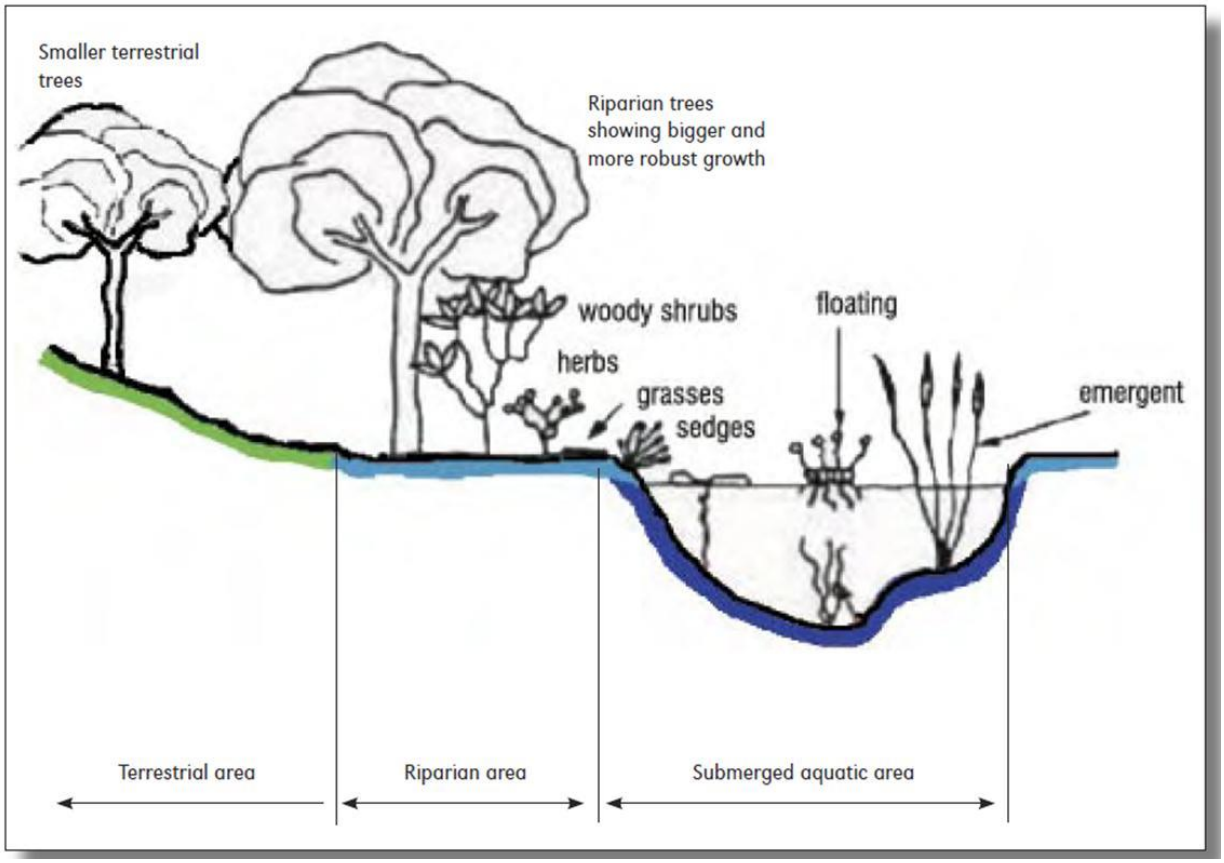

Figure 14: A cross section through a typical riparian area (DWAF Guidelines, 2008).

Buffers

Aquatic buffer zones which 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 15.

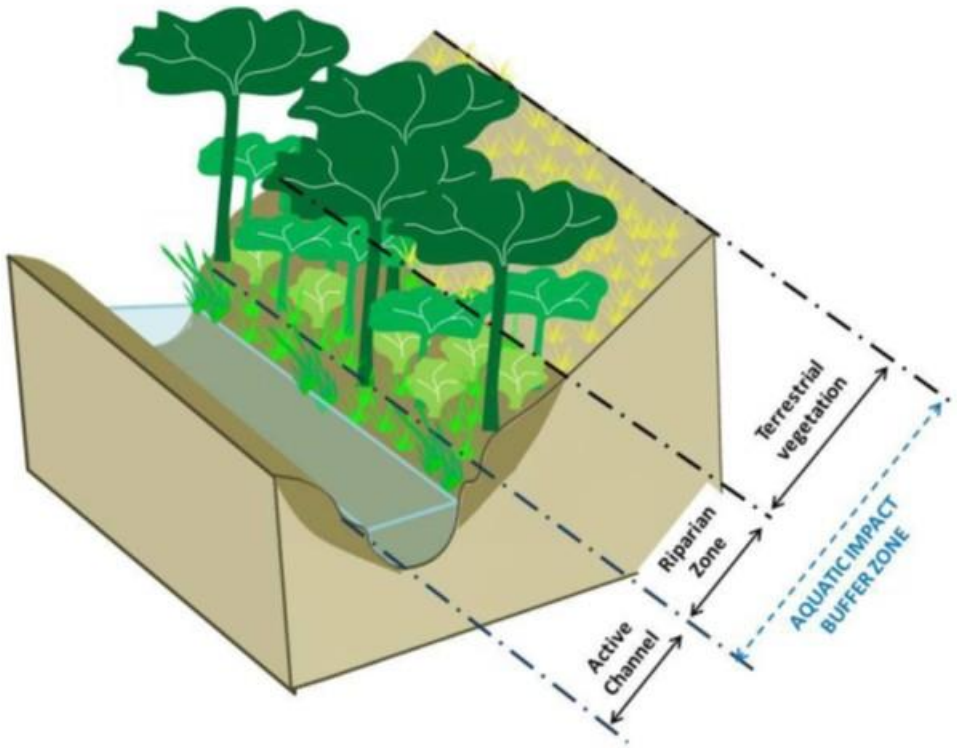

Figure 15: Schematic diagram indicating the boundary of active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone (Macfarlane et al, 2015).

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.

b) 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.

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 step-wise assessment process for buffer zone determination (Macfarlane and Bredin, 2017) is illustrated if Figure 16.

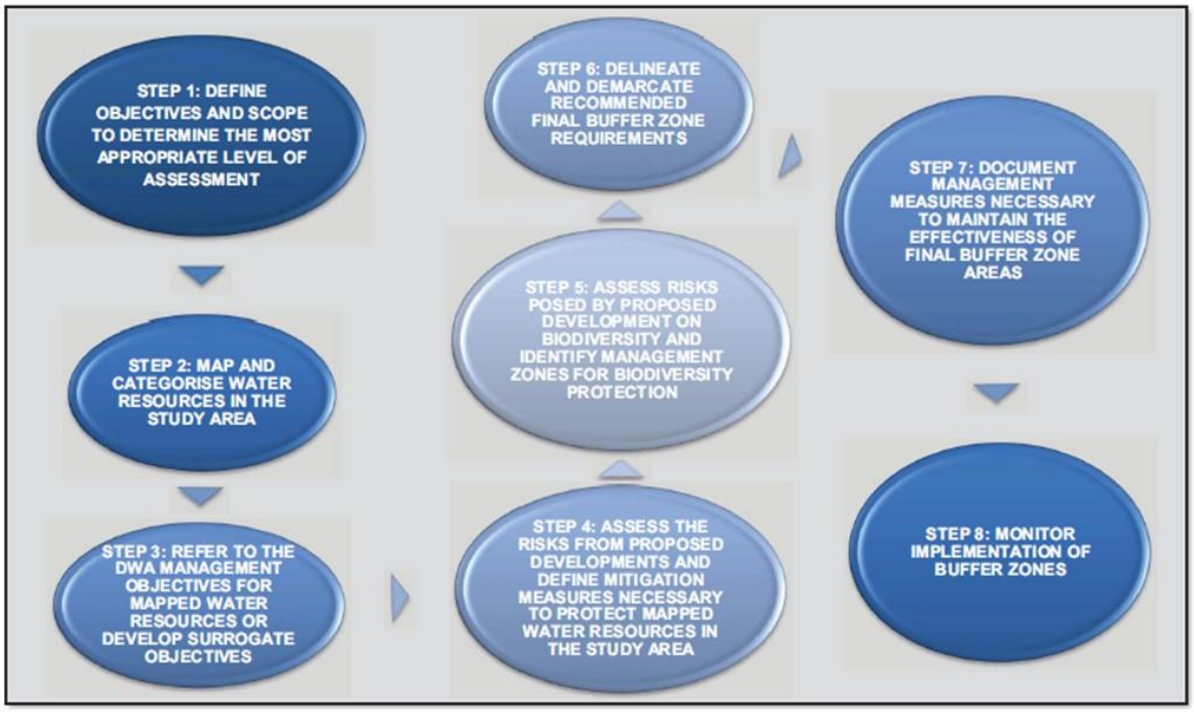

Figure 16: Overview of the step-wise assessment process for buffer zone determination (Macfarlane and Bredin, 2017).

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.

Task 1.2.3.4 Biota – Aquatic invertebrates and Fish

Aquatic 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 incorporate 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 recognized bio-parameters and methods will be used:

- Aquatic invertebrates: South African Scoring System version 5 (SASS5).

- Fish communities: Fish Response Assessment Index (FRAI). 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.
- Riparian vegetation: Riparian Vegetation Index (VEGRAI)

Aquatic biota

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 incorporate the habitat aspects, a proper basis for biological diversity could be obtained.

The Aquatic specialist assessed the condition of the proposed development and its impact on the aquatic environment. The following recognized bio-parameters and methods were used:

- Aquatic invertebrates (South African Scoring System version 5 — SASS5).
- Fish communities (Fish Response Assessment Index - FRAI)
- Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

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 (30 x 30 cm square with 0.5 mm 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 follow:

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 done by method of kick-sampling, but 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 similar to that of sand.

Marginal vegetation (MV): *This is the overhanging grasses, bushes, twigs and reeds from the riverbank.* Sampling is done 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 done by the application of 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 and it was attempted to sample 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.

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 will be 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 sketched indicating the different habitats and the various components thereof. Sampling takes place in each

of the different habitats. These different habitats 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 finished. Each habitat shocked is timed. It is necessary to take care (as far as possible) when shocking so as not to disturb the rest of the habitat still to be worked. As each habitat is completed the fish species caught, are identified, recorded and released back into their respective habitats.

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 habitats. As with method (a) all aspects of the habitat type are recorded as well as the fish species, numbers, age class and health. The number of throws / efforts per a habitat is also recorded.

Task 1.2.4 Describe the ecological importance and sensitivity (EIS) as well as the Socio-cultural Importance (SI) of the affected reach/es of the watercourse including the functions.

Ecological Importance and Sensitivity (EIS)

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

This approach estimates and classifies the ecological importance and sensitivity of the streams in a catchment by considering a number of components surmised to be indicative of these characteristics.

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

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species

diversity should be taken into account for both the instream and riparian components of the river.

- Habitat diversity should also be considered. This can include specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc.
- With reference to the first two points, biodiversity in its general form should be taken into account as far as the available information allows.
- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species should be considered.
- The presence of conservation or relatively natural areas along the river section should also serve as an indication of ecological importance and sensitivity.
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes should also be considered. Consideration of both the biotic and abiotic components is included here.

More detail and tables regarding the assessment of ecological importance and sensitivity can be obtained from the document by Kleynhans et al (DWA&F, 1999).

Ecological Category (EC)

The PES is assessed according to six metrics that represents a very broad qualitative assessment of both the instream and riparian components of a river. The metrics used in the PES model and an explanation of what they refer to is explained in Table 4 (DWA, 2013). Each metric is scored from zero to five.

Table 4: PES metrics and explanations (DWA, September 2013)

Metrics	Comment
Potential instream habitat continuity modification	Modifications that indicate the potential that instream connectivity may have been changed from the reference. Indicators: Physical obstructions (e.g. dams, weirs, causeways). Flow modifications (e.g. low flows, artificially high velocities, physico-chemical "barriers").
Potential riparian/wetland habitat continuity modification	Modifications that indicate the potential that riparian/wetland connectivity may have been changed. Indicators: Physical fragmentation, e.g. inundation by weirs, dams; physical removal for farming, mining, etc.
Potential instream habitat modification activities.	Modifications that indicate the potential of instream habitats that may have been changed from the reference. Includes consideration of the functioning of instream habitats and processes, as well as habitat for instream biota specifically. Indicators: Derived likelihood that instream habitat types (runs, rapids, riffles, pools) may have changed in frequency (temporal and spatial). Assessment is based on flow regulation, physical

	modification and sediment changes. Land use/land cover (erosion, sedimentation), abstraction etc. may indicate the likelihood of habitat modification. The presence of weirs and dams are possible indicators of causes of instream habitat change. Certain introduced biota (e.g. carp, crustacea and mollusca) may also cause habitat modification. Eutrophication and resulting algal growth as well as macrophytes may also result in substantial changes in habitat availability.
Potential riparian/wetland zone modifications	Modifications that indicate the potential that riparian/wetland zones may have been changed from the reference in terms of structure and processes occurring in the zones. Also refers to these zones as habitat for biota. Indicators: Derived likelihoods that riparian/wetland zones may have changed in occurrence and structure due to flow modification and physical changes due to agriculture, mining, urbanization, inundation etc. Based on land cover/land use information. The presence and impact of alien vegetation is also included.
Potential flow modification	Modifications that indicate the potential that flow and flood regimes have been changed from the reference. Indicators: Derived likelihood that flow and flood regimes have changed. Assessment based on land cover/land use information (urban areas, inter-basin transfers), presence of weirs, dams, water abstraction, agricultural return flows, sewage releases, etc.
Potential physico-chemical modification activities	Activities that indicate the potential of physico-chemical conditions that may have changed from the reference. Indicators: Presence of land cover/land use that implies the likelihood of a change of physico-chemical conditions away from the reference. Activities such as mining, cultivation, irrigation (i.e. agricultural return flows), sewage works, urban areas, industries, etc. are useful indicators. Algal growth and macrophytes may also be useful response indicators.

A six-point rating system (0-5) is followed, where metrics of the drivers and biological responses are scored in terms of the degree to which they have changed compared to the natural or close-to-natural reference (if necessary, half points such as 1.5 and so on can also be used):

0 = No discernable change from reference/close to reference

1 = Small modification from reference

2 = Moderate modification from reference

3 = Large modification from reference

4 = Serious modification from reference

5 = Extreme modification from reference

These qualitative ratings are expert knowledge-based, and are assessed by the relevant expert in a particular speciality. It is preferable that the relative difference between for example, 0 – 1 be the same as between 3 – 4. However, this is difficult to control and is currently exclusively based on expert knowledge.

The calculation of the Ecological Categories of drivers and biological responses is done by totalling the weighted scores and expressing this as a percentage of the maximum. This value indicates the percentage change away from the expected reference and must be subtracted from 100 to arrive at the percentage value that represents the EC. This value is used to place the EC of the component in a particular category that ranges from A to F (Table 5).

Table 5: Generic ecological categories for EcoStatus components (Kleynhans et al, 2009).

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

After the Ecological Categories of the driver and biological response components are determined, there remains the issue of how to integrate these to provide an indication as to the EcoStatus. Deriving the EcoStatus from the Ecological Categories of components is based on the following principles (Kleynhans *et al*, 2005):

- The Ecological Categories of the physical drivers (hydrology, geomorphology and physico-chemical integrity) are not integrated to provide an indication of the EcoStatus purely based on the drivers.
- Information on the driver metrics, i.e. how different they are from the

reference is considered when assessing the biological responses. This is an expert knowledge approach and the attributes and environmental requirements of the biota should be considered when doing this.
- The biological responses are considered to provide the best indication of the EcoStatus of the river because it integrates the effect of the driver components

The steps in deriving the EcoStatus are:

- Criteria are considered that provide an indication of the relative indicator value of the two instream biological groups, fish and invertebrates. These criteria are used to weigh the relative importance of these two groups as indicators of in-stream health. The Ecological Categories of the two biological groups are proportioned according to these weights and combined to provide the in-stream Ecological Category.
- A suitable index to get an indication of riparian vegetation Ecological Category within the EcoStatus context is not yet available. Consequently the riparian vegetation zone can only be considered conceptually and in terms of its influence on the in-stream EC. In this regard the influence, importance and integrity of the riparian vegetation zones, i.e. marginal, lower and upper vegetation, are considered in terms of its significance for the instream biota. Some indication of the health of the riparian vegetation can also be gleaned from the geomorphological driver where certain metrics of this driver do serve as indicators.
- The riparian vegetation Ecological Category and the instream Ecological Category are integrated based on a proportioning of weights according to the availability of high confidence information. This provides the EcoStatus of the river.
- Where riparian vegetation information is insufficient, the instream EC is used as the best indicator of the EcoStatus of the river.

The *modus operandi* followed by DWS's Directorate: Resource Directed Measures (RDM) is that, if the EIS is high or very high, the ecological aim should be to improve the condition of the river. However, the causes related to a particular PES should also be considered to determine if improvement is realistic and attainable. This relates to whether the problems in the catchment can be addressed and mitigated. If the EIS evaluated as moderate or low, the ecological aim should be to maintain the river in its PES. Within the Ecological Reserve context, Ecological Categories A to D can be recommended as future states (REC - the Recommended Ecological Category) depending on the EIS and PES. Ecological Categories E and F PES are regarded as ecologically unacceptable, and remediation is needed.

a) <u>Socio-cultural Importance (SI)</u>

Make use of existing information.

> **<u>Task 1.2.5</u>** <u>Discuss existing land and water use impacts (and threats) on the characteristics of the watercourse.</u>

Make use of existing information, especially using the background data from the PESEIS project (DWA, September 2013).

Task 1.2.6 List and map sensitive environments in proximity of the project locality-sensitive environments include wetlands, nature reserves, protected areas, etc.

3.2 Establish Critical Biodiversity Areas

Maintaining biodiversity patterns and ecological processes and the ecosystem services derived from these, requires integrated management over large areas of land. The landscape approach to conservation is a system wide one where protected areas are embedded in a matrix of land-uses that strives for biodiversity compatibility. Herein biodiversity management objectives are integrated into the plans, decisions and practices of a wide range of land users. These land-use guidelines are designed to help achieve this (MTPA, 2014).

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.

To establish how important the site is for meeting biodiversity targets, a number of resources and tools are used. Specifically, the Land-Use Decision Support Tool (LUDS) and the MBCP 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.

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a. Land-Use Decision Support Tool (LUDS)

To establish how important the site is for meeting biodiversity targets, a number of resources and tools are used. Specifically, the Land-Use Decision Support Tool (LUDS) used extensively to compile the LUDS Report (BGIS, 2019). 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 guide for biodiversity planning but should not replace specialist ecological assessments.

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?

b. The Ecological Importance (EI) and Ecological Sensitivity (ES)

The EIS of SQs are assessed to obtain an indication of its vulnerability to environmental modification within the context of the PES. This would relate to the ability of the SQ to endure, resist and able to recover from various forms of human use.

c. Freshwater Ecosystem Priority Areas (FEPAs)

National Freshwater Ecosystem Priority Areas (NFEPA) map products provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or FEPAs. FEPA maps provide a single, nationally consistent information source for incorporating freshwater ecosystem and biodiversity goals into planning and decision-making processes. These maps are therefore directly applicable to the National Water Act, feeding into Catchment Management Strategies, classification of water resources, reserve determination, and the setting and monitoring of resource quality objectives. FEPA maps are also directly relevant to the National Environmental Management: Biodiversity Act (Act No. 10 of 2004; RSA, 2004), informing both the listing of threatened freshwater ecosystems and the process of bioregional planning provided for by this Act.

The base criteria of the river FEPA are the following: "Rivers had to be in a good condition (A or B PES) to be chosen as FEPAs" (Nel *et al*., 2011).

FEPAs provide an important input into EIAs, informing decision makers on freshwater ecosystems that need to be taken into account in environmental assessments and authorisations (Driver et al, 2011). FEPAs should inform the EIA process in the following way:

- The presence of a FEPA means that a freshwater specialist must be consulted for the assessment.

- Anticipated impacts on a FEPA that may result in an ecological condition lower than A or B should be ranked as having medium to high significance.
- Any activity that will have an overall residual impact on wetland or river FEPAs and their immediate surrounds greater than a low negative significance, is not acceptable from the point of view of managing and conserving freshwater ecosystems, and must be avoided.
- The cumulative effect of development impacts should ideally be considered in the case of sub-quaternary catchments associated with FEPAs (i.e. the specialist should be aware of other developments in the sub-quaternary catchment that are likely in the near future and should highlight possible cumulative impacts).
- Unavoidable development must require special mitigation measures that would reduce the overall impact of the activity or development to low negative significance, or must require a biodiversity offset.

If a river qualifies as a FEPA river, a four-step process should be followed for taking the FEPA into account in EIAs and will supply information on the Mlwati River as part of the Mpumalanga Tourism and Parks Agency (MTPA) systematic biodiversity plans. However, the Mlwati River and its immediate catchment is not a river FEPA and therefore the four-step route is not followed.

Task 3.2 Provide an assessment of the risks associated with the water use/s and related activities.

a) Section 21(c) and (i) Risk-Based Assessment and Authorisation Guideline (DWS, Edition 02, final October 2014)

In terms of section 22 of the NWA a person may only use water if it is permissible under Schedule 1, a continuation of an Existing Lawful Use (ELU), a General Authorisation (GA), a licence or the requirement for a licence has been dispensed with under section 22(3).

There are 11 different types of water uses contemplated in terms of the NWA Section 21, but the purpose of this Risk-Based Water Use Authorisation Guideline is to deal with section 21(c) and (i) water uses only.

Water use in terms of section 21(c) and (i) of the NWA is:

• (c) impeding or diverting the flow of water in a watercourse; and

• (i) altering the bed, banks, course or characteristics of a watercourse.

Unlike some water uses referred to in Section 21, e.g. (a) and (b) which are consumptive and which impacts are usually clearly evident, easier to manage and quantifiable, section 21(c) and (i) water uses are non-consumptive and their impacts more difficult to detect and manage. They are also generally difficult to clearly quantify.

However, if left undetected these impacts can significantly change various attributes and characteristics of a watercourse, and water resources, especially if left unmanaged and uncontrolled. Thus, the risks posed by Section 21(c) and (i) water uses on watercourses and water resources are an important consideration during the authorisation of these water uses.

Risk-Based Management is an adaptive management approach used for assessing and managing the impacts of particular water uses on a watercourse, the risks and hazards these pose and actions required to mitigate them. It is a very prudent and effective approach to be used in instances where the easy detection and quantification of impacts and risks are difficult to achieve.

b) **Risk Assessment using the Risk Matrix**

The Risk Assessment was done in accordance with the Risk Matrix (Based on DWS 2014 publication: Section 21 c and I water use Risk Assessment Protocol and as contained as Appendix A in GN509 of 26 August 2016) and it was carried out considering the risk rating of the proposed project activities after implementing mitigation measures.

Detailed methodology regarding the risk assessment is provided in Appendix 3.

4. Results

4.1 Locality

Task 1.1.1. Provide a description of the location of the watercourse at which the water use/s is to take place

Ngodwana Dam is next to Ngodwane and is located in Mpumalanga, South Africa. The Sappi Ngodwana Dam was constructed on the Farm Ngodwana 1030 JT., Ngodwana.
Ngodwana Dam is a 41 m high zoned earth fill Category III Dam and has a length of 7.69 kilometres. The dam is located on a tributary of the Elands River, Mpumalanga Province, directly upstream from the N4 highway and the Ngodwana Paper Mill, 40 km from Mbombela.

Figure 17: The Ngodwana River emerges from the Ngodwana Dam and flows past SAPPI Ngodwana Paper Mill to its confluence with the Elands River.

The planned project activities will take place in the area below the Ngodwana Dam and the river which forms part of the assessment is the Ngodwana River (X21H-01060). The study area is between the dam outlet and the N4 highway, close to the confluence of the Ngodwana River and the Elands River. The Ngodwana Dam is a man-made Ngodwana lake with a 10 m^3 χ 10^6 m^3 water storage facility that was constructed in the early 1980s on the lower Ngodwana River, a tributary of the Elands River. The SAPPI Paper Mill uses water stored in the Ngodwana Dam (owned and managed by Sappi).

Task 1.1.2 Provide a locality map/s indicating the relevant catchment, surrounding land use, towns, infrastructure etc.

The Ngodwana Dam is situated in the Ngodwana catchment, approximately 2 kilometres south of the town Ngodwana, Mpumalanga. Refer to Figure 18 for the position of the dam site. The coordinates of the dam outlet are 25°34'52.51"S and 30°40'24.93"E.

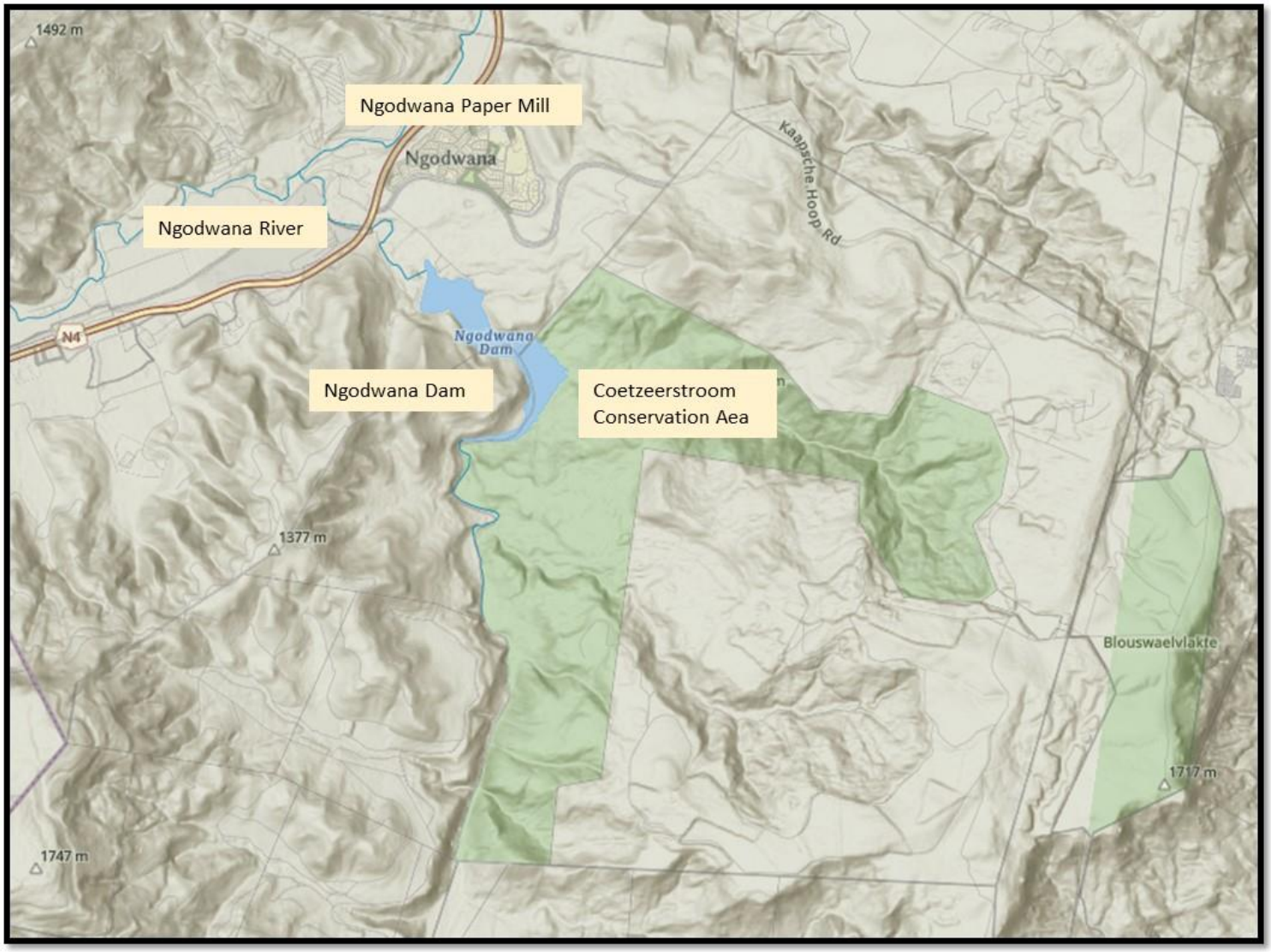

Figure 18: The Ngodwana Dam, illustrating the nearby town, SAPPI Mill and hilly topography.

Task 1.1.3 Provide the catchment reference number.

The catchment reference numbers were obtained from the DWS PESEIS documents. The project site in the Ngodwana River is situated in the X21H catchment, and the Sub-Quaternary Reach that the project is located in, is X21H-01060 (Figure 19). The Google Earth image in Figure 19 indicates the location of the Project Area in the Sub-Quaternary Reach X21H-01060.

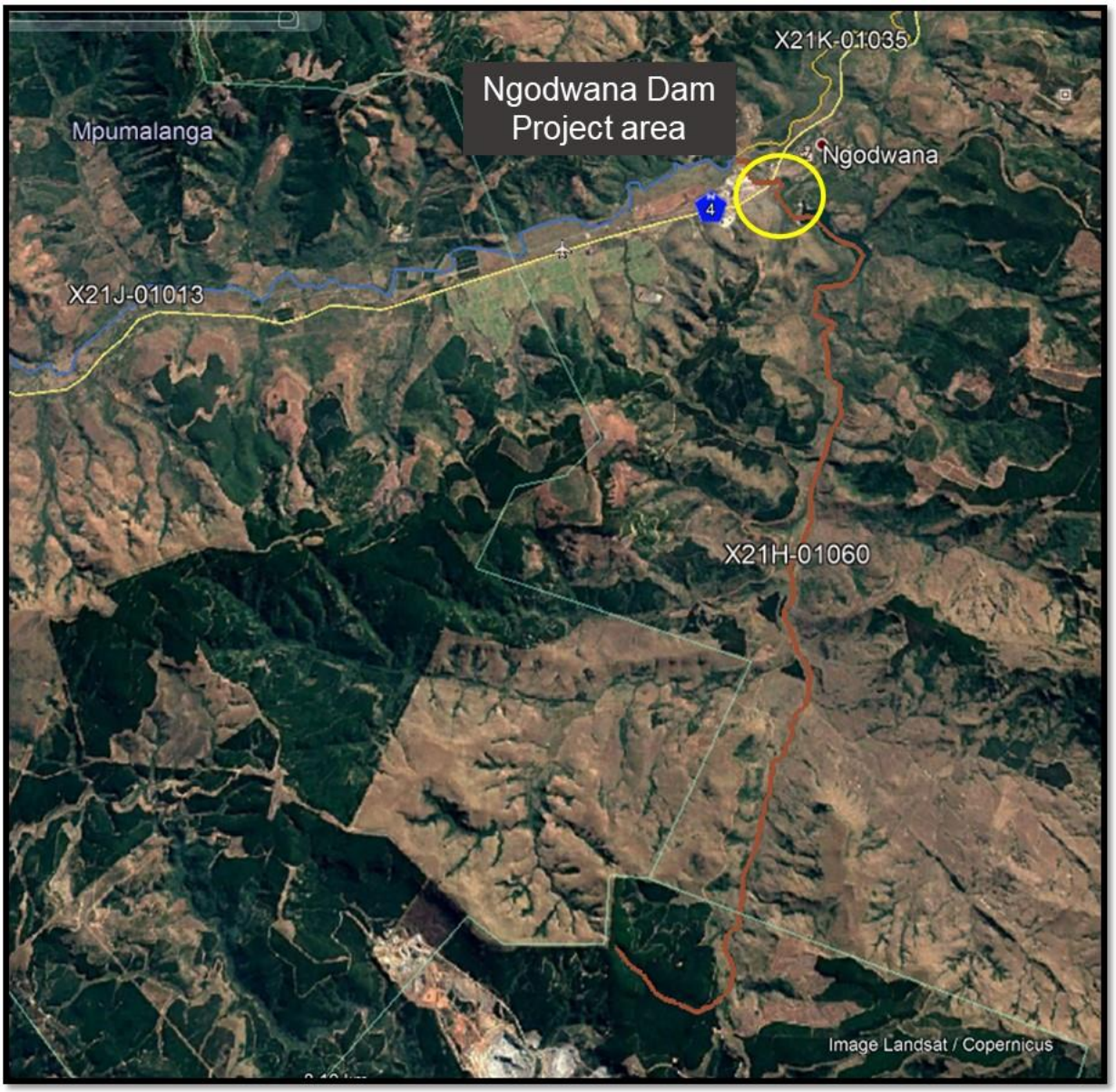

Figure 19: A Google Earth image indicates the location of the Project Area in the Sub-Quaternary Reach X21H-01060.

4.2 Description

Task 1.2.1 Provide the name and/or description of the affected watercourse.

The Ngodwana River is a tributary of the Elands River at an altitude ranging between 940 and 960 m.a.s.l. Its confluence with the Elands River is at the Ngodwana Sappi Paper Mill with the lower reaches impounded for water usage by the mill. The Ngodwana River is situated in the X21H catchment (Figure 19). The upper portion of the catchment drains commercial forestry land, with the lower portions flowing mostly through natural vegetation stocked with cattle.

The Ngodwana River firstly flows in an easterly direction before flowing in a northerly direction past the Ngodwana Pulp and Paper Mill towards the Elands River. The river falls within the upper foothills geomorphological zone, dominated by alluvial cobble-bed, rapids, riffles, runs, glides, and pools. Trees, shrubs, herbaceous plants, and grasses dominate the marginal zone, with commercial forestry and grassland with scattered trees and shrubs in the surrounding landscape (Roux, et al. 2016).

Task 1.2.2 *Provide a **map** indicating the segment and affected reach/es of the watercourse in which the water use/s is to take place and which indicates/delineates the regulated area, including:*

1.2.2.1 The extent of the riparian habitat.

Figure 20 presents a Google Earth image which indicates the segment and affected reach of the Ngodwana River in which the water use/s is to take place. It also delineates the regulated area in the Sub-Quaternary Reach X21H-01060.

Figure 20: The map which indicates the segment and affected reach of the Ngodwana River in which the water use/s is to take place and which indicates/delineates the regulated area (Yellow rectangle).

1.2.2.1 The extent of the riparian habitat.

The riverine environment of the Ngodwana 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: “River—a linear landform with clearly discernable bed and banks, which permanently or periodically carries a concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit” (Figure 21). Riverine vegetation is important for bank stabilization, where root structures minimise erosion of banks under moderate to high flows.

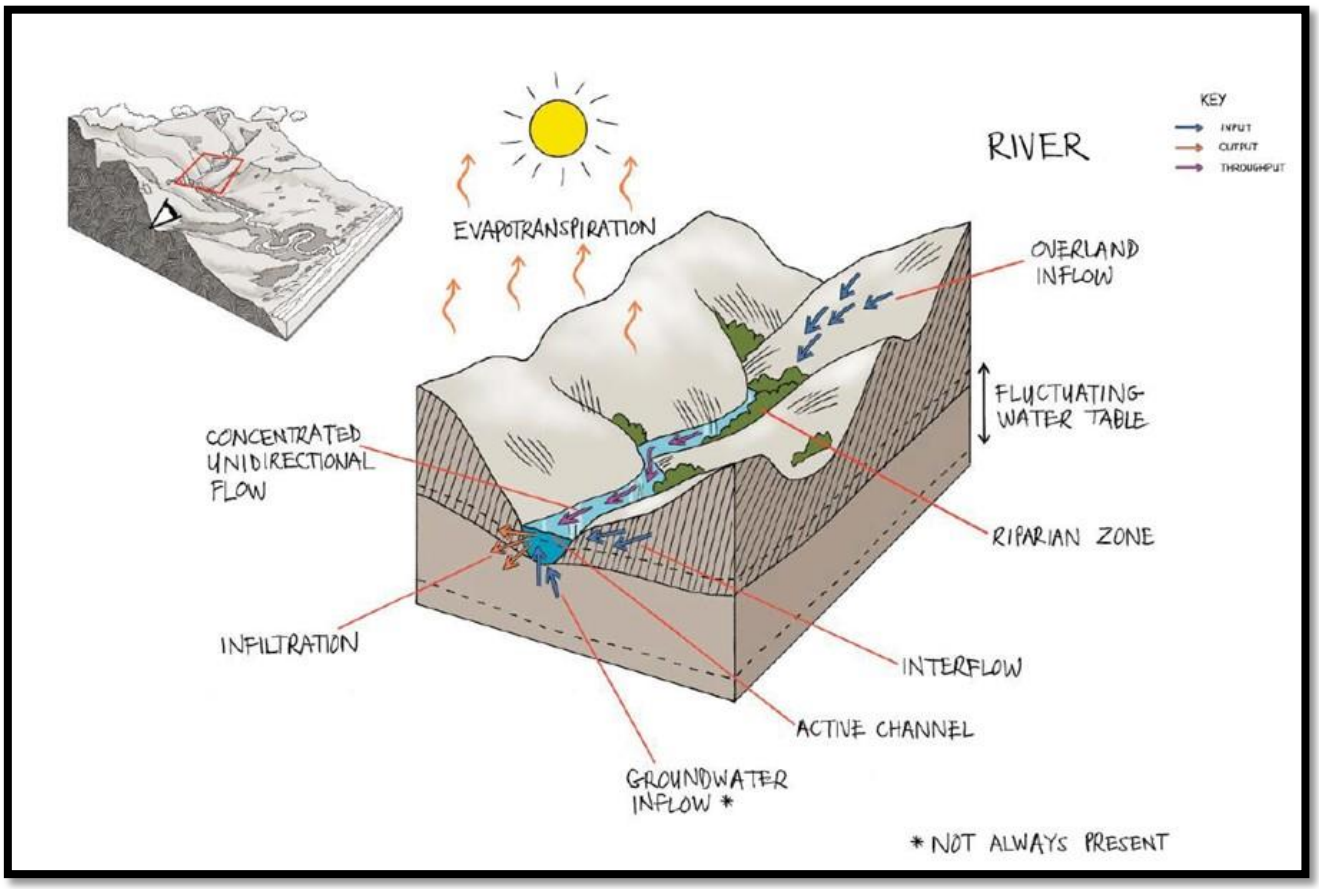

Figure 21: A diagram of a typical River (Ollis et al, 2013).

During the survey of the Ngodwana Dam project, the Ngodwana River environment was surveyed by doing 2 riparian transects in order to establish the extent of the riparian zone, the Present Ecological State of the areas, as well as identifying issues relating to possible impacts (current and future) in the study area.

Figure 22 consists of a map which was compiled by using a Google Earth image and it indicates the survey transects in the river and also supplies an indication of the human impact in the area surrounding these drainage lines. The coordinates of the transects are summarised in Table 6.

Table 6: The coordinates of the transects surveyed in the project area (see Figure 22).

Project site	Coordinates Start
Survey site 1	25°34'32.33"S 30°39'45.18"E
Survey site 2	25°34'55.75"S 30°40'15.58"E
Transect 1	25°34'32.64"S 30°39'44.31"E to 25°34'31.19"S 30°39'46.11"E
Transect 2	25°35'10.35"S 30°40'7.37"E to 25°34'49.49"S 30°40'18.36"E

The transects which were surveyed as part of the riparian delineation, were also assessed for the presence of all local flora which could potentially be influenced by the project activities. The two survey sites were surveyed for freshwater biota at the river points.

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 23 and 24 and the results for the vegetation survey for the areas are summarised in Table 7.

Transect 1 is a simple transect (71m) through the Ngodwana River north of the N4 highway where it was also accessible to do aquatic biota studies (Figure 23). This site is impacted by developments up to the edge of the riparian zone (Figure 24). The riparian zone consisted of a narrow band of riparian trees, and the riverbed is overgrown with Thatching reed (*Phragmites mauritianus*). The flow of the river here is medium to fast over cobble riffles and rocky rapids with good overhanging vegetation.

Transect 2 was done over the extensive of the dam wall (314m) to include a seepage area on the eastern side, run through wetland areas created by seepage from the dam environment, over the Nngodwana River below the dam spillway, and through a narrow floodplain to end against the macro-channel bank of the system (Figure 24).

At Transect 2 the Nngodwana River riparian zone proper consists of larger riparian trees on the channel banks, which extends into the wide seepage area of the dam. The river bed in this reach is scoured due to turbulent high flows over the dam spillway, forming pools surrounded by reeds. Here are less stones in current habitats than at Transect 1.

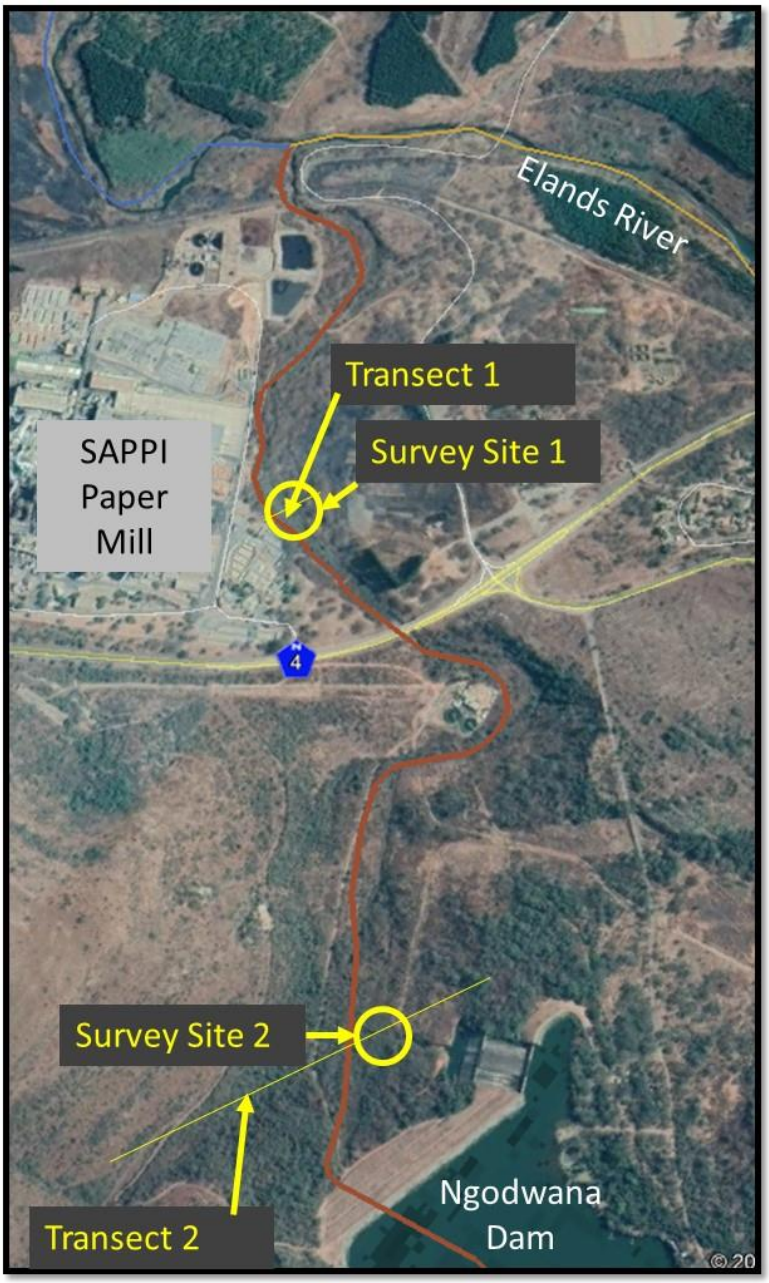

Figure 22: This Google Earth photo illustrates the placement of the riparian survey sites and transects in riparian zone of the project area.

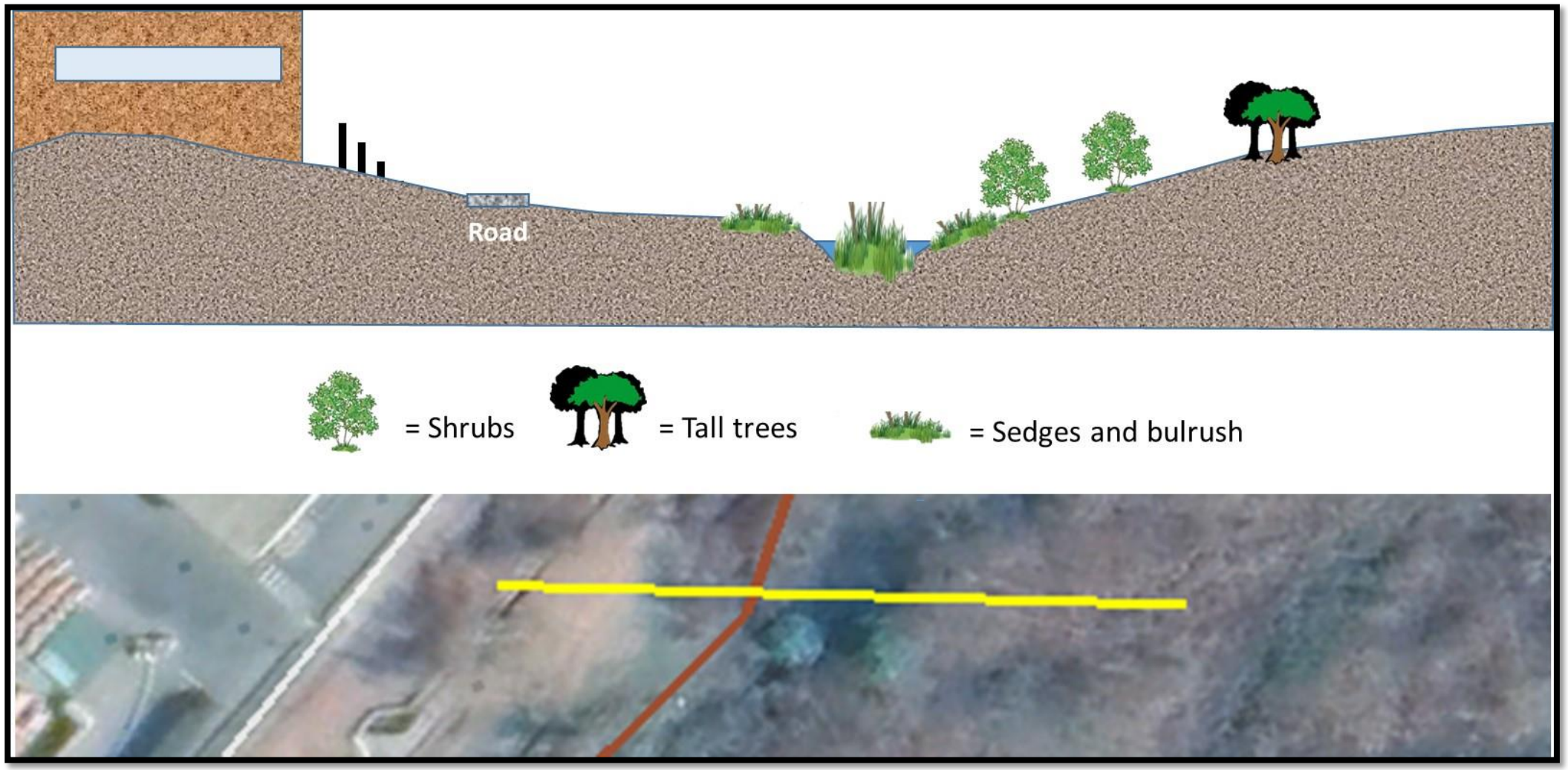

Figure 23: Transect 1 crossing the Ngodwana River bed and riparian zones.

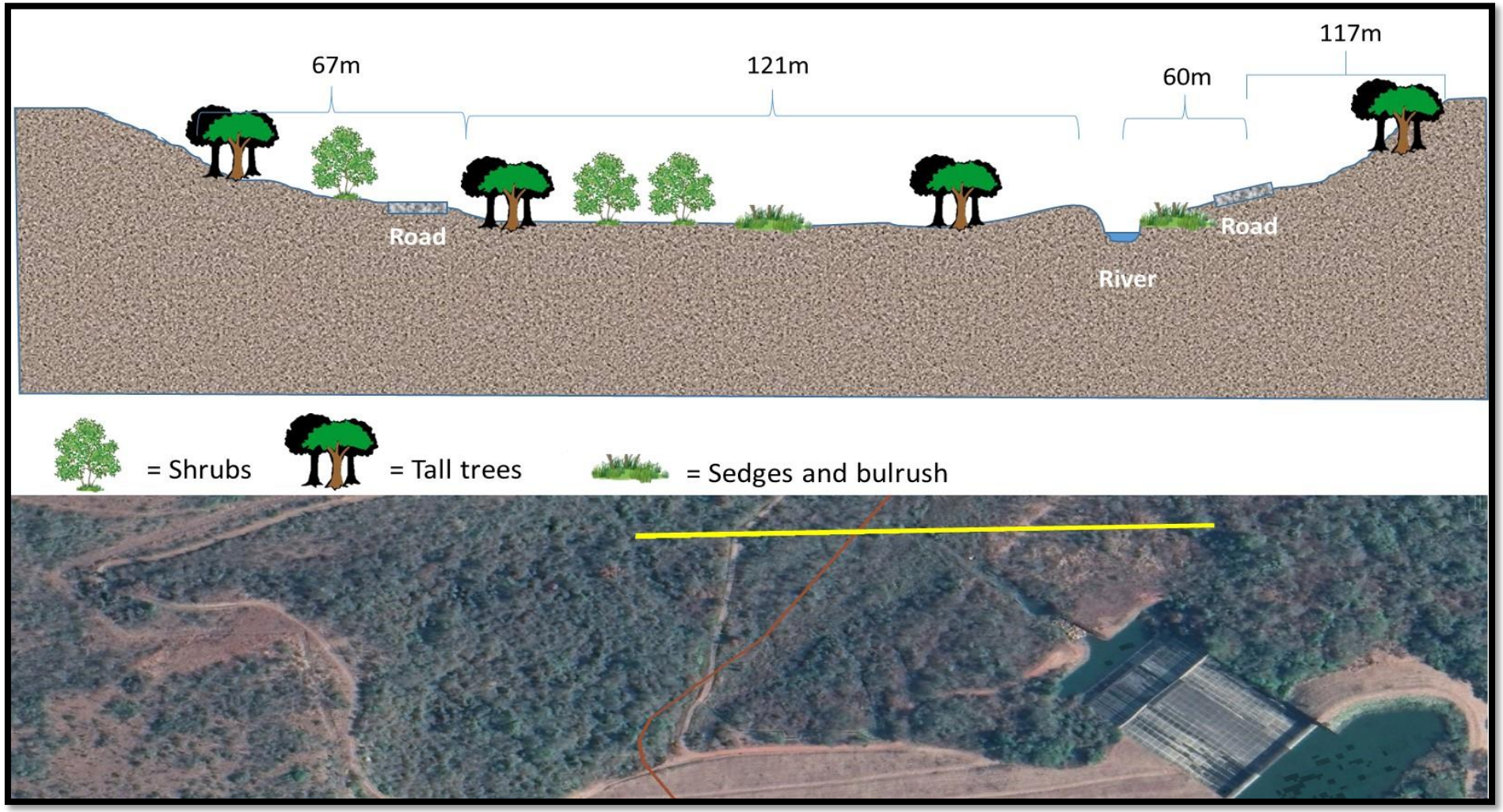

Figure 24: Transect 2 crossing the Ngodwana River bed and riparian zones.

Although Transect 2 is an extensive transect (314m), the Nngodwana River riparian zone proper consists of narrow bands of proper riparian (total = 50m). The results for the vegetation survey for the areas are summarised in Table 7.

Table 7: The vegetation observed along the two transects (Transects 1 and 2) in the Ngodwana River project area (Figure 22).

Transect 1	**Transect 2**
Marginal	
Paperbark thorn (*Vachellia sieberana*)	Weeping lavender tree (*Heteropyxis natalensis*)
Common hook thorn (*Senegalia caffra*)	Sweet thorn (*Vachellia karroo*)
River climbing thorn (*Senegalia schweinfurthii*)	Paperbark thorn (*Vachellia sieberana*)
Buffalo-thorn (*Ziziphus mucronata*)	Robust thorn (*Vachellia robusta*)
River bushwillow (*Combretum erythrophyllum*)	River bushwillow (*Combretum erythrophyllum*)
Robust thorn (*Vachellia robusta*)	Red crowberry (*Searsia chirindensis*)
Water berry (*Syzygium cordatum*)	Broom cluster fig (*Ficus sur*)
*Bugweed (*Solanum mauritianum*)	Buffalo-thorn (*Ziziphus mucronata*)
*Christmas berry (*Lantana camara*)	Bushman's grape (*Rhoicissus tridentata*)
*Yellow bells (*Tecoma stans*)	Fever tree (*Vachellia xanthophloea*)
*Japanese liguster (*Ligustrum lucidum*)	Flute willow (*Salix mucronata*)
	River climbing thorn (*Senegalia schweinfurthii*)
	Water berry (*Syzygium cordatum*)
	Common hook thorn (*Senegalia caffra*)
	*Christmas berry (*Lantana camara*)
	*Yellow bells (*Tecoma stans*)
	*Syringa (*Melia azedarach*)
	*Bugweed (*Solanum mauritianum*)
	*Japanese liguster (*Ligustrum lucidum*)
Instream	
Thatching reed (*Phragmites mauritianus*)	Thatching reed (*Phragmites mauritianus*)
Sedges	Sedges
	Ferns

*Alien plants

Task 1.2.3 Present Ecological State or PES

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):

- Hydrological Driver Assessment Index (HAI)
- Geomorphology Driver Assessment Index (GAI)
- Physico-chemical Driver Assessment Index (PAI)
- Fish Response Assessment Index (FRAI)
- Macro Invertebrate Response Assessment Index (MIRAI)
- Riparian Vegetation Response Assessment Index (VEGRAI)

Due to the complexity of the HAI, GAI and PAI (only used during a Comprehensive Reserve Determination) the EcoStatus Level 3 determination has been used for this study. Each of these models result in an Ecological Category expressed in terms of A to F where A represents the close to natural and F a critically modified condition.

1.2.3 Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

1.2.3.1 ***Flow*** *and* ***sediment regimes*** *at appropriate flows*

1.2.3.2 ***Water quality*** *(including the* ***physical, chemical and biological characteristics*** *of the water) in relation to the flow regime*

1.2.3.3 Riparian and In-stream ***Habitat****.*

1.2.3.3.1 ***Morphology*** *(physical structure)*

1.2.3.3.2 ***Vegetation***

1.2.3.4 ***Biota***

Clarification of water resources according to the NWA

According to the definitions in the National Water Act (Act No. 36 of 1998), "water resource'' includes a **watercourse**, surface water, estuary or aquifer. Where an application for a water use license is being applied for, all wetlands within 500m of the proposed development should ideally be mapped. Seasonal or intermittent rivers are included in the National Wetland Classification System (SANBI, 2009) with the Rivers and streams category:

"Rivers and streams: This type of water resource is described as a channel (river, including the banks) in the National Wetland Classification System (SANBI, 2009). This is defined as *"an open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually*

exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterizes the hydrodynamic nature of these units." According to the classification system, channels generally refer to rivers or streams (including those that have been canalized) that are subject to concentrated flow on a continuous basis **or periodically during flooding**. This definition is consistent with the NWA (Act No. 36 of 1998) which makes reference to (i) a river or spring and (ii) a **natural channel** in which water **flows** regularly or **intermittently** within the definition of a water resource. As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks which can be identified and delineated."

It is important to note that 'Riparian habitat' may be associated with either of these systems and is regarded by DWS as part of the water resource and 'regulated area'. **Riparian habitat** is defined in the NWA (Act No. 36 of 1998) as *"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."* Areas of riparian habitat which are saturated or flooded for prolonged periods would be considered 'wetlands' (in terms of the NWA) and should be mapped as such. Some riparian areas, however, are not 'wetlands' (e.g. where characteristic riparian trees have very deep roots drawing water from many metres below the surface). These areas do however provide a range of important services that maintain basic aquatic processes, services and values requiring protection in their own right. Where present, the boundary of the riparian habitat should therefore also be clearly delineated (Macfarlane et al 2010).

Current state (Present Ecological State or PES) of the project area.

Figure 25 illustrates the land cover map supplied by the LUDS Report of the Ngodwana River project and surrounding area. Industrial water use in the catchment is limited and consists mostly of the Sappi paper mill at Ngodwana. The water requirements of the Ngodwana paper mill are supplied from the Ngodwana Dam, which is situated in the Elands catchment.

The main anthropogenic impacts on the Elands River include:

- The Sappi Ngodwana Mill and the associated pulp and paper activities
- The influence of the Ngodwana dam wall on the flow and water quality within the lower Ngodwana River
- Nutrient loading taking place due to the treated sewage that is released into the river in the upper reaches and in the vicinity of the Mill
- And the agricultural activities within the Elands River system.

PES supporting information

The PESEIS data from the Department of Water and Sanitation Desktop PESEIS assessment (DWS, 2014), supplies most of the current status information of the relevant sub-quaternary river reaches (SQRs) for South Africa. The objective of the PESEIS is to provide desktop level information on ecological issues as it relates to the protection and management of SQRs.

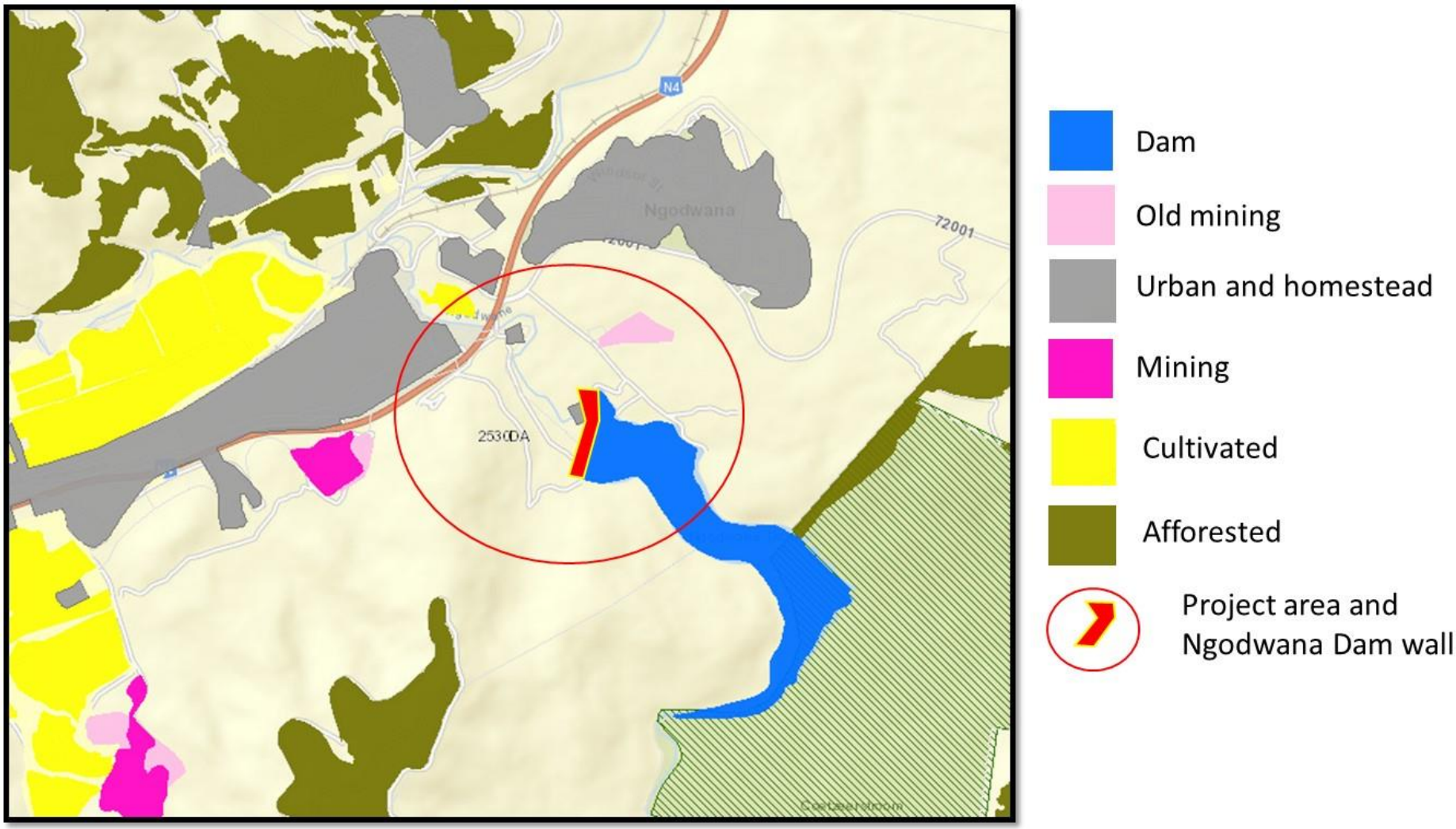

Figure 25: The land cover map supplied by the LUDS Report of the Ngodwana River project area and the surrounding area.

Description of the affected watercourse

The Ngondwana River falls within the upper foothills geomorphological zone, dominated by alluvial cobble-bed, rapids, riffles, runs, glides, and pools. Trees, shrubs, herbaceous plants, and grasses dominate the marginal zone, with commercial forestry and grassland with scattered trees and shrubs in the surrounding landscape (Roux, et al. 2016).

Task 1.2.3.1 Flow and sediment regimes at appropriate flows.

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for water resources, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve be determined and requirements met before other economic activities can be satisfied (DWA, 2007).

Catchment characteristics

The Ngodwane Dam catchment is predominantly dolomitic (56%) and, in addition, has plantations of exotic forest covering 28% of the catchment. The full supply area of Ngodwane Dam is 87ha, which is equivalent to 0.38% of the catchment area (Altus de Beer Consulting Engineer, 2019).

Table 8: Catchment characteristics.

Physical characteristic	Value	Units
Catchment area	229	km^2
Average channel slope	0.0173	-
Length of longest watercourse	26	km
Length to catchment centre	13	km
Mean annual precipitation	1068	mm
Percentage of catchment under afforestation	28	%
Percentage of catchment with dolomitic exposure	56	%

Table 9: Flood peaks.

Flood event	Flood peaks in m3/s)
10-year	249
20-year	338
50-year	496
100-year	650
200-year	832

Task 1.2.3.2 Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime.

During a field study in 2016, water quality were measured in the Elands River at the Ngodwana River confluence (downstream of the dam), as well as at a tributary in the Ngodwana River upstream of the dam (Roux et al, 2016). The results of the test are summarised in Table 10.

Table 10: Water quality parameters in the Elands River at the Ngodwana River confluence (X2ELAN-ROODE - downstream of the dam), as well as a site in the Ngodwana River (X2NGOD-NOOIT) and at a tributary in the upstream of the dam (X2HOUT-UITZI) during a field study in 2016 (Roux et al, 2016).

SITE CODE	SAMPLE DATE	WATER SAMPLE CODE	TDS	Nitrate & Nitrite as N	Nitrate NO_3 as N	Nitrite NO_2 as N	Chlorides as Cl	Total Alkalinity as $CaCO_3$	Fluoride as F	Sulphate as SO_4	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Conductivity at 25° C in mS/m	pH-Value at 25 ° C	Ortho Phosphate PO_4 as P	Silicon as Si	Free & Saline Ammonia as N	Ammonium as N	Zinc as Zn	Aluminium as Al
X2ELAN-ROODE	28-Sep-16	EC05	750	0.14	0.14	<0.1	116.00	158	<0.20	248.00	57.20	46.9	130.00	1.84	116.0	8.17	<0.1	9.55	<0.20	<0.20	<0.01	0.07
X2HOUT-UITZI	27-Sep-16	EC02	54	<0.1	<0.1	<0.1	1.00	45	<0.20	1.23	9.40	5.95	1.80	0.29	9.65	8.55	<0.1	7.09	<0.20	<0.20	<0.01	0.04
X2NGOD-NOOIT	27-Sep-16	EC01	58	<0.1	<0.1	<0.1	1.25	51	<0.20	1.25	9.53	5.78	5.11	0.38	10.7	8.387	<0.1	10.3	<0.20	<0.20	<0.01	0.09

Task 1.2.3.3 Riparian and In-stream Habitat.

Task 1.2.3.3.1 Morphology (physical structure).

Index of Habitat Integrity (IHI)

The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans 1996).

Habitat integrity assessment is approached from an in-stream and riparian zone perspective. Both of these are formulated according to metric groups, each with a number of metrics that enable the assessment of habitat integrity. The model functions in an integrated way, using the results from the assessment of metric groups, or metrics within a metric group, for the assessment of other metric groups where appropriate.

The Instream Index of Habitat Integrity (IIHI) and the Riparian Index of Habitat Integrity (RIHI) is based on the methods outlined in Kleynhans *et al*., 2008.

Table 11: The in-stream IHI: evaluated for the Ngodwana River in the study area.

	MRU
INSTREAM IHI	
Base Flows	3,5
Zero Flows	3,5
Floods	3,0
HYDROLOGY RATING	**3,4**
pH	
Salts	-0,5
Nutrients	-0,5
Water Temperature	
Water clarity	
Oxygen	
Toxics	
PC RATING	**0,2**
Sediment	-1,0
Benthic Growth	0,5
BED RATING	**0,8**
Marginal	-0,5
Non-marginal	-0,5
BANK RATING	**0,5**
Longitudinal Connectivity	2,0
Lateral Connectivity	2,5
CONNECTIVITY RATING	**2,0**
INSTREAM IHI %	**69,2**
INSTREAM IHI EC	**C**

INSTREAM CONFIDENCE	3,1

Table 12: The riparian IHI: evaluated for the Ngodwana River in the study area.

	MRU
RIPARIAN IHI	
Base Flows	3,0
Zero Flows	3,0
Moderate Floods	4,0
Large Floods	3,5
HYDROLOGY RATING	**3,4**
Substrate Exposure (marginal)	1,0
Substrate Exposure (non-marginal)	1,0
Invasive Alien Vegetation (marginal)	1,0
Invasive Alien Vegetation (non-marginal)	2,0
Erosion (marginal)	0,0
Erosion (non-marginal)	1,0
Physico-Chemical (marginal)	1,5
Physico-Chemical (non-marginal)	0,5
Marginal	1,5
Non-marginal	2,0
BANK STRUCTURE RATING	**1,8**
Longitudinal Connectivity	0,0
Lateral Connectivity	0,5
CONNECTIVITY RATING	**0,1**
RIPARIAN IHI %	**61,6**
RIPARIAN IHI EC	**C/D**
RIPARIAN CONFIDENCE	**3,2**

The outcome of the in-stream and riparian IHI evaluated for the Ngodwana River in the study area, resulted in an in-stream IHI of 69.2% (C) (Table 11) which classifies as “Moderately modified” according to the Habitat Integrity Categories in Table 13. The riparian IHI of 61.6 (C/D) falls in the “Moderate change” category (Table 12 and 13). The finer scale rating (C/D) of the riparian IHI relates to the EC rating table (Appendix 2) where C/D matches a score of >57.4 and <62.01, which puts it in the “Fair” category.

Table 13: The ratings for the Habitat Integrity Categories prescribed to the IHI model (Kleynhans et al, 2008).

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken	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 / 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	0-19

The reason why the Ngodwana River is classified in these lower categories can be attributed to the following impacts on the system:

- The major impact due to the Ngodwana Dam and its impact on:
    - Flows (regulated)
    - Seasonality (flows)
    - Water quality downstream
    - Bed and bank scouring during high flows
- Roads and bridges
- Alien invading plants in and around the river.

Task 1.2.3.3.2 Vegetation

According to the IHI evaluation (Table 12), the Riparian Zone Habitat Integrity is “Moderate change”, and the C/D score indicates some major impacts at this stage on the riparian habitats:

- Roads;
- Dams;
- Vegetation removal;
- Alien invading plants

Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

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 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 metrics in VEGRAI firstly describe the status of riparian vegetation in both its current and reference states and secondly, compare differences between the two states as a measure of vegetation response to an impact regime.

The riparian vegetation zones (Marginal, Lower and Upper) are used as the metric groups. For the simplified Level 3 version, the Lower and Upper zones were combined to form the Non-Marginal metric group (zone).

A range of metrics for each metric group is selected, of which some are essential for both Levels 3 and 4 (Abundance and Cover) and the others are optional (Species Composition, Population Structure and Recruitment). The metrics are then rated and weighted and an Ecological Category (A-F) determined which represents the Ecological Category for the riparian vegetation state.

Impact evaluation on riparian zone and interpretation

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.

This approach relates to the National Water Act which aims to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. The protection of water resource quality is essential to achieve this:

``Resource quality'' means the quality of all the aspects of a water resource including,

- the quantity, pattern, timing, water level and assurance of in-stream flow;
- the water quality, including the physical, chemical and biological characteristics of the water;
- the character and condition of the in-stream and riparian habitat; and
- the characteristics, condition and distribution of the aquatic biota
- considering the functions of the riparian vegetation, these have been summarized as:

    - Sediment trapping,
    - Nutrient trapping
    - Bank stabilization and bank maintenance,
    - Contributes to water storage,
    - Aquifer recharge,
    - Flow energy dissipation,
    - Maintenance of biotic diversity,
    - Primary production.

Most of these functions relate to in-stream habitat conditions and it follows the basic consideration when assessing the condition of the riparian vegetation, and thus impacts should be interpreted in terms of the influence on the in-stream habitat.

In most rivers the riparian marginal zone consists of shrubs and forbs, sometimes very dense; some reeds in level areas and abundant root wads of riparian trees. Some of these riparian trees are in the marginal zone and overhang the river. The riparian non-marginal zone consists of larger trees and marginal shrubs and forbs in the under-storey.

Table 14: 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 flow of the river here is medium to fast over cobble riffles and rocky rapids with good overhanging vegetation. The river bed in this reach is scoured due to turbulent high flows over the dam spillway, forming pools surrounded by reeds. Numerous alien exotic plants. Water quality impacted by the Dam.	The river falls within the upper foothills geomorphological zone, dominated by alluvial cobble-bed, rapids, riffles, runs, glides, and pools.
Non-marginal	Vegetation Removal Exotic Vegetation Water Quantity Water Quality	Cover Abundance Species Composition	The riparian zone consisted of a narrow band of riparian trees, and the riverbed is overgrown with Thatching reed (*Phragmites mauritianus)*. Numerous alien exotic plants. The riparian zone proper consists of larger riparian trees on the channel banks.	Trees, shrubs, herbaceous plants, and grasses dominate the marginal zone, grassland with scattered trees and shrubs in the surrounding landscape

Table 15: 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	1,0	1,0	3,0	Alien removal teams also impact on indigenous riparian species.			
EXOTIC INVASION	3,0		4,0	5 aggressive alien species present and abundant.			
WATER QUANTITY	4,0	1,5	3,0	Dam wall interfere with flows; sometimes results in non-flow situations.			
WATER QUALITY	1,5	1,5	3,0	Dammed water and overflow over top unnatural in composition, temperature and oxygen content.			
AVERAGE			3,3				
		RESPONSE METRIC RATINGS					
VEGETATION COMPONENTS	**RESPONSE METRIC**	**CONSIDER? (Y/N)**	**RATING**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**		
WOODY	COVER	Y	2,5	3,0	Removed by scouring of overflows or removed due to human actions. Lack of flows.		
	ABUNDANCE	Y	3,0	3,0	Removed by scouring of overflows or removed due to human actions. Lack of flows.		
	SPECIES COMPOSITION	Y	2,0	3,0	Mostly larger woody species removed.		
			2,5	3,0			
NON-WOODY	COVER	Y	2,0	3,0	Eroding banks and scoured river beds. Lack of surface water during zero overtopping.		
	ABUNDANCE	Y	2,0	3,0	Eroding banks and scoured river beds. Lack of surface water during zero overtopping.		
	SPECIES COMPOSITION	Y	2,5	3,0	Reeds stabilise areas.		
			2,2	2,0			
VEGETATION COMPONENTS	**CONSIDER? (Y/N)**	**RANK**	**WEIGHT**	**RATING**	**WEIGHTED RATING**	**MEAN CONFIDENCE**	**NOTES: (give reasons for each assessment)**
WOODY	Y	1,0	100,0	2,5	2,50	3,0	More susceptible to impacts.
NON-WOODY	Y	2,0	60,0	2,2	1,30	2,0	Stabilize easier.
CHANGE (%) IN MARGINAL ZONE CONDITION				**47.5**	3,80	2,5	

Table 16: 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	1,0	0,5	3,0	Alien removal teams also impact on indigenous riparian species.			
EXOTIC INVASION	3,0		3,0	5 aggressive alien species present and abundant.			
WATER QUANTITY	4,5	2,0	3,0	Dam wall interfere with flows; sometimes results in non-flow situations.			
WATER QUALITY	1,0	0,5	3,0	Dammed water and overflow over top unnatural in composition, temperature and oxygen content.			
AVERAGE			3,0				
		RESPONSE METRIC RATINGS					
VEGETATION COMPONENTS	**RESPONSE METRIC**	**CONSIDER? (Y/N)**	**RATING**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**		
WOODY	COVER	Y	1,5	3,0	Removed by scouring of overflows or removed due to human actions. Lack of flows (damming).		
	ABUNDANCE	Y	1,5	3,0	Removed by scouring of overflows or removed due to human actions. Lack of flows (damming).		
	SPECIES COMPOSITION	Y	1,0	3,0	Mostly larger woody species removed.		
			1,3	3,0			
NON-WOODY	COVER	Y	1,0	2,0	Fires, flooding and scouring.		
	ABUNDANCE	Y	1,0	3,0	Fires, flooding and scouring.		
	SPECIES COMPOSITION	Y	1,0	2,0	More robust alien plants dominate and recover fast.		
			1,0	1,7			
VEGETATION COMPONENTS	**CONSIDER? (Y/N)**	**RANK**	**WEIGHT**	**RATING**	**WEIGHTED RATING**	**MEAN CONFIDENCE**	**NOTES: (give reasons for each assessment)**
WOODY	Y	2,0	85,0	1,3	1,13	3,0	Woody species established.
NON-WOODY	Y	1,0	100,0	1,0	1,00	1,7	Alien vegetation competition.
	CHANGE (%) IN NON-MARGINAL ZONE CONDITION		**23.1**		2,13	2,3	

Table 17: The vegetation integrity evaluation of the riparian zone in the project area.

LEVEL 3 ASSESSMENT						
METRIC GROUP	**ALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**	**NOTES: (give reasons for each assessment)**
MARGINAL	52,5	27,6	2,5	1,0	100,0	Mostly impacted by the influence of the dam and flows.
NON MARGINAL	76,9	36,4	2,3	2,0	90,0	Less impacted by the influence of the dam and flows.
	2,0				190,0	
LEVEL 3 VEGRAI (%)				64,1		
VEGRAI EC				**C**		
AVERAGE CONFIDENCE				2,4		

According to the VEGRAI assessment (Table 17) for the Ngodwana River, the Ecological Class is a C (64.1%). The final scores of the VEGRAI assessment regarding the riparian and marginal zone integrity of the Ngodwana River in the project area are presented in Table 18.

Table 18: A summary of the VEGRAI scores of the Ngodwana River in the project area.

River system	Non-marginal zone condition % change	Marginal zone condition % change	Level 3 VEGRAI	VEGRAI EC
Ngodwana River	23.1%	47.5%	64.1%	C

The vegetation integrity score is 64.1% which represents an Ecological Class C (60-79). This score reflects a "Moderately modified" status (Table 19).

Table 19: Generic ecological categories for EcoStatus components (modified from Kleynhans 1996 & 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

Riparian delineation

During the process of riparian delineation, two transects were surveyed, one transect per site. 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 depicted in Figures 23 and 24 in the previous section. The true riparian tree species noted in the project area, are listed in Table 20.

Table 20: Riparian indicator plant species observed in the riparian zone along the Ngodwana River during the survey.

FAMILY	*TAXON*	HABITAT
RHAMNACEAE	Buffalo thorn *(Ziziphus mucronata)*	In a wide variety of habitats, in open woodland, often in alluvial soils along rivers, and frequently on termite mounts; it is said to indicate the presence of underground water.
COMBRETACEAE	River bushwillow (*Combretum erythrophyllum*)	Along river banks where it can form thick stands, with trunks reclining in and overhanging the water.
MYRTACEAE	Water berry (*Syzygium cordatum*)	Along stream banks, in riverine thicket and forest, always near water or along watercourses, and in KZN, forming stands of almost pure swamp forest.
SALICACEAE	Flute willow (*Salix mucronata*)	Stream and river banks, in a wide range of habitats.

Riparian delineation and habitat evaluation was done according to the DWAF Guidelines (2005) and DWAF updated manual (2008) (see Methods Task 1.2.3.3.2 Vegetation). Figure 26 depicts the Ngodwana River with the riparian zone delineated. The delineation shapefiles will be available as Appendix 4.

The entire area below the Ngodwana dam wall (314m) consists of wetlands, both natural and created by the dam environment. Although areas are supported by seeping water from the groundwater, some important natural wetland systems are present in the area below the dam wall. These areas are depicted in Figure 26 and described in more detail further down in this section.

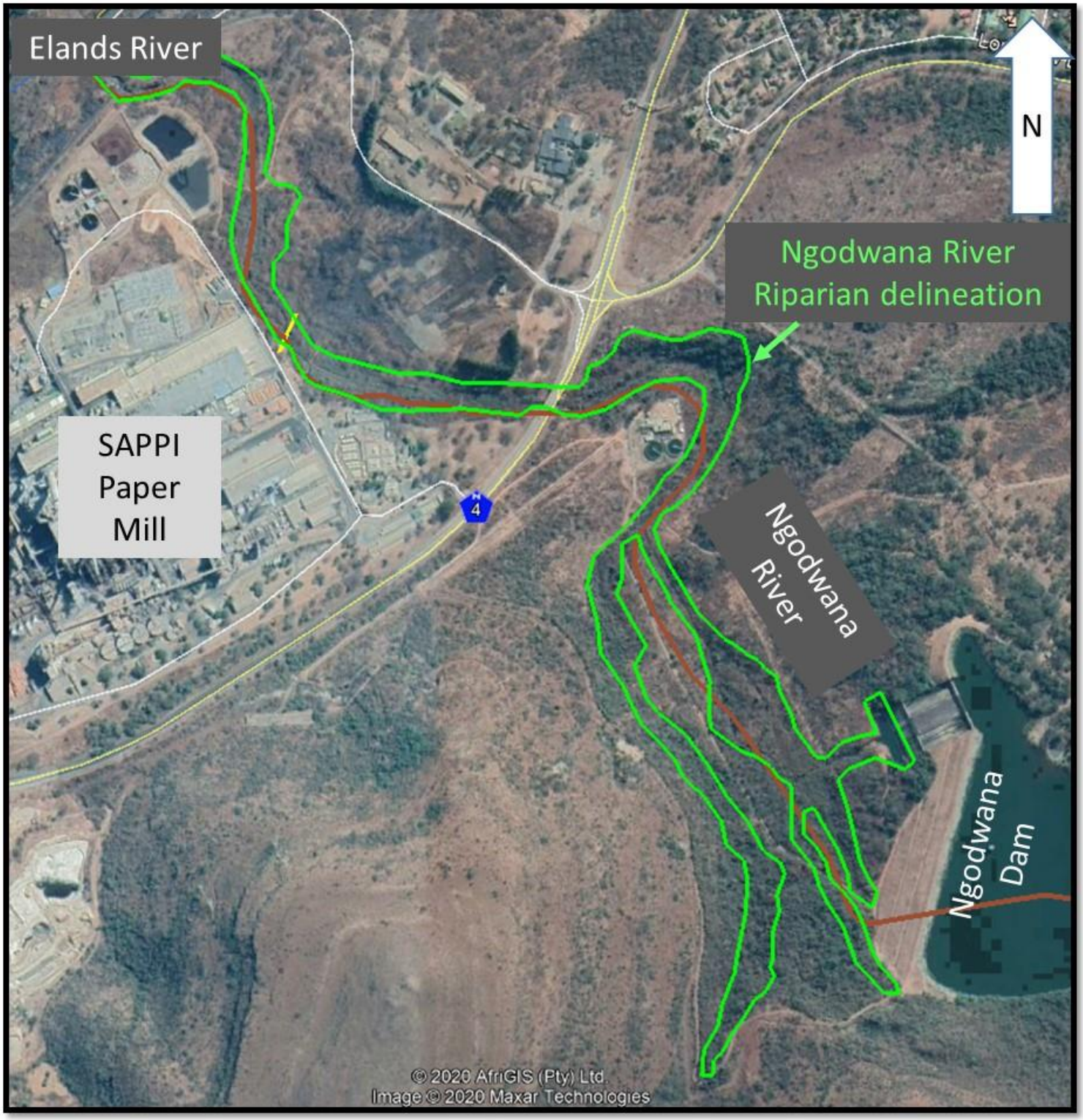

Figure 26: The delineated riparian zone (green lines) of the Ngodwana River catchment in the project area.

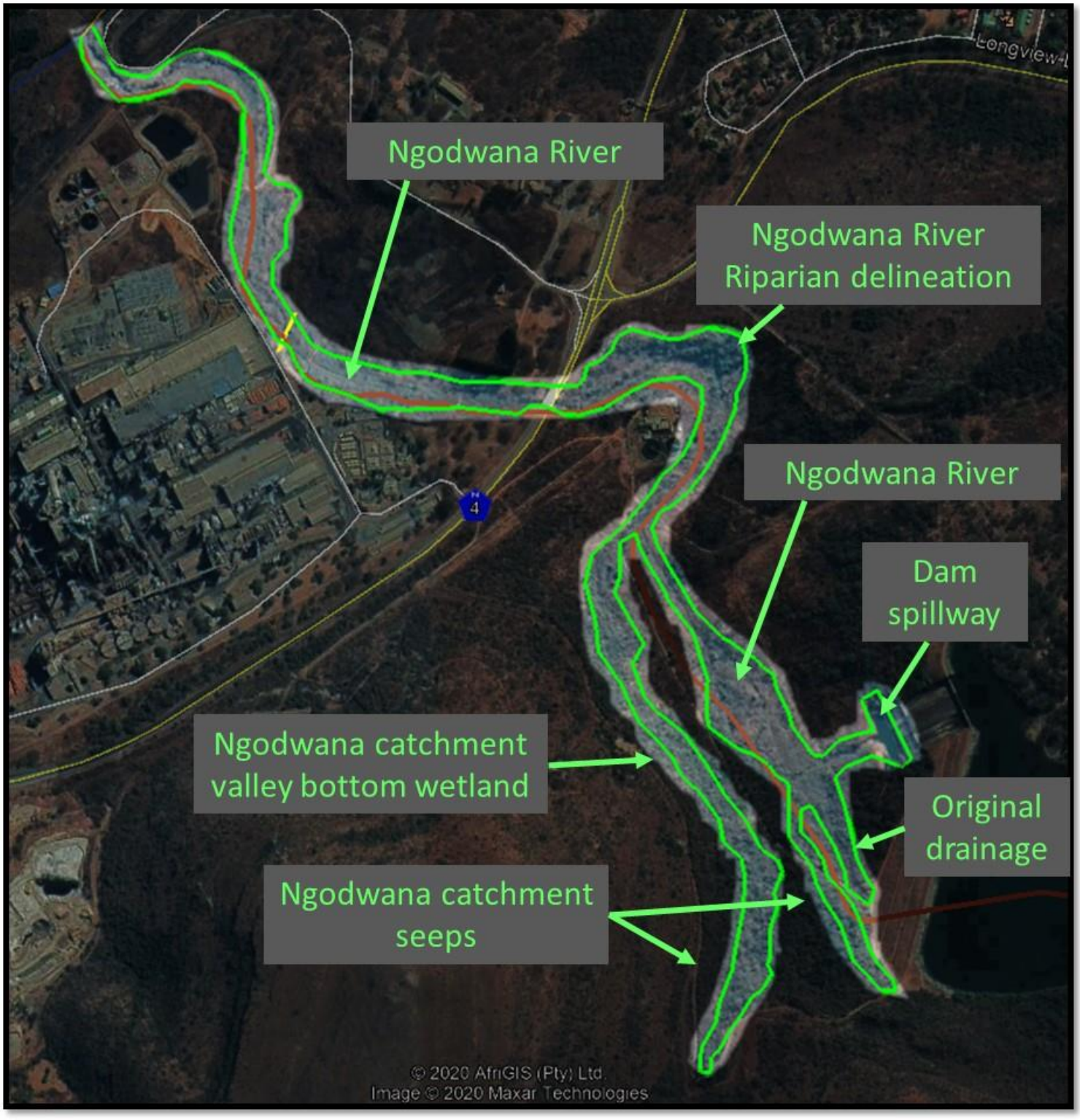

Figure 27: The entire area below the Ngodwana dam wall (314m) consists of wetlands, both natural and created by the dam environment. These areas are illustrated here and described in more detail below.

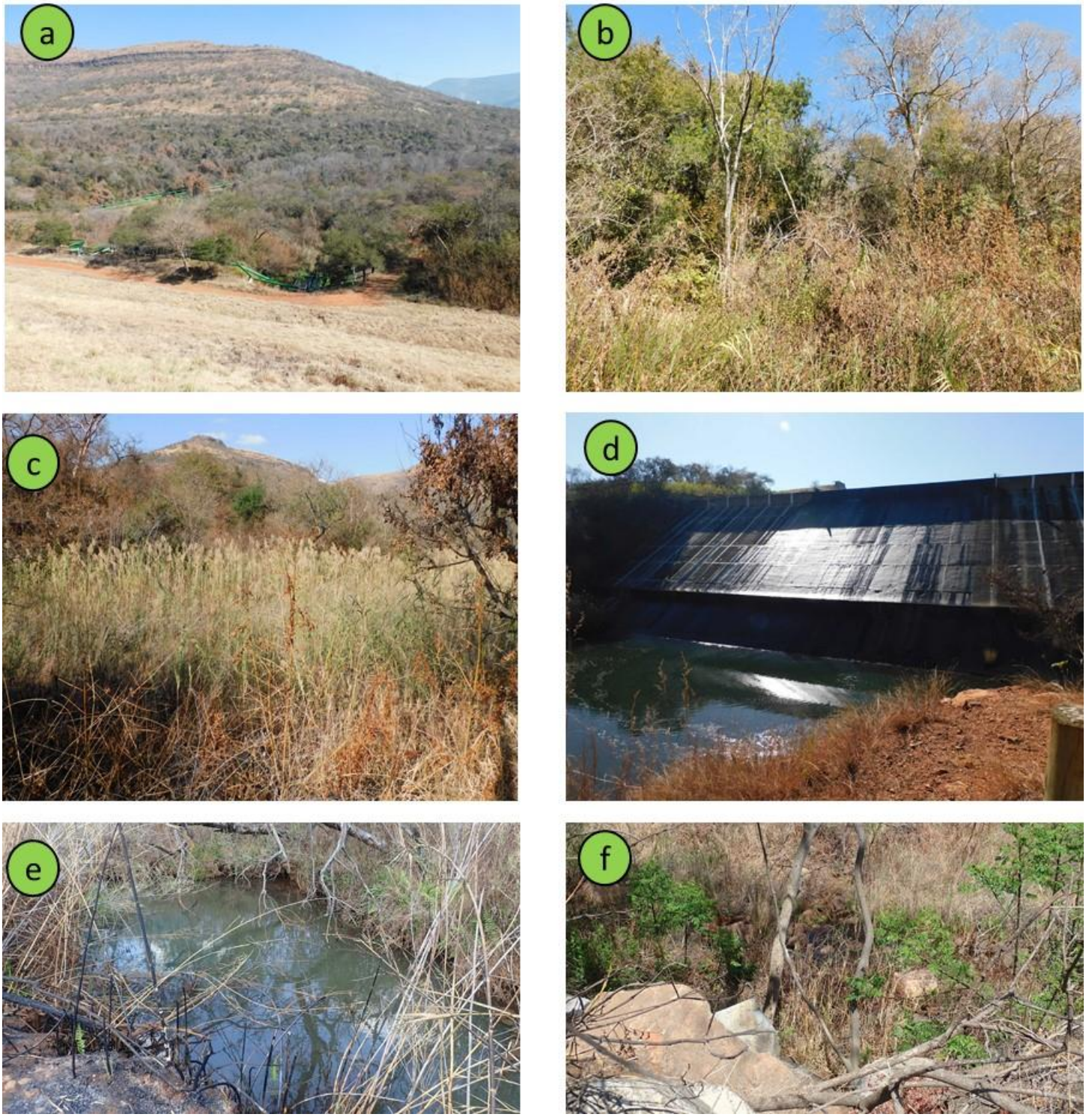

Figure 28: The entire area below the Ngodwana dam wall.

28a. A view of the area below the dam wall.
28b. The lush wetland vegetation in the seepage wetlands.
28c. The overgrown river bed of the Ngodwana River.
28d. The spillway over the dam wall.
28e. The river reach below the spillway.
28f. The Ngodwana River lower down towards the N4.

In the Classification System, the source zone at the upper end of a river would typically be classified as one of the wetland types (e.g. a seep, an unchannelled valley bottom wetland, depression or wetland flat) and not as part of a river. Figure 27 shows two wetland seeps originating on the slope of the mountain and drain down into the area below (Figure 26), one becomes a valley bottom wetland which joins the Ngodwana River just before the Water Works, while the other shorter seepage joins the original drainage line of the Ngodwana River below the dam.

The spillway created a short section of channelled flow whenever the spillway overflows before its confluence with the original Ngodwana River channel. The riparian zone in most of the places is between 20 and 50 meters wide and patches of reed, sedges and hydrophilic grasses are scattered in the river bed.

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 proposed Ngodwana Dam project, and the implemetation will be recapitulated in the mitigation section (4.3 Risk assessment).

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. Buffer zones will serve as a mitigating measure for impacts created by the construction and operational phases of the proposed project.

A buffer zone is therefore proposed for the Ngodwana Dam project. Should it be instated, some of the existing structures are already inside the buffer zone, and other planned activities will be incorporated into this zone due to the existing structures. It might appear if the purpose of the buffer zone will be risked here. To address this, the implementation of a buffer zone will be used to emphasize the importance of the riparian zone and the ecology in

the project area. The area included in the buffer zone, as well as the core areas in the riverine zone, should have explicit and very strict biodiversity conservation management measures and the operating teams should be well aware of this.

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 Ngodwana Dam (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 Ngodwana River system.

Mapping the line from which Aquatic Impact Buffer Zones will be delineated:

In the Ngodwana project area, two lines were used during the buffer establishment:

- The outer edge of the riparian zone (green line in Figure 29).
- The riparian buffer of the different riparian corridors (Yellow line in Figure 29).

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).

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 Task 1.2.4 the PES for the Ngodwana River in the study area was established as a “C” (Moderately modified) (Table 44) and the Ecological Importance and Sensitivity is rated as “Low” for the riparian vegetation and “high” for the riverine biota.

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 was done in accordance with the Risk Matrix (Based on DWS 2015 publication: Section 21 (c) and (I) water use Risk Assessment Protocol. It is contained in Appendix A in GN509 of 26 August 2016) and were completed with the desktop buffer zone tool which has 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 threats of planned activities on water resources and determine desktop buffer requirements:

Results according to the desktop buffer tool for the project site:

Proposed development / activity:

Sector: Transportation infrastructure.

Sub-sector: Unpaved roads

Climatic factors:

MAP Class: 801 - 1000mm

Rainfall intensity: Zone 3

Determine the Risk Posed by Proposed Activities on Water Resources

Once both threats posed by potential land uses/activities and the inherent sensitivity of receiving water resources have been assessed, this information is used to evaluate the risks posed by such activities on the water resource under consideration (Table 22). Risk scores are calculated by multiplying threat and sensitivity scores to obtain a risk score for each impact type evaluated as illustrated in Table 21.

Table 21: Risk classes used in this assessment.

Risk Class	Risk Score	Description
Very low	<0.3	The proposed development/activity poses a very low risk to the water resource under investigation for the threat type assessed.
Low	0.3-0.5	The proposed development/activity poses a low risk to the water resource under investigation for the threat type assessed.
Moderate	0.51-0.7	The proposed development/activity poses a moderate risk to the water resource under investigation for the threat type assessed.
High	0.71-0.9	The proposed development/activity poses a high risk to the water resource under investigation for the threat type assessed.
Very high	>0.91	The proposed development/activity poses a very high risk to the water resource under investigation for the threat type assessed.

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.

Table 22: The site-based desktop buffer requirements for the Buffer Segment 1: Ngodwana River.

Buffer attributes	Buffer Segment 1: Ngodwana River
Slope of the buffer	Gentle (2.1 - 10%)
Vegetation characteristics (Construction phase)	Good: Moderately robust vegetation with good interception potential (e.g. good condition tufted grass stands).
Vegetation characteristics (Operational phase)	Fair: Moderately robust vegetation with fair interception (e.g. tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (e.g. kikuyu pasture).
Soil permeability	Moderate: Deep moderately textured soils (e.g. sandy loam) OR shallow (<30cm) well drained soils.
Micro-topography of the buffer zone	Dominantly Non-uniform topography: Dominantly irregular topography with some major concentrated flow paths (i.e. erosion gullies, drains) that will substantially reduce interception.
Site-based aquatic impact buffer requirements (without additional mitigation measures)	
Construction Phase	**18m**
Operational Phase	**19m**

Table 23: The site-based desktop buffer requirements for the Buffer Segment 2: Ngodwana catchment valley bottom wetland.

Buffer attributes	Buffer Segment 2: Ngodwana catchment valley bottom wetland
Slope of the buffer	Moderately steep (20.1 - 40%)
Vegetation characteristics (Construction phase)	Ideal: Robust vegetation with high interception potential (e.g. dense tall grass stands).
Vegetation characteristics (Operational phase)	Good: Moderately robust vegetation with good interception potential (e.g. good condition tufted grass stands).
Soil permeability	Moderately low: Deep moderately fine textured soils (e.g. loam & sandy clay loam) OR shallow (<30cm) moderately drained soils.

Micro-topography of the buffer zone	Dominantly Non-uniform topography: Dominantly irregular topography with some major concentrated flow paths (i.e. erosion gullies, drains) that will substantially reduce interception.
Site-based aquatic impact buffer requirements (without additional mitigation measures)	
Construction Phase	**21m**
Operational Phase	**22m**

Table 24: The site-based desktop buffer requirements for the Buffer Segment 3: Ngodwana catchment seep wetland.

Buffer attributes	Buffer Segment 3: Ngodwana catchment seep wetland
Slope of the buffer	Steep (40.1 - 75%)
Vegetation characteristics (Construction phase)	Ideal: Robust vegetation with high interception potential (dense tall grass stands).
Vegetation characteristics (Operational phase)	Ideal: Robust vegetation with high interception potential (dense tall grass stands).
Soil permeability	Low: Deep fine textured soils with low permeability (e.g. clay, sandy clay & clay loam) OR shallow (<30cm) soils with low to moderately low permeability.
Micro-topography of the buffer zone	Dominantly Non-uniform topography: Dominantly irregular topography with some major concentrated flow paths (i.e. erosion gullies, drains) that will substantially reduce interception.
Site-based aquatic impact buffer requirements (without additional mitigation measures)	
Construction Phase	**24m**
Operational Phase	**24m**

Final aquatic impact buffer requirements (including practical management considerations) for the Buffer Segment 1: Ngodwana River:

Construction Phase: 18 m
Operational Phase: 19 m
Final aquatic impact buffer requirement: 19 m

Final aquatic impact buffer requirements (including practical management considerations) for the Buffer Segment 2: Ngodwana catchment valley bottom wetland.

Construction Phase: 21 m
Operational Phase: 22 m
Final aquatic impact buffer requirement: 19 m

Final aquatic impact buffer requirements (including practical management considerations) for the Buffer Segment 3: Ngodwana catchment seep wetland:

Construction Phase: 24 m

Operational Phase: 24 m
Final aquatic impact buffer requirement: 24 m

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.

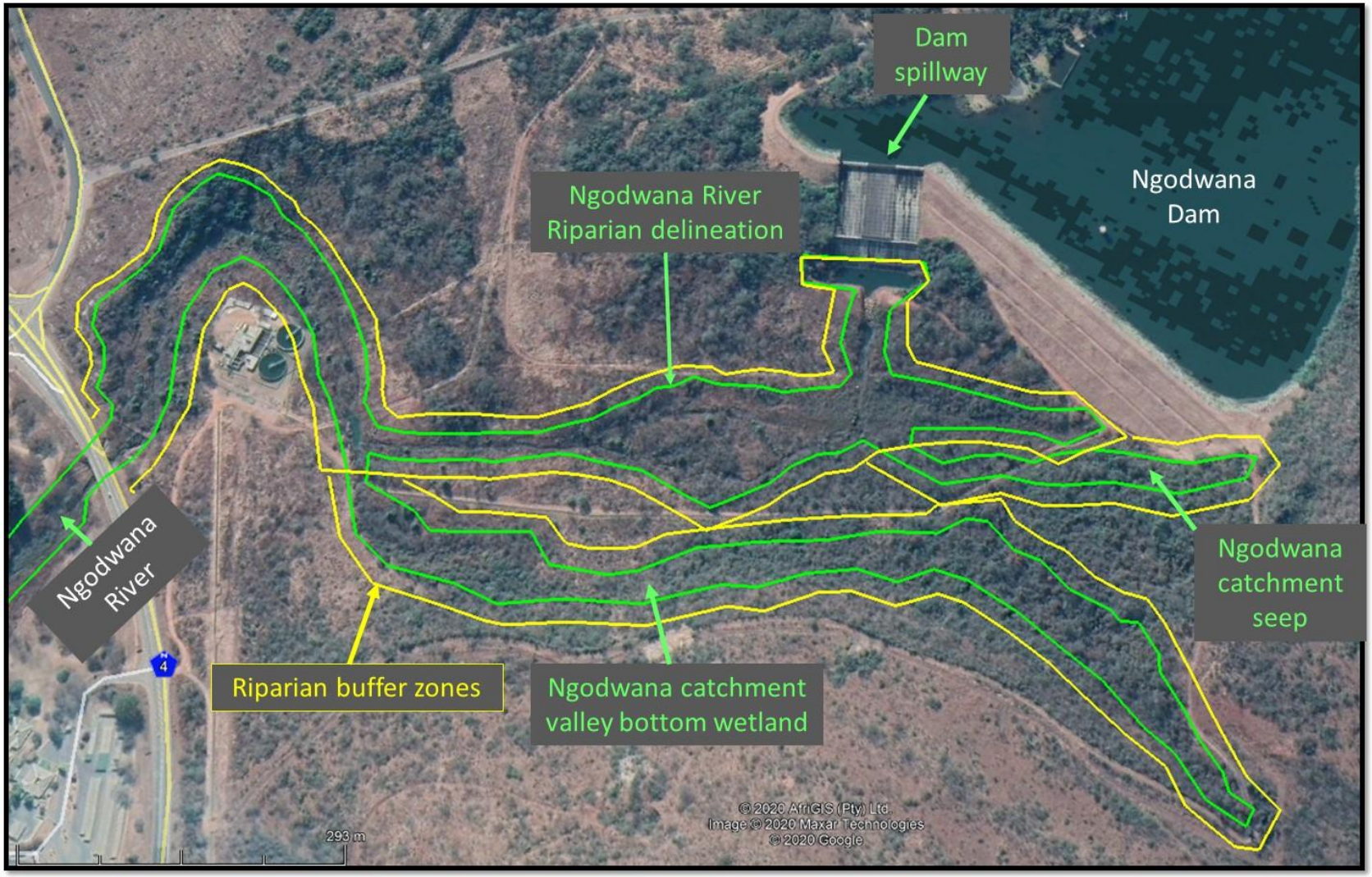

Figure 29: Delineation of the water course components (Ngodwana project area): Boundary of the riparian zone (green line), and final aquatic impact buffer (yellow line).

The implementation and management of the final buffer area areas should be monitored throughout the duration of construction activities to ensure that the effectiveness of the final buffer zone areas is maintained, and that management measures are implemented appropriately. Regular inspections during the operational phase should also be undertaken to ensure that functions are not undermined by inappropriate activities.

Task 1.2.3.4 Biota

Aquatic Invertebrates and Fish

During a field study in 2016 by the team of the Mpumalanga Tourism and Parks Agency (MTPA). Undertook a river monitoring exercise in the Elands River and made use of three sites which is important to refer to in this report (Roux et al, 2016):

- the Elands River at the Ngodwana River confluence (X2ELAN-ROODE - downstream of the dam),
- a site in the Ngodwana River upstream of the dam (X2NGOD-NOOIT)
- as well as at a tributary in the Ngodwana River upstream of the dam (X2HOUT-UITZI)

The reason for using these sites, is due to the fact that the X2HOUT-UITZI and X2NGOD-NOOIT sites are upstream of the Ngodwana Dam and can serve somehow as a reference point for less disturbed habitat and water quality, while the X2ELAN-ROODE Site is below the dam in the Elands River below the SAPPI Paper Mill.

The two sites evaluated for the current project are situated between the two upstream sites and the Elands River sites; both the current project sites are below the dam outflow and upstream of the Elands River.

The X2HOUT-UITZI and X2NGOD-NOOIT sites falls within the upper foothills geomorphological zone, dominated by alluvial bedrock, cobble-bed, riffles, runs, glides, and pools. Reeds, shrubs, and herbaceous plants with grasses dominate large portions of the immediate riparian zone. Commercial pine trees (right bank facing downstream) are located within the riparian zone. The Ngodwana Pulp and Paper Mill, the Ngodwana villages, commercial forestry, and citrus orchids are the main upstream land-uses.

The Uitzight site (X2HOUT-UITZI) is located on the Houtboschloop, a tributary of the Ngodwana River, merging with the Ngodwana River a few kilometres upstream from Ngodwana Dam. The site falls within the upper foothills geomorphological zone, dominated by alluvial cobble-bed, rapids, riffles, runs, glides, and pools. Trees, shrubs, and herbaceous plants dominate the marginal zone, with grassland and scattered trees and shrubs the surrounding landscape.

It was mentioned in the 2016 report that the Ngodwana River was stagnant during the survey period, indicating that the stream has become intermittent below the dam wall.

Aquatic habitat assessment

Aquatic surveys and bio-monitoring 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 July 2020 the following parameters were measured - IHAS (Integrated Habitat Assessment System) and HQI (Habitat Quality Index) with the results summarized in Table 25. Site 1 near the Elands River confluence consisted of dense reed beds, good overhang and riffles, while Site 2 below the dam wall consisted of scoured pools and good overhang.

Table 25: The habitat parameters as measured at the stream sites of the Ngodwana River between the dam and the confluent reach.

SITE	IHAS%	CATEGORY	HQI%	CATEGORY
SITE 1	68	Fair	80	Good
SITE 2	60	Fair	62	Fair

During the July 2020 survey, the IHAS and HQI scores at Site 1 were classified as “Fair” to “Good” due to the fast flowing riffles and associated habitats. Site 2 habitat consisted mostly of pools and marginal habitats with little rocky riffles and slower flows, resulting in the aquatic habitat availability consisting of “Fair” scores (Table 25).

Aquatic invertebrate assessment

The X2HOUT-UITZI Site upstream of the Ngodwana Dam and X2ELAN-ROODE Site below the dam in the Elands River below the SAPPI Paper Mill will be used as two reference sites (not natural reference).

During a field study in 2016, the X2NGOD-NOOIT site in the Ngodwana River upstream of the dam had an ASPT of 6.7, and although the Ecological Category was not stated, it probably would have been at least a B/C category. During the same period the Elands River at the Ngodwana River confluence (downstream of the dam), had an ASPT of 6.0 with an Ecological Category of a C (Roux et al, 2016).

Based on MIRAI of the Uitzight Site (X2HOUT-UITZI), stream conditions were categorised as a category B/C (slightly to moderately modified), with taxa associated with fast to moderate flows still dominant. Some of the sensitive taxa are present at lower abundances, which is considered natural since flow conditions provided a habitat template with more depositional zones and less deep-fast flowing riffles-rapids.

The macro-invertebrates were sampled according to the SASS5 method at the two sites, and Table 26 lists the macro-invertebrates sampled at the site and reflects the SASS5 scores for the July 2020 survey.

Table 26: SASS5 scores of the different habitat types at Site 1 (a complete table of this summarized version can be viewed in Appendix 1).

TAXON	Stones	Vegetation	GSM	Total
Oligochaeta 1			A	A
Potamonautidae 3	1			1
Atyidae (Shrimp) 8		B		B
Baetidae 1 spp 4	B	B	1	B
Heptageniidae 10	A			A
Leptophlebiidae 13	A			A
Aeshnidae 8	1	1		A

Hydropsychidae 1= 4	A			A
Philopotamidae 10		A		A
Gyrinidae 5		A	A	B
Psephenidae 10	A			A
SASS Score	52	35	10	76
No of families	7	5	3	11
ASPT	7.4	7.0	3.3	6.9

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

Table 27: SASS5 scores of the different habitat types at Site 2 (a complete table of this summarized version can be viewed in Appendix 1).

TAXON	Stones	Vegetation	GSM	Total
Oligochaeta 1			B	B
Atyidae (Shrimp) 8		B		B
Baetidae 1 spp 4	B	A		B
Coenagrionidae 4		A		A
Aeshnidae 8	1			1
Gomphidae 6			A	A
Gerridae 5	A	A		B
Nepidae 3		1		1
Veliidae 5		1		1
Hydropsychidae 1= 4	A			A
Dytiscidae 5		A		A
Gyrinidae 5		A	A	B
Psephenidae 10	1			1
Chironomidae 2		A	B	B
Simuliidae 5	A	A		B
SASS Score	36	46	14	75
No of families	6	10	4	15
ASPT	6.0	4.6	3.5	5.0

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

Table 28: A summary of the IHAS, HQI and SASS scores at the Ngodwana River in the project area.

SURVEY SITE	Habitat scores		SASS5 Scores		
	IHAS %	HQI %	SASS score	Number of families	ASPT
Site 1	68	80	76	11	6.9
Site 2	60	62	75	15	5.0

Judging from Table 29, the habitat scores are “Fair” to “Good” at Site 1 (Table 28), while at Site 2, all habitat scores are “Fair”. The lack of running water habitats, such as riffles and rapids, reflected in the macro-invertebrate scores at Site 2, resulting in the “Fair” SASS scores (Table 29), while the favourable stones-in-current habitats at Site 1, resulted in HQI score of 80% (“Good”).

The better habitat quality at Site 1 also reflects in the macro-invertebrate scores, where the ASPT score at Site 1 is 6.9 ("Good" very close to "Excellent"), while the ASPT score at Site 2 is 5.0 (borderline between "Fair" and "Good"). Although Site 1 had a lower number of Families, these were mostly more sensitive taxa.

Table 29: 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 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

The survey results of the macro-invertebrates during July 2020 of both sites were used to run the MIRAI model and Table 30 summarises the results.

Table 30: The final MIRAI score sheet for the Ngodwana River in the project area (July 2020).

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	72,2	*0,345*	24,8876	1	100
HABITAT	H	64,1	*0,259*	16,5685	3	75
WATER QUALITY	WQ	71,6	*0,069*	4,94064	4	20
CONNECTIVITY & SEASONALITY	CS	68,8	*0,328*	22,5456	2	95
						290
INVERTEBRATE EC				68,9424		
INVERTEBRATE EC CATEGORY				C		
>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 Ngodwana River in the project area was placed within the limits of an ecological state category Class C (68.9%), which means this reach is “Moderately modified” (Table 31).

The fact that the status is “Moderately modified” can mainly be attributed to the presence of the Ngodwana Dam upstream of the survey sites, which intercept most flow events and seriously affects the natural hydrology of the river.

Table 31: 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)

During a field study in 2016 the Elands River at the Ngodwana River confluence (downstream of the dam), and the Ngodwana River upstream of the dam was surveyed for fish (Roux et al, 2016). During the survey, five indigenous species of fish of an expected nine species were collected as well as a single female rainbow trout (*Oncorhynchus mykiss*) filled with eggs. This exotic alien and invasive species is a predatory species which will have a negative impact on the indigenous fish species present.

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 categorized into metric groups with constituent metrics that relate 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.

Table 32 explains the 8 steps followed in the calculation of the FRAI.

Table 32: Main steps and procedures in the calculation of the FRAI

STEP	PROCEDURE
River section earmarked for assessment	As for study requirements and design
Determine reference fish assemblage: species and frequency of occurrence	Use historical data & expert knowledge Model: Use eco-regional and other environmental information Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	Hydrology Physico-chemical Geomorphology or Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	Assess fish habitat potential Assess fish habitat condition
Representative fish sampling at site or in river section	Sample all velocity depth classes per site if feasible Sample at least three stream sections per site

Collate and analyse fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	Rate the FRAI metrics in each metric group Enter species reference frequency of occurrence data Enter species observed frequency of occurrence data Determine weights for the metric groups Obtain FRAI value and category Present both modelled FRAI & adjusted FRAI.

Determine reference fish assemblage: species and frequency of occurrence

The X2HOUT-UITZI and X2NGOD-NOOIT sites upstream of the Ngodwana Dam and X2ELAN-ROODE Site below the dam in the Elands River below the SAPPI Paper Mill, will be viewed as reference sites (not natural reference).

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 FROC was developed to be used in the following programmes:

- the FRAI
- procedures that requires a reference fish assemblage (e.g. extrapolation from known sites to unknown sites)

Fish are considered to be one of the important indicators of river health and their responses to modified environmental conditions are measured in terms of the Fish Response Assessment Index (FRAI) (Kleynhans 1999; Kleynhans *et al*. 2005). This index is based on a combination of fish species habitat preferences as well as intolerance to habitat changes, and the present frequency of occurrence of species compared to the reference frequency of occurrence (Kleynhans, Louw, & Moolman, 2007).

The list of species is based on species that are expected to be present or to have been present under close to reference habitat conditions. 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.

The rating of the FROC refers to the reference fish frequency of occurrence (FROC) in a particular ecologically defined reach of a river. Ratings are scored from 1 to 5.

Rating of the reference fish FROC refers to the reference fish frequency of occurrence in a particular ecologically defined reach of a river. This means that FROC ratings are derived based on conditions at the particular site as well as the available habitat in the reach for species expected under reference conditions.

Basic habitat conditions that were considered in terms of the FROC of species are based on intolerance and preference rating as contained in the FRAI (Kleynhans *et al.* 2005). The presence and abundance of habitat features such as velocity-depth classes, cover types

(including substrate) and the characteristics of the natural flow regime (especially the degree of perenniality) in a river reach under reference conditions formed the basis for the expert judgment of the FROC (Kleynhans, Louw, & Moolman, 2007).

There is no FROC Data available for the Ngodwana River (project reach). On the other hand, fish data from the for reports of Roux et al (2016) are available and will be used as an indication of the species with the potential to migrate up the river and inhabit the viable habitats in the Ngodwana River. Fortunately the PESEIS data (DWS 2014) is also available and the combination of data sets will be adequate to run the FRAI.

Table 33: Expected Reference and Habitat derived from the PESEIS data and survey results of Le Roux et al (2016), of fish in the Ngodwana area (two sites upstream of dam, one at Elands confluence). Observed species (HIGHLIGHTED) (Skelton, 2016).

Scientific Names (Expected species)	Common Name	Species abbreviation	Present PESEIS	Roux et al 2016	Observed 2020
Anguilla mossambica	Longfin eel	AMOS	No	No	No
Enteromius anoplus	Chubbyhead barb	BANO	Yes	Yes	No
Enteromius argenteus (*crocodilensis*)	Rosefin barb	BARG	Yes	Yes	Yes
Enteromius polylepis	Smallscale yellowfish	BPOL	Yes	Yes	No
Amphilius uranoscopus	Mountain catfish	AURA	Yes	Yes	No
Chiloglanis bifurcus	Incomati suckermouth	CBIF	Yes	Yes	No
Chiloglanis pretoriae	Limpopo Rock catlet	CPRE	Yes	Yes	Yes
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	Yes	Yes	Yes
Tilapia sparrmanii	Banded tilapia	TSPA	Yes	Yes	Yes
Alien/Introduced					
Oncorhynchus mykiss	Rainbow trout	OMYK	No	Yes	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.

Determine present state for drivers

The purpose is to provide information on the fish response and associated habitat condition and *vice versa* (i.e. fish responses that are possible, given certain habitat conditions). This assessment considers the whole river section to be studied. If information on the drivers is available, these should be used.

In the project area, the Ngodwana River flows are largely impacted by the presence of the Ngodwana Dam. Scouring flows when the spillway overflows and no-flows during drought periods are the main drivers that will impact on habitat, thus influencing the presence of fish species. The poor water quality of the Elands River downstream of the SAPPI Ngodwana Paper Mill renders the Ngodwana River a refuge for sensitive species, which will disappear when the river cease to flow. The Elands River with its poor water quality can also become a migration barrier for fish migrating from downstream areas.

Sampling site selection

During the July 2020 survey, two river sites for aquatic biota was sampled in the Ngodwana River below the dam wall. Site 1 is a site in the Ngodwana River north of the N4 highway where it was also accessible to do aquatic biota studies (Figure 22). The flow of the river here is medium to fast over cobble riffles and rocky rapids with good overhanging vegetation.

Site 2 was selected below the dam spillway, where the river bed is scoured due to turbulent high flows over the dam spillway, forming pools surrounded by reeds. Here are less stones in current habitats than at Site 1.

Fish habitat assessment at site

Habitat potential assessment

Habitat assessment refers to an evaluation of fish habitat potential (i.e. the potential that the habitat provides suitable conditions for a fish species to live there) at a site in terms of the diversity of velocity-depth classes present and the presence of various cover types at each of these velocity-depth classes. This provides a framework within which the presence, absence and frequency of occurrence of species can be interpreted. Habitat assessment includes a general consideration of impacts that may influence the condition or integrity of fish habitat at a site (Kleynhans, Louw, & Moolman, 2007).

The two aquatic sampling sites has different habitat types which resulted in different species assemblages. Site 1 is dominated by rifle-rapid habitats over cobble and rocks with an abundance of over hanging reeds and root wads. Site 2 is a reach with pools, slower flows and overhanging vegetation, including trees in the marginal areas.

Table 34: Fish velocity-depth classes and cover present in the project sites (project area) during the July 2020 survey.

FISH VELOCITY-DEPTH CLASSES AND COVER PRESENT AT SITE (Abundance: 0=absent; 1=rare; 2=sparse; 3=moderate; 4=abundant; 5=very abundant)			
SLOW DEEP: 1	SLOW SHALLOW: 2	FAST DEEP: 1	FAST SHALLOW: 3
Overhanging vegetation: 4	Overhanging vegetation: 4	Overhanging vegetation: 4	Overhanging vegetation: 4
Undercut banks & root wads: 3	Undercut banks & root wads: 2	Undercut banks & root wads: 4	Undercut banks & root wads: 1
Substrate: 1	Substrate: 1	Substrate: 4	Substrate: 4
Aquatic macrophytes: 0	Aquatic macrophytes: 0	Aquatic macrophytes: 0	Aquatic macrophytes: 0
Water Column: 4	Water Column: 2	Water Column: 2	Water Column: 1

Remarks:	Remarks:	Remarks:	Remarks:
Only slow deep habitats in pools.	Some slow shallow habitats on the edges of the pool.	Good stones in current habitats at Site 1	Good riffle habitats at Site 1

Habitat Condition

The purpose is to provide an indication of the deviation of the habitat from the reference condition. In contrast to the assessment of driver conditions or the Index of Habitat Integrity (IHI) in a river section (Tables 11 and 12), fish habitat condition assessment is done for the site and modifications that have a direct influence on fish habitat at the site are considered.

Table 35: Habitat Cover Ratings (HRC) and Site Fish Habitat Integrity Index (SHI) of the two fish monitoring sites during the March 2020 survey.

HCR's:	Slow - Deep	Slow - Shallow	Fast - Deep	Fast - Shallow	Classification: Pools/Backwaters: Slow-<0.3m/s Shallow-<**0.5**m Riffles/Runs/Rapids: Slow-<0.3m/s Shallow-<**0.3**m Rating: **0**=Absent; **1**=Rare (<5%); **2**=Sparse(5-25%) **3**=Moderate(25-75%); **4**=Extensive(>75)
Overhanging vegetation	4	3	4	4	
Bank undercut root wads	3.	1	2	1	
Substrate	1	1	4	4	
Macrophyte	0	0	0	0	

SHI:	**Score**	**Comments**	
Water abstraction:	0	None	
Flow modification:	5	In-stream Dams	RATINGS
Bed modification:	3	Scouring	0 :None
Channel modification:	2	In-stream Dams and scouring	1: Small
Inundation:	4	In-stream Dams	2:Moderate
Exotic macrophytes:	1	Scattered	3:Large
Solid waste disposal:	1	Rubbish	4:Serious
Indigenous vegetation removal:	1	Local wood collecting and construction disturbance	
Exotic vegetation encroachment	2	Riparian	5:Critical
Bank erosion:	1	Scouring	

According to Table 35, the habitat integrity of the Ngodwana River is mostly impacted by the presence of the Ngodwana Dam and some local people activities.

Fish sampling

Sampling effort and results are reported per velocity-depth class sampled.

- **Slow-deep:** A large seine net can be used. A cast net, (diameter = 1.85 m, mesh size = 2.5 cm) can be used in pools. In this case, only the cast net was used and the capture results are recorded as number of fish caught during each effort.

- **Slow-shallow:** A small seine net (5 m long, 1.5 m deep, mesh size = 1 mm) can be used to sample fish. An electrical shocking apparatus should preferably be used. Capture results are recorded as the number of fish caught per time unit (minutes) with an electro-shocker. Both the electrical shocking apparatus and cast net were used in this case.

The following habitats were not sampled as there were none present:

- **Fast-deep:** An electrical shocking apparatus, one operator and two dip net handlers are used in such habitat types. Capture results are recorded as number of fish caught per time unit (minutes).

- **Fast-shallow:** Capture results are recorded as number of fish caught per time unit (minutes) with an electrical shocker.

Due to the terrain and flows in the river only electro-shocking and cast netting methods were applied.

Table 36: Habitats sampled and the sampling effort made per survey site.

HABITATS SAMPLED AND EFFORT

SAMPLING EFFORT	SLOW DEEP	SLOW SHALLOW	FAST DEEP	FAST SHALLOW
Electro shocker (minutes)	20 minutes	20 minutes	20 minutes	20 minutes
Small seine (mesh size, length, depth, efforts)				
Large seine (mesh size, length, depth, efforts)				
Cast net (dimensions, efforts)	10 casts	10 casts	10 casts	10 casts
Gill nets (mesh size, length, time)				

Table 37: Fish sampled during the survey.

SPECIES SAMPLED	SLOW DEEP	SLOW SHALLOW	FAST DEEP	FAST SHALLOW
Rosefin barb *(Enteromius argenteus)*			1	1
Limpopo Rock catlet *(Chiloglanis pretoriae)*				3
Southern mouthbrooder (*Pseudocrenilabrus philander*)		3		
Banded tilapia (*Tilapia sparrmanii*)	1			

Collate and analyse fish sampling data per site

All the information collected during the survey is then collated in the tables of the FRAI model and analyzed throughout the database spreadsheets. The FRAI model calculates the ranks, weights and ratings to eventually provide an Ecological Class for the three sites.

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 38 indicates the weights of the different metric groups for fish at C sites.

Table 38: The weight allocated to the different metric groups in the model.

METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	97,14
COVER	71,43
FLOW MODIFICATION	100,00
PHYSICO-CHEMICAL	51,43
MIGRATION	57,14
IMPACT OF INTRODUCED	45,71

According to Table 38, the “Flow Modification” metric carries the most weight due to the impact of the Ngodwana Dam wall, followed by “Velocity-depth” and “Cover” metrics caused by lack of surface flows certain times of the year due to the presence of the dam. Stagnant pools during no-flow situations and poor water quality in the Elands River explain the Physico-chemical metric, while both the dam wall and poor water quality obstacles impact on fish migration. The Rainbow trout in the upper Ngodwana River flags the “Impact of Introduced”.

Table 39: The FRAI results at the study sites during the current surveys with the expected and observed fish species and the resultant ecological class.

AUTOMATED	
FRAI (%)	54.9
EC: FRAI	D

ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	REFERENCE FREQUENCY OF OCCURRENCE	EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	1,00	0,00
BANO	BARBUS ANOPLUS WEBER, 1897	3,00	2,00
BARG	BARBUS ARGENTEUS GÜNTHER, 1868	4,00	3,00
BPOL	LABEOBARBUS POLYLEPIS BOULENGER, 1907	4,00	2,00
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	2,00	0,00
CBIF	CHILOGLANIS BIFURCUS JUBB & LE ROUX, 1969	3,00	1,00
CPRE	CHILOGLANIS PRETORIAE VAN DER HORST, 1931	4,00	3,00
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	4,00	3,00
TSPA	TILAPIA SPARRMANII SMITH, 1840	4,00	3,00

The relative FRAI score at this reach in the Ngodwana River was placed within the limits of an ecological state category Class D (54.9%), which means this reach is “Largely modified” according to Table 40 “Largely modified” and according to Appendix 2, a Category D represent a “Large change” (42.01 – 57.4).

Table 40: 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	c. 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 and moderately intolerant species. Impairment of health may become very evident.	20 to 39
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

Task 1.2.4 The ecological importance and sensitivity (EIS) and Socio-cultural Importance (SI) of the affected reach/es of the watercourse.

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.

Present Ecological State or PES

The purpose of EcoClassification is to gain insight 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.

The state of the river is expressed in terms of biophysical components:

- Drivers (physico-chemical, geomorphology, hydrology), which provide a particular habitat template; and
- Biological responses (fish, riparian vegetation, riverine fauna (other than fish) and aquatic invertebrates).

Ecological importance and sensitivity (EIS)

The PESEIS data from the Department of Water and Sanitation Desktop PESEIS assessment (DWS, 2014), supplies most of the current status information of the relevant sub-quaternary river reaches (SQRs) for South Africa. The objective of the PESEIS is to provide desktop level information on ecological issues as it relates to the protection and management of SQRs. For management purposes, this refers specifically to the consideration of ecological reserve issues, water use licensing issues and EWRM (including the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) activities) and the determination of priorities for monitoring.

The data analysis for the PESEIS of the Ngodwana River catchment was evaluated during 2011. Figures 30 to 32 supplies a summary of the Ecological Importance and Ecological Sensitivity of the Ngodwana River obtained from the DWS PES-EIS model (Kotze et al 2013).

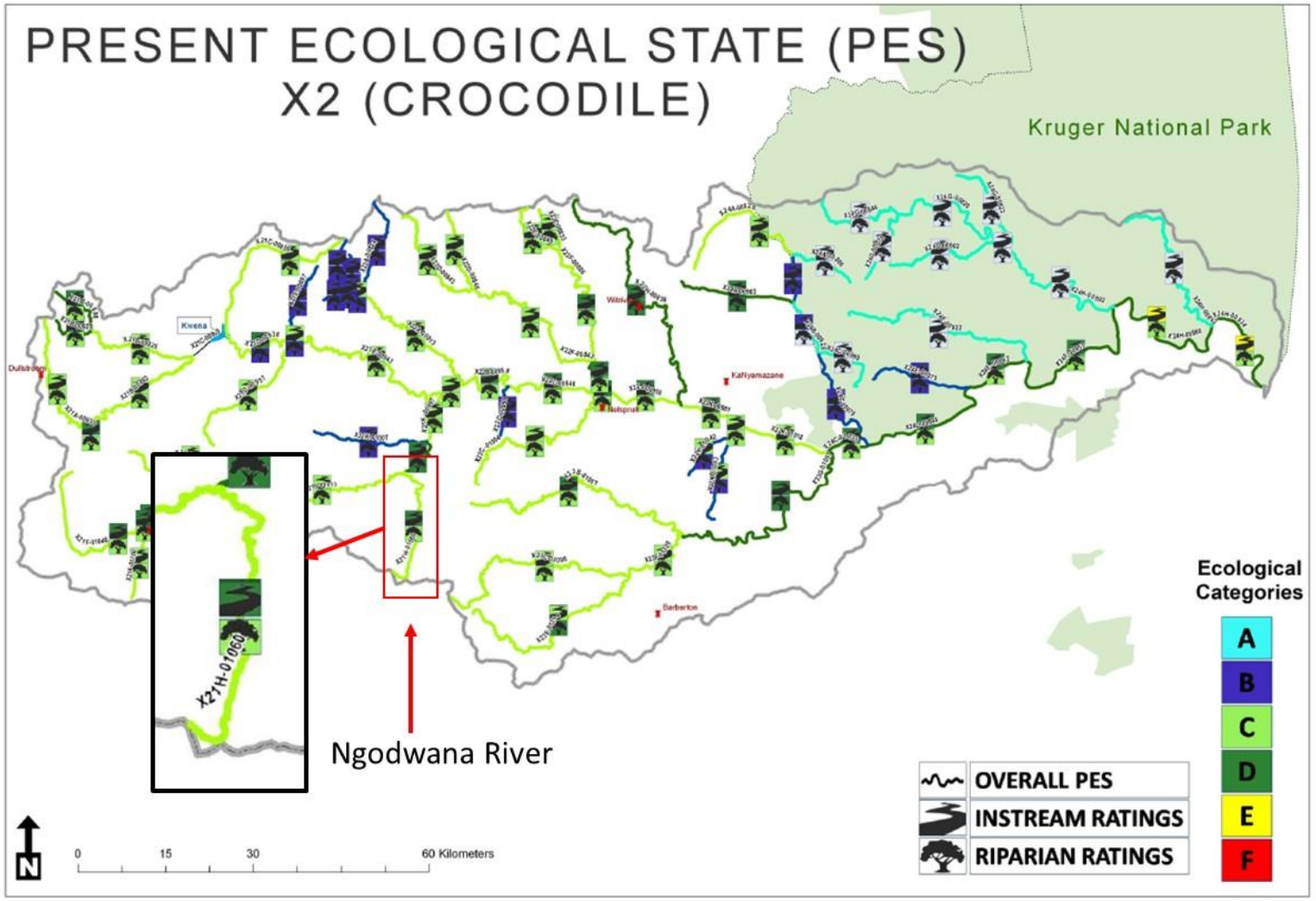

Figure 30: The PESEIS information as regards to the PES of the Ngodwana River, were obtained from the DWS PES-EIS model (Kotze et al 2013).

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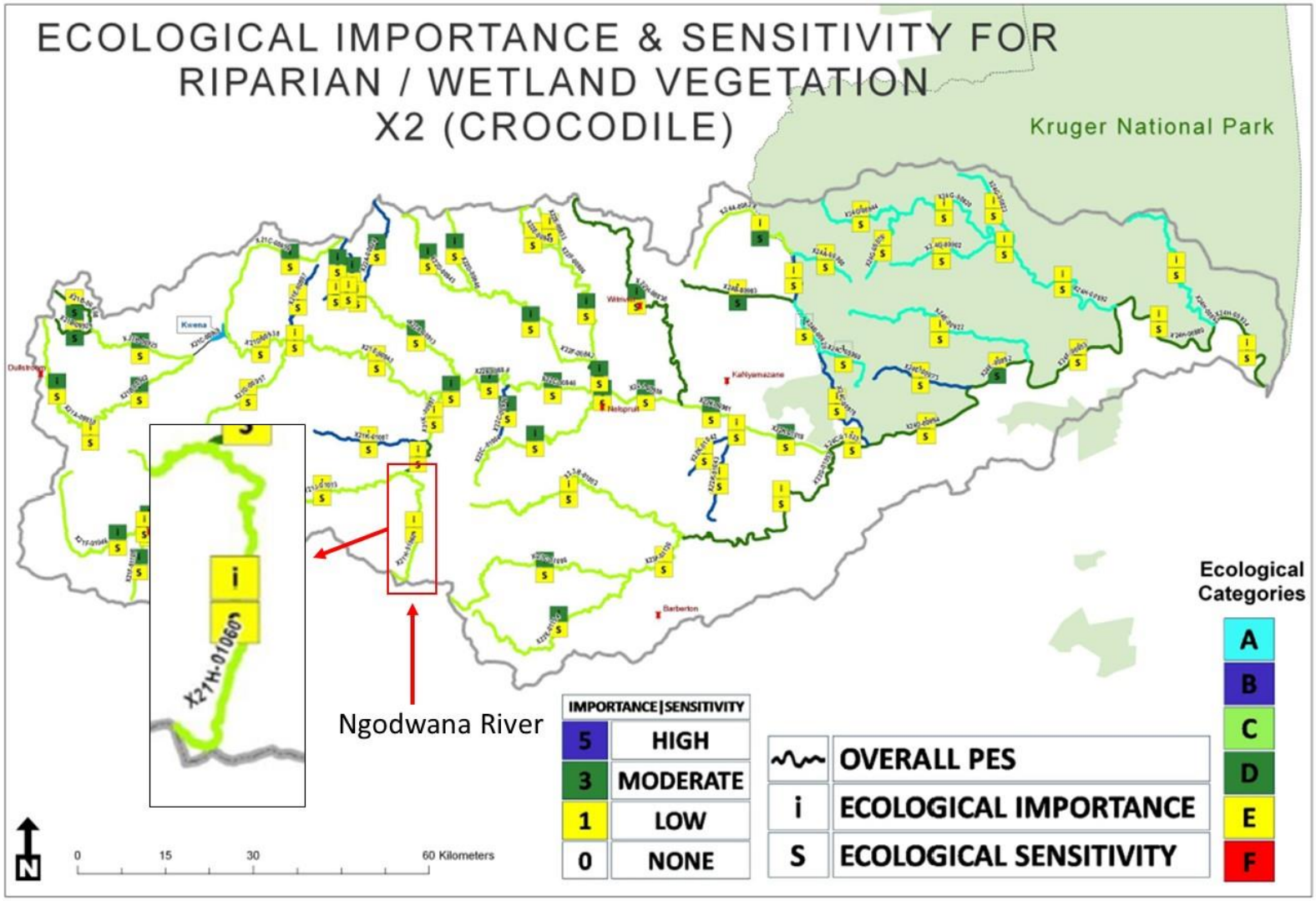


Figure 31: The PESEIS information regarding the EI and ES for the riparian vegetation of the Ngodwana River, were obtained from the DWS PES-EIS model (Kotze et al 2013).

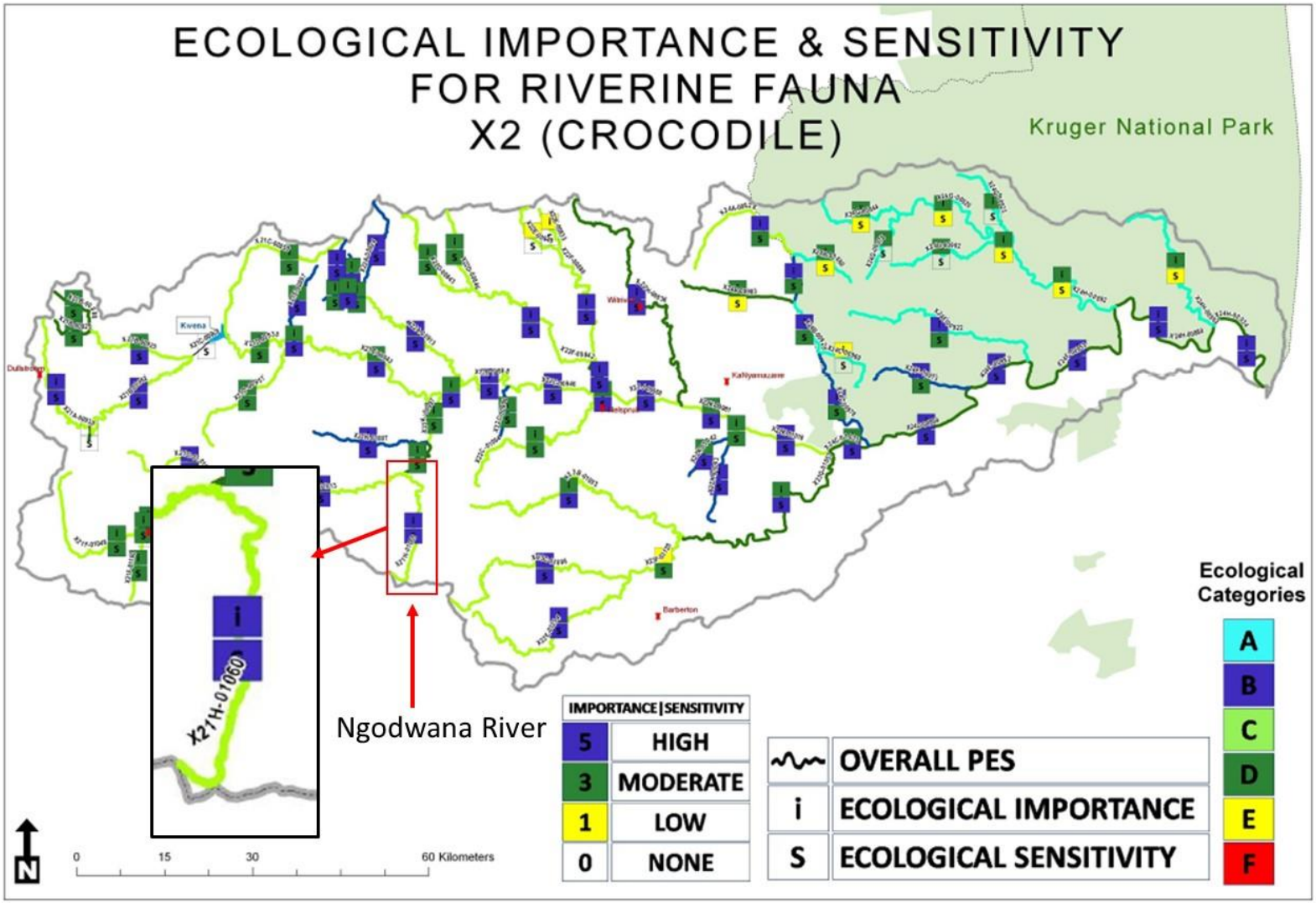


Figure 32: The PESEIS information regarding the EI and ES for the riverine fauna of the Ngodwana River, were obtained from the DWS PES-EIS model (Kotze et al 2013).

Information illustrated in Figure 30 regarding the Ngodwana River indicates that the PES of the tributary falls into a “C” Ecological Category (Moderately modified). The instream rating is “D” and the Riparian rating is “C” (Figure 30). Both the Ecological Importance and Sensitivity aspects regarding the riparian vegetation are considered to be “Low” and thus classified as a Class “E” category (Figures 31 and 32). On the other hand, both the Ecological Importance and Sensitivity aspects regarding the riverine biota are considered to be “High” and thus classified in a Class “B” category (Figures 31 and 32).

Table 41: 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

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.

Ecological Category (EC)

EcoStatus Definition: "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 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 42). 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 42: Assessing the Ecostatus and Ecoclassification of the Ngodwana River.

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	3	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	70		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	3	40		
FISH ECOLOGICAL CATEGORY	11	290	**54,9**	**D**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	4	100		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	2	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	50		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	9	240	**68,9**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		530	**63,2**	**C**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0,50	27,45
Confidence rating for **macro-invertebrate** information	3	0,50	34,45
	6	1,00	61,90
INSTREAM ECOLOGICAL CATEOGORY	EC		C/D

RIPARIAN VEGETATION	EC %	EC
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**64,1**	C

ECOSTATUS	Confidence rating	Proporitons	Modified weights
Confidence rating for instream biological information	3	0,43	26,53
Confidence rating for riparian vegetation zone information	4	0,57	36,63
	7	1,00	63,16
ECOSTATUS	EC		C

The Ecostatus of the river is rated as a C (63.1%), which means it is “Moderately modified”. The finer scale categories (Appendix 2) rates it as “Moderate change”. The EC most influenced is that of the Fish grouping which is in an EcoStatus D (54.9%): “Largely modified”. The Invertebrate assemblage categorized in an EcoStatus C (68.9%): “Moderately modified”. Collectively these in-stream groups have an In-stream Ecological Category of an EcoStatus B (63.2%): “Moderately modified”.

Table 43: 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

Table 44: The table below provides the available parameters that were instrumental to establish the PES of the Project Area:

Parameter	Score %	Category	Description
In-stream IHI	69.2	C	Moderately modified
Riparian IHI	61.6	C/D	Moderate change.
VEGRAI	64.1	C	Moderately modified
MIRAI	68.9	C	Moderately modified
FRAI	54.9	D	Largely modified
Mean EI Class			Moderate
Ecological Sensitivity			Very high
EcoStatus		C	Moderately modified
PES		C	Moderately modified

Table 44 lists the parameters that were instrumental in providing the project area with a PES Category of a “C”, which equates to a “Moderately modified” status.

Socio-cultural Importance (SI)

Ngodwana Mill has been in operation since 1966 and entered the dissolving pulp (DP) market in 2013 with the conversion of part of the mill’s paper grade pulp production to DP production. The mill produces paper grade pulp for own and for market consumption, as well as newsprint, containerboard and DP. It is located along the N4 national road in the scenic Elands Valley, 50 km from Mbombela, the capital city of Mpumalanga province.

Conveniently situated amidst Sappi’s own commercial forestry operations, the mill produces 330,000 tons of paper pulp for own consumption, 250,000 tons of DP and 380,000 tons of paper (newsprint and kraft linerboard used for packaging) per annum. 70% of the mill’s product is exported and the balance is used locally.

The mill generates its own energy in the form of steam and electricity from renewable and other sources. On average, the mill exports power to the national grid, helping to fuel the growing local economy.

Ngodwana Mill is a major role player in the province, contributing over ZAR 5 billion annually to the local economy. The mill employs over 1,000 staff and 700 contractors and more than 43,000 people in the province depend on Sappi for their livelihood.

Since the mill produced its first pulp fifty years ago, the mill has undergone numerous significant expansions, including the addition of two paper machines, a coal-fired power boiler and a DP plant.

The mill plays a positive role in the surrounding community by supporting a wide range of social upliftment programmes:

- Skills development and training:
- Education: The mill is involved in several educational projects, including:
    - Sappi Early Childhood Development Centre (ECD)
    - Programme for Technological Careers (PROTEC)
- HIV/AIDS risk management programme
- Community outreach

Opportunities to improve water use efficiencies are limited for the industrial sector, mainly because of the state-of-the-art technologies already being applied. An example is seen in the Ngodwana mill which is one of the most modern pulp and paper mills in the world. It only discharges one-tenth as much effluent as the international average for mills the same size. Also, this effluent is not discharged into the river, but used for irrigation purpose. However, this irrigation is causing water quality problems (through leaching of salts).

Task 1.2.5 Discuss existing land and water use impacts (and threats) on the characteristics of the watercourse.

The large number and diversity of water resource use activities in the study are known to pose a threat to the viability of the populations of local fishes (O'Brien 2012). These stressors include water quality and quantity impacts and threats from alien and invasive fishes and habitat alterations. Water quality alteration threats include point source pollution events such as the chronic accidental spill and the continuous diffuse release of effluent

from the pulp and paper mill, various agriculture activities in the area and partially treated effluent from the Machadodorp, Waterval-Boven and Ngodwana wastewater treatment works (Ferreira *et al.* 2009; O'Brien 2012).

Water quantity impacts include the alteration of volume, timing and duration of flows in the Elands River by the pulp and paper-making activities at Ngodwana, which includes the management of the man-made Ngodwana Lake (Ferreira *et al.* 2009; O'Brien 2012). The man-made Ngodwana Dam is a 10 m^3 χ 10^6 m^3 water storage facility that was constructed in the early 1980s on the lower Ngodwana River, a tributary of the Elands River.

Shortly after construction, a recreational sport angling activity was established by local community members who established extra-limital populations of the mozambique tilapia (*Oreochromis mossambicus*), redbreast tilapia (*Tilapia rendalli*), sharptooth catfish (*Clarias gariepinus*), sidespot barb (*Barbus neefi*), the silver robber (*Micralestes acutidens*) and bushveld smallscale yellowfish (*L. polylepis*) and alien species including common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*) and rainbow trout (O. *mykiss*) in the lake (ERYCA 2004; Schroeder pers. comm., 16 February 2005)

The Mill uses water from the Ngodwana River, flowing into and stored in the Ngodwana Dam (owned and managed by Sappi). The water from the Ngodwana Dam is then treated at the fresh water treatment facility by flocculation followed by clarification. Lime addition for pH control occurs before the water is filtered through a sand filter. Disinfection is achieved by chlorination. The water from the treatment facility is currently sent to the existing reservoir prior to distribute for use at the mill.

According to Table 45, it is clear that the largest impact on the Ngodwana River reach are the presence of the Ngodwana Dam and the inundation of the landscape (Severity: “Large”). Other “Moderate” impacts include the spreading of alien vegetation, commercial forestry, effluent runoff from industries, sedimentation of the river, vegetation removal and over-grazing by cattle.

Table 45: The impact metrics and ratings of the current identified influences on the Ngodwana River catchment.

Ngodwana X21H-1060		RATINGS
METRIC	IMPACT/ SEVERITY/EXTENT	
Abstraction,	Small	1
Agricultural fields,	None	0
Algal growth,	Small	1
Bed and Channel disturbance,	Small	1
Canalization,	None	0
Chicken farms,	None	0
Low water crossings,	Small	1
Large dams,	Large	3
Small (farm) dams,	Small	1
Erosion,	None	0
Alien aquatic macrophytes,	None	0
Alien vegetation,	Moderate	2
Feedlots,	None	0
Forestry,	Moderate	2

Overgrazing/trampling,	None	0
Inundation,	Moderate	2
Industries,	None	0
Interbasin transfers,	None	0
Increased flows,	None	0
Irrigation,	None	0
Mining,	None	0
Natural areas/nature reserves,	None	0
Recreation,	None	0
Roads,	Small	1
Runoff/effluent: Industries,	Moderate	2
Runoff/effluent: Irrigation,	None	0
Runoff/effluent: Mining,	None	0
Runoff/effluent: Urban areas,	None	0
Sedimentation,	Moderate	2
Grazing (land-use),	Moderate	2
Urbanization,	None	0
Vegetation removal,	Moderate	2

Task 1.2.6 List and map sensitive environments in proximity of the project locality- sensitive environments include wetlands, nature reserves, protected areas, etc.

The Project Area is situated in the Mbombela Local Municipality, Mpumalanga Province. The SAPPI Ngodwana Dam is situated on the Farms Roodewal 470 JT and Grootgeluk 477 JT, directly south of the N4, West of Nelspruit (Figure 1).

To establish how important the site is for meeting biodiversity targets, the Land-Use Decision Support Tool (LUDS) was 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 guide 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.

Before the field study, the team will establish how important the site is for meeting biodiversity targets. To do this, 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 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 MTPA's requirements for assessing and mitigating environmental impacts of developments, or in terms of the listed activities in the EIA regulations?

The key results of the LUDS Report are summarized in Table 46. The information is extracted for the area from national datasets available on the Biodiversity Geographic Information System (BGIS).

Table 46: The key results of the LUDS Report, as extracted for the SAPPI Ngodwana project area, are obtained from the national datasets available on the BGIS website.

National Data Set	**Aspect**	**Present**
National terrestrial information: Ngodwana 638 and 1030 (Mpumalanga).		
South African District	Ehlanzeni	Mpumalanga
South African municipal boundaries	Mbombela	MP322
Quarter-degree grid square		2530DA
Terrestrial CBAs		
Bioregion	**National vegetation map**	**Status**
Savanna Biome (Lowveld)	SVI 9 Legogote Sour Bushveld	Threatened ecosystem status: Vulnerable
Critical Biodiversity Area	Irreplaceable	
Aquatic Critical Biodiversity Areas		

Water Management Area (WMA)	Inkomati WMA	FEPA WMA
Sub Water Management Area	Crocodile Catchment	
Ecoregion 1	Northern escarpment mountains	
Ecoregion 2	10.02	
Ecological Support Areas	Strategic water source areas	Top 50% of strategic water resource area
Freshwater CBAs and ESAs	ESA: Important sub-catchment	FEPA sub-catchment
	CBA: Rivers	FEPA rivers
	Fish support area	*Chiloglanis bifurcus* (EN)
NFEPA river FEPAs – sub-quaternary catchments	FEPA sub-quaternary catchment	
River Unit (NFEPA)	Ngodwana	10_P_U
Quaternary catchment	X21H	X21H-01060
PES (1999)	Class C	Moderately modified

Ecological Support Areas: 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 *Critical Biodiversity Area map* is a map of Critical Biodiversity Areas and Ecological Support Areas based on a systematic biodiversity plan. Critical Biodiversity Areas and Ecological Support Areas are areas that require safeguarding to ensure the continued existence of biodiversity, ecological processes and ecosystem services. A Critical Biodiversity Area map, often developed at provincial level, provides the basis for a biodiversity sector plan.

Freshwater Ecosystem Priority Areas (FEPAs) were identified based on a range of criteria dealing with the maintenance of key ecological processes and the conservation of ecosystem types and species associated with rivers, wetlands and estuaries FEPA maps show various different categories, each with different management implications. The categories include river FEPAs and associated sub-quaternary catchments, wetland FEPAs, wetland clusters, Fish Support Areas and associated sub-quaternary catchments, fish sanctuaries, phase 2 FEPAs and associated sub-quaternary catchments, and Upstream Management Areas. NFEPA map products provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or FEPAs.

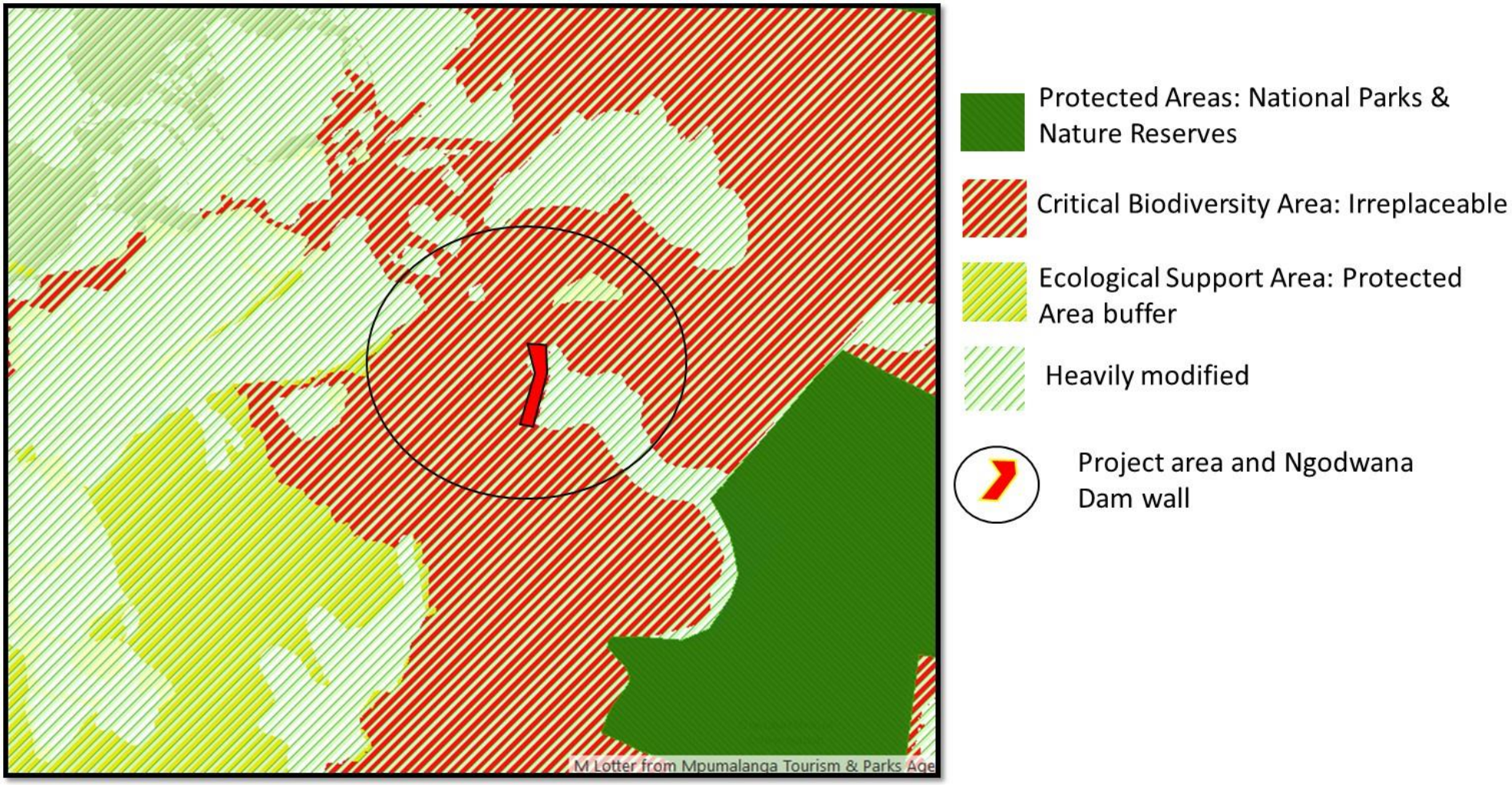


Figure 34: A map obtained by the 2014 Mpumalanga Biodiversity Sector Plan to indicate the Terrestrial CBAs related to the project locations (black circle). Dark green = Protected Area National Parks & Nature Reserves (Mpumalanga Biodiversity Sector Plan, 2014).

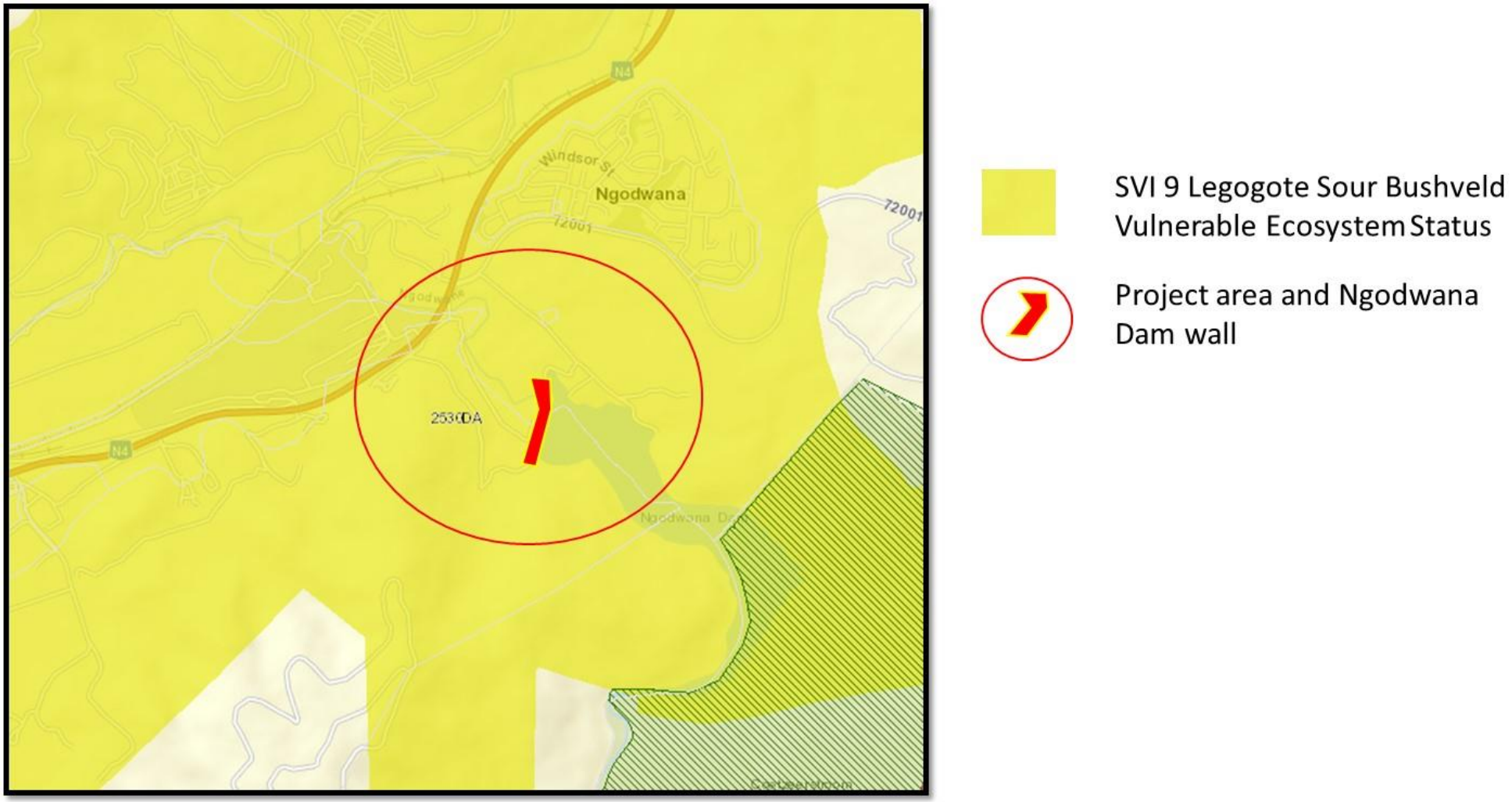


Figure 35: A map obtained by the 2014 Mpumalanga Biodiversity Sector Plan to indicate the vegetation type covering the project location, (red circle) (Mpumalanga Biodiversity Sector Plan, 2014).

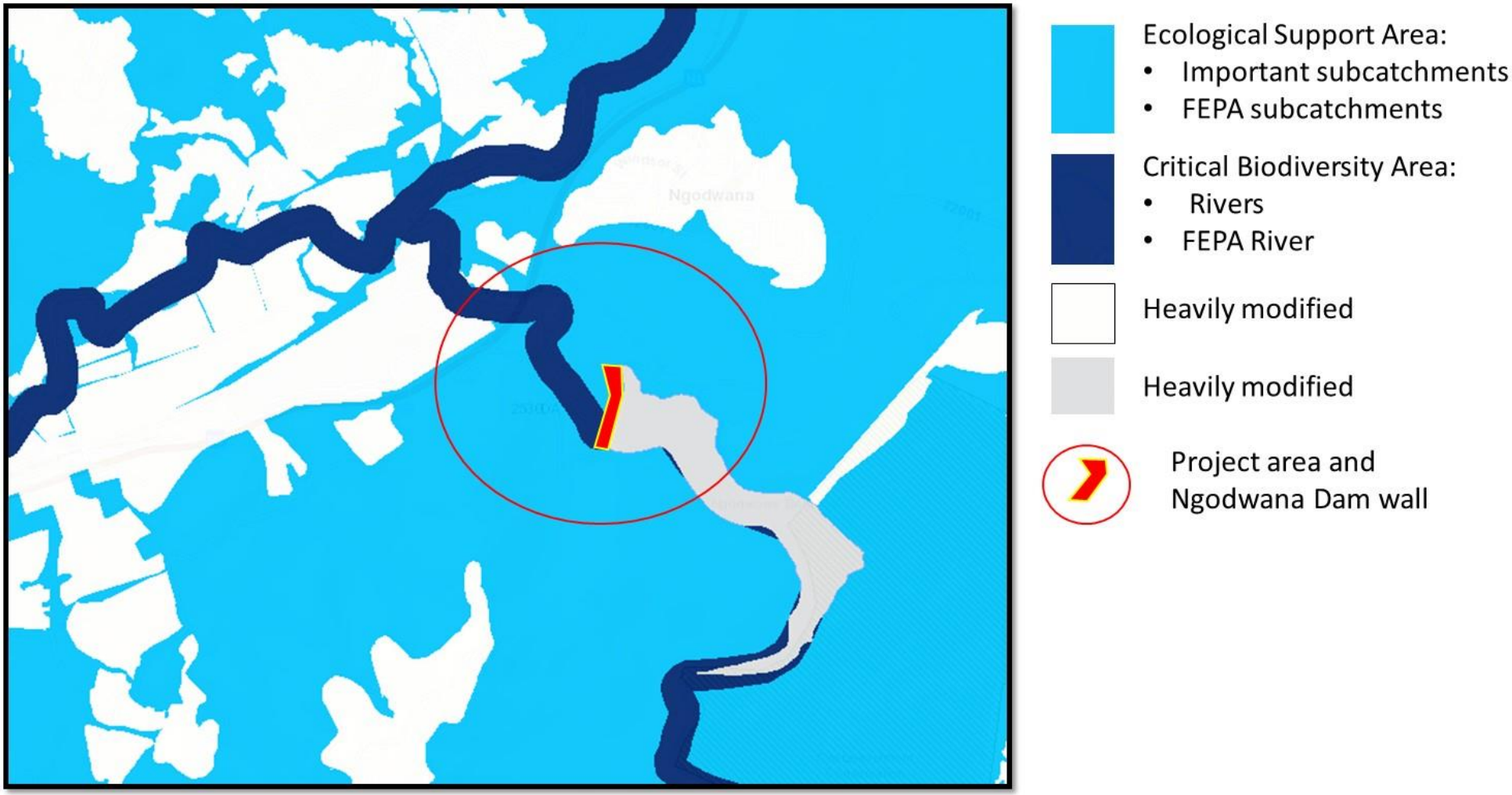


Figure 36: A map obtained by the 2014 Mpumalanga Biodiversity Sector Plan to indicate the Freshwater CBAs and ESAs in the project area, (red circle) (Mpumalanga Biodiversity Sector Plan, 2014). Light blue = Ecological Support Areas; Dark blue = Critical Biodiversity Areas (Mpumalanga Biodiversity Sector Plan, 2014).

According to Figures 34 to 36 and Table 46, the entire project area falls into the following sensitive areas:

- Terrestrial:
  - Critical Biodiversity Area: Irreplaceable
  - Vulnerable Ecosystem status: Legogote Sour Bushveld
- Freshwater
  - Critical Biodiversity Area:
    - Rivers
    - FEPA river
    - Fish support area
  - Ecological Support Area:
    - Important subcatchments
    - FEPA subcatchments

With these overarching sensitive landscape properties, it is paramount to approach the construction and operation phases of the entire project with caution.

The Ngodwana River is a river FEPA, which means it is a river reach that is required for meeting biodiversity targets for river ecosystems and threatened fish species. The Desired Management Objectives of a river in the Critical Biodiversity Area category, are to maintain the river in a natural state with no loss of ecosystems, functionality or species; no flexibility in land-use options.

Since the river is also situated in an Ecological Support Area, the Desired Management Objectives are to minimise habitat and species loss through judicious planning and maintain basic ecosystem functionality and ecological condition within the surrounding landscape (sub-catchment).

4.3 Risk Assessment:

Task 3.2.1 Provide an assessment of the risks associated with the water use/s and related activities.

The Risk Assessment for this project 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 (Appendix 3).

Infrastructural components to be evaluated for the risk assessment

Infrastructural components of the SAPPI Ngodwana 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.

Aspects: The Ngodwana Dam and associated infrastructure components within the regulated area have potential impacts which are listed below:

Construction

- **Activity 1.** Stabilizing the berm and toe drain
  - **Aspect 1.1:** Vegetation clearing
  - **Aspect 1.2:** Disturbance - Altering the bed, banks, course of a watercourse
  - **Aspect 1.3:** Disturbance - Noise and movement
  - **Aspect 1.4:** Impacting the small stream on the western slope
- **Activity 2.** Raising of the right flank embankment
  - **Aspect 2.1:** Vegetation clearing
  - **Aspect 2.2:** Topping soil on the embankment
- **Activity 3.** Establish stockpile areas
  - **Aspect 3.1:** Vegetation clearing
- **Activity 4.** Haul route **–** both sides of the river
  - **Aspect 3.1:** Vegetation clearing
  - **Aspect 3.2:** Fragmentation or riparian corridor
  - **Aspect 3.3:** Impacting stream flow of the small stream on the western slope
  - **Aspect 3.4:** Erosion and siltation
- **Activity 5.** Site establishment area and footbridge
  - **Aspect 4.1:** Vegetation clearing
  - **Aspect 4.2:** Erosion and siltation
- **Activity 6.** Alien invading vegetation
  - **Aspect 5.1:** Introduction of alien vegetation

Operational

- **Activity 6:** Haul route **–** both sides of the river
  - **Aspect 6.1:** Dust
- **Activity 7:** Alien invading vegetation
  - **Aspect 7.1:** Spreading of alien vegetation

Construction

Activity 1. Stabilizing the berm and toe drain

Dam wall berm and toe drain

The dam remediation is to ensure the continued safe operation of this 41 m high zoned earth-fill Category III dam and the stability of the main and right flank embankments and its foundations (Ecoleges, 2020).

The scope of construction works to be included in the rehabilitation and to be authorised is:

1. Stabilizing berm (Figure 37) on the downstream face of the main embankment to RL 941.3 m, including approximately 30 000 m^3 of earthworks, a new internal drainage system (sand & gravel filters, rock toe and drain pipes with inspection concrete manholes) and gabion retaining walls.

2. Subsoil pipe drains above the berm of 133 m length with inspection concrete manholes.

Figure 37: Dam wall berm and toe drain to be stabilised.

Figure 38:

38a. A panoramic view of the area below the dam wall (July 2020).
38b. An aerial photo of the Gondwana Dam being constructed during the early 1980s. Note the denuded area from riverine area all the way to the spillway.

38c. The area below the dam wall (July 2020). Note how the denuded area illustrated in Figure 38b recovered. The vegetation that established in the denuded area is about 60% indigenous and 40% alien invaders.
38d. and 38e: Two photos taken from the Gondwana Dam wall: Photo 38d) during the period when the wall was constructed (early 1980s) and photo 38e) July 2020 during the current survey period.

Activity 2. Raising of the right flank embankment

Right flank embankment

3. Raising of the right flank embankment to prevent overtopping and failure during large floods and to improve the stability of the embankment (earthworks to be confirmed).

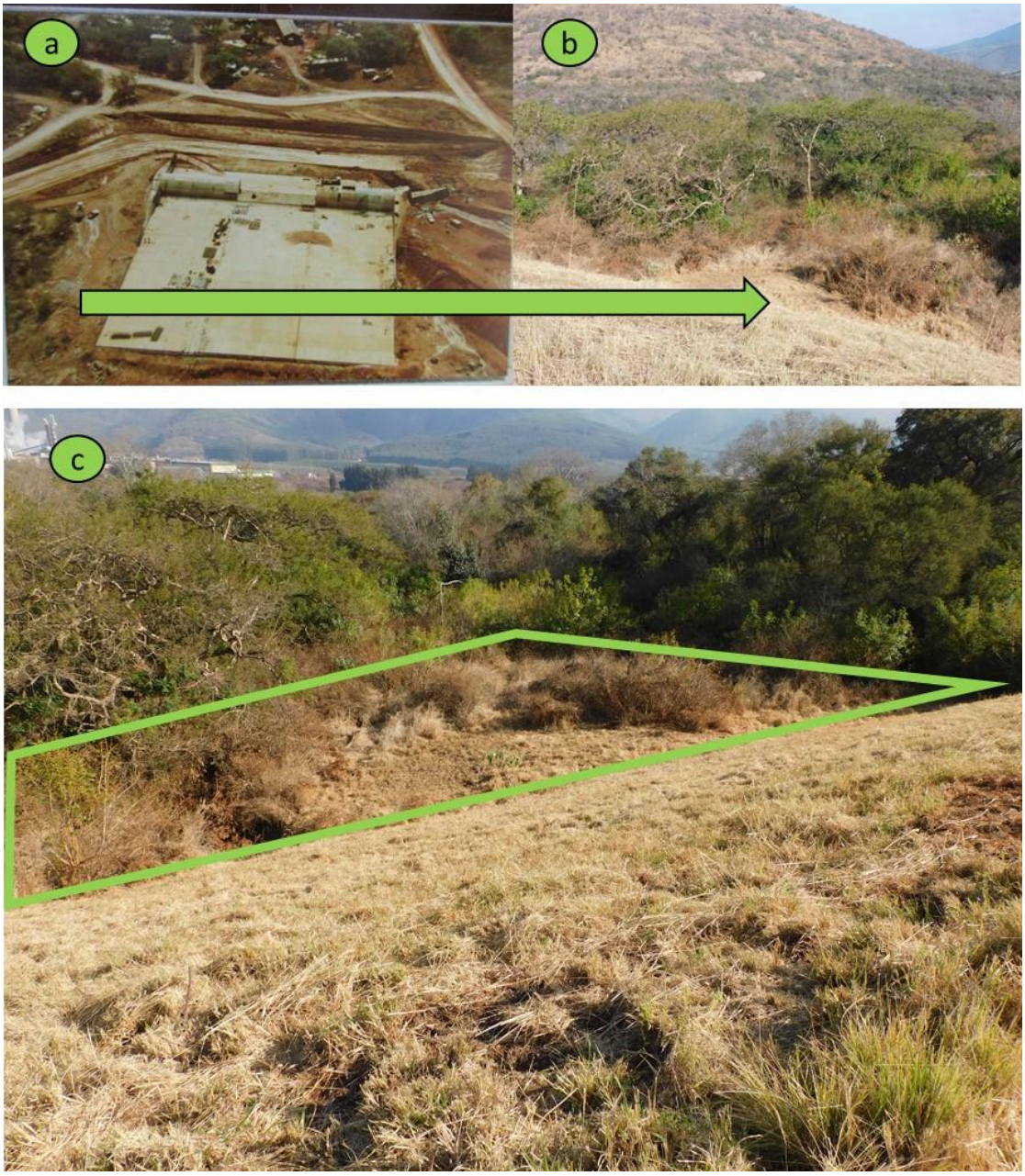


Figure 39:

39a. and 39b. Two photos taken from the Gondwana Dam right flank embankment: Photo 39a) during the period when the wall was constructed (early 1980s) and photo 39e) July 2020 during the current survey period. Note the denuded area on the right flank embankment during construction (39a) and the regrowth in (39b).
39c. The area below the toe of the dam (green rectangle) is regularly cleared of vegetation as part of maintenance.

Activity 3. Establish stockpile areas

There are two stockpile areas planned for the project: The Fishing Club Temporary Stockpile and the WTW Temporary Stockpile.

Figure 40:

40a. The WTW Temporary Stockpile near the N4 (Figures 8 and 9).

40b and 40c. The low woodland area which is earmarked for the stockpile area.

Figure 41:

41a-41d. The Fishing Club Temporary Stockpile is planned on an area with no ecological value – old mining/dumping area (Figures 8 and 9).

Figure 42: This figure shows the locations of the two temporary stockpile areas.

Activity 4. Haul route **–** both sides of the river

#1 Haul route to the north flank

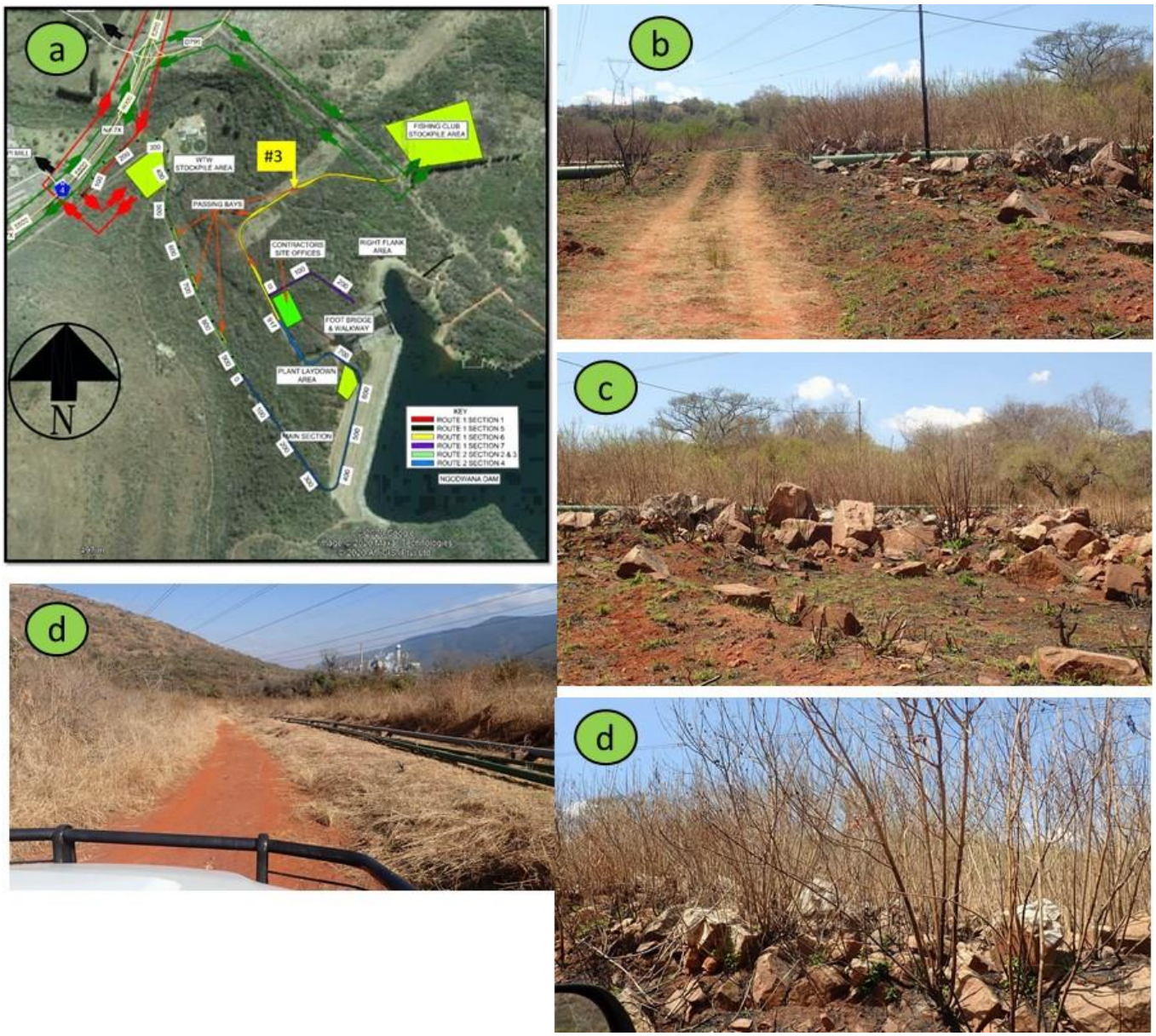
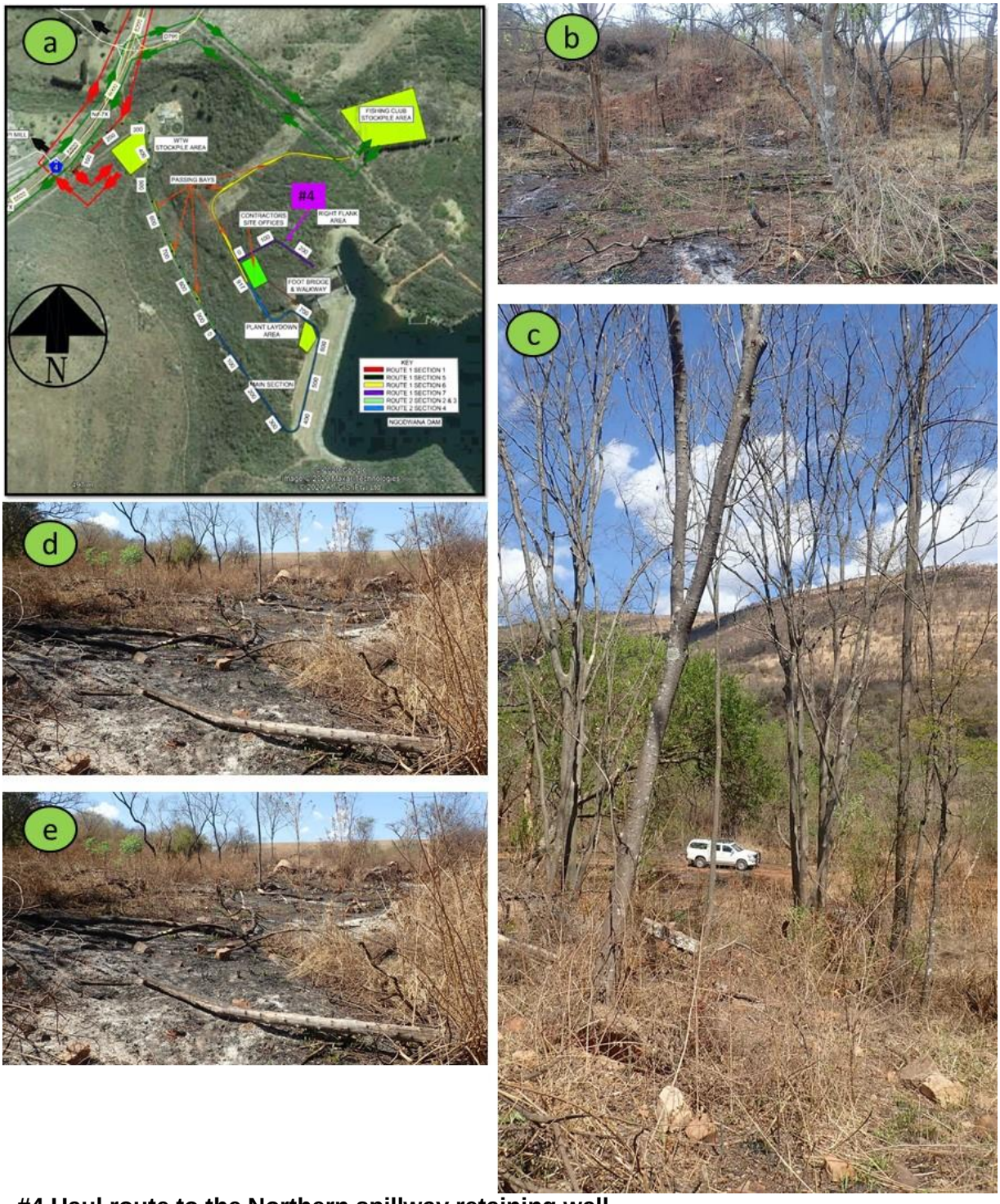


Figure 43:

43a. The proposed Ngodwana Dam haul road route (#3) to the north flank (Figures 8 and 9).

43b to 43d. Photos of the established dirt road which will be upgraded.



#4 Haul route to the Northern spillway retaining wall.

Figure 44:

44a. The proposed #4 Haul route to the Northern spillway retaining wall (Figures 8 and 9).

44b to 44e. Photos of the area identified as the best route – signs of previous activities indicate historical human interference, however a small number of trees will have to be removed for the route clearing.

#5 Haul route past the SAPPI's Water Treatment Works (WTW).

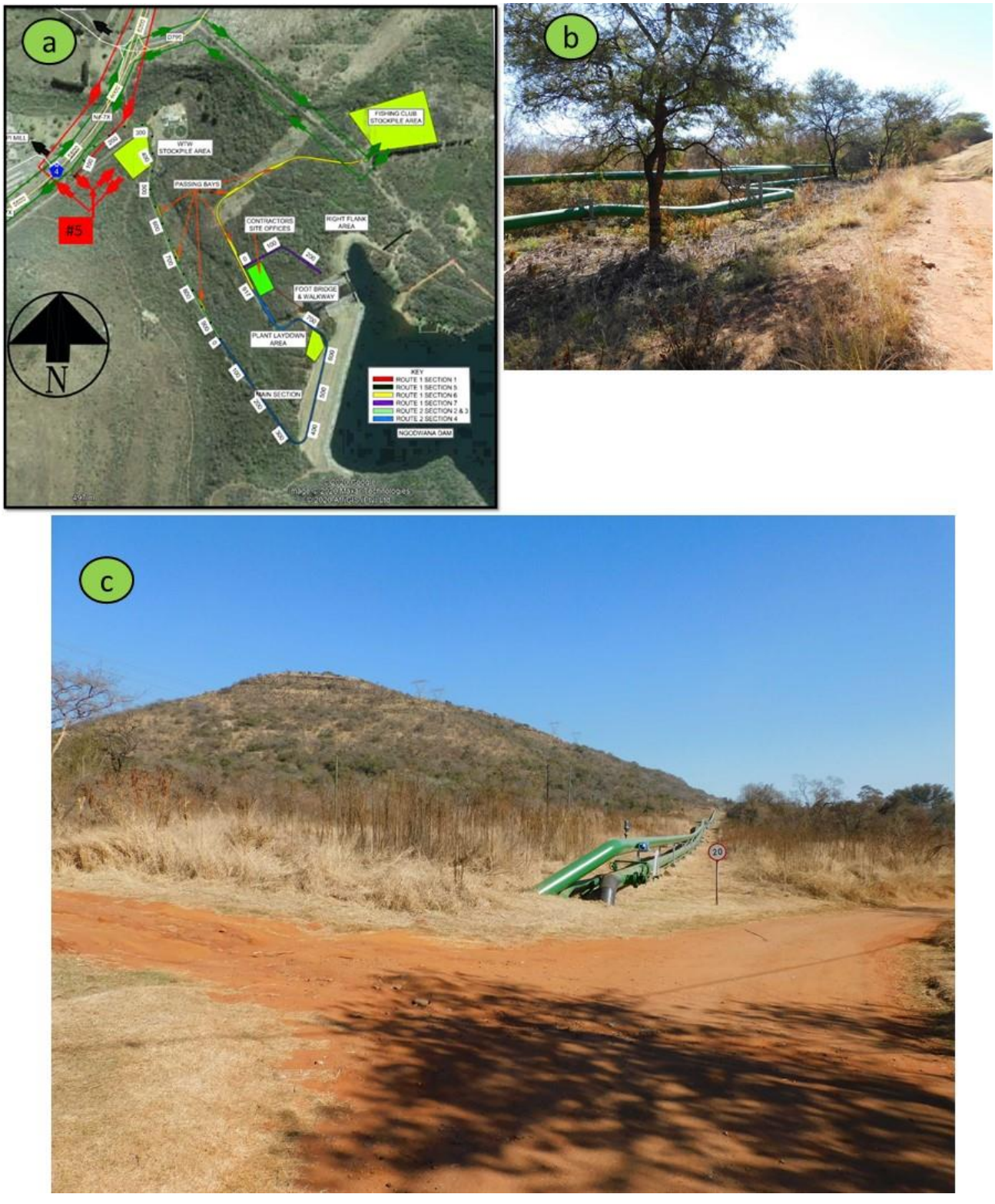


Figure 45:

45a. The proposed #5 Haul route past the SAPPI's Water Treatment Works (WTW) (Figures 8 and 9).

45b and 45c. Photos of the existing road past the SAPPI's Water Treatment Works (Figures 8 and 9).

45b to 45e. Photos of the area identified as the best route – signs of previous activities indicate historical human interference, however a small number of trees will have to be removed for the route clearing.

#7 Haul route west of the Ngodwana River.

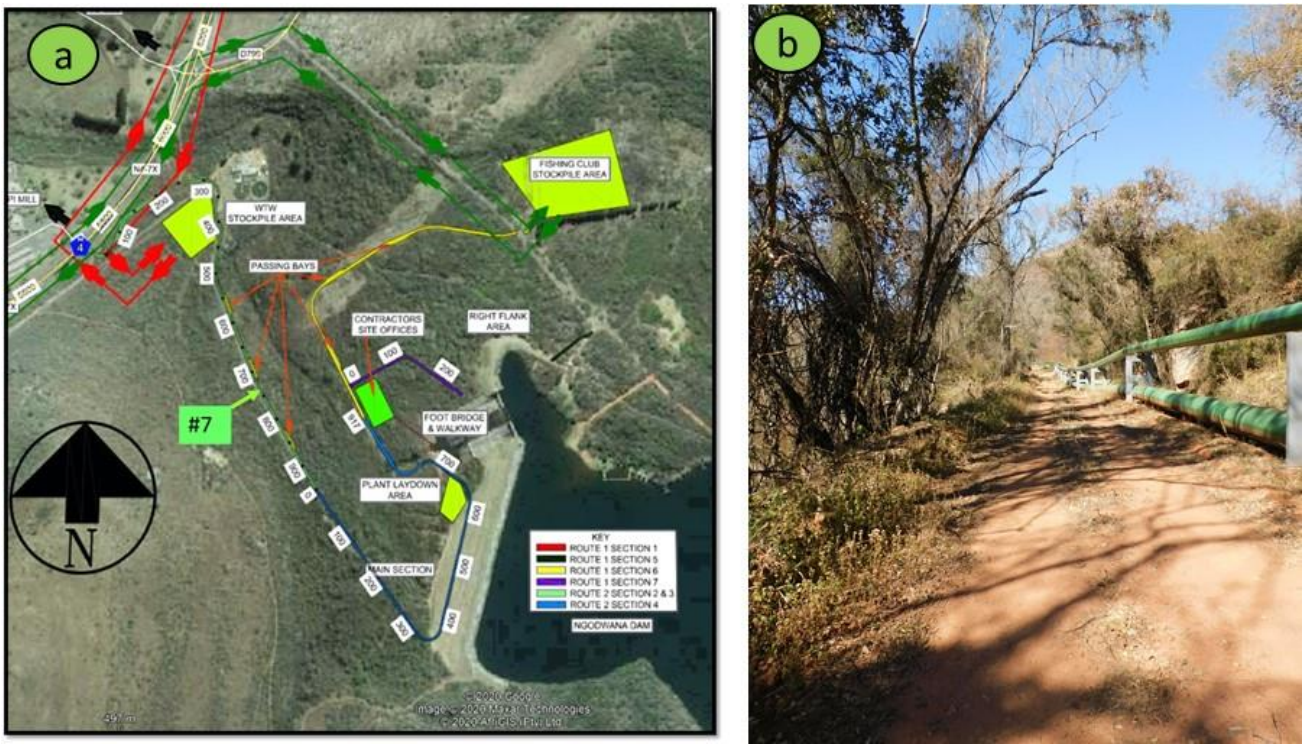


Figure 46:

46a. The proposed new #7 Haul route west of the Ngodwana River (Figures 8 and 9).

46b. Existing road and water pipeline.

<u>#8 New haul route up the embankment of the dam.</u>

Figure 47:

47a. The proposed new #5 Haul route up the embankment of the dam (Figures 8 and 9).

47b. Existing road at the toe of the dam.

47c. and 47d. Existing road going northwards towards the WTW.

47e. Large white stinkwood trees in areas west of the existing road

Haul road #8 will link up with haul road #3 and haul road #7. Figure 49 illustrates the areas where the proposed haul routes intersects with the riparian buffer zones. Four areas of intersections have been identified: Points 7.1 and 7.2 on the #7 haul road, and Points 8.1 and 8.2 on the proposed #7 haul road.

- **Point 7.1:** Here the existing #7 haul road crosses the Ngodwana catchment valley bottom wetland over an existing bridge structure.
- **Point 7.2:** Here the existing #7 haul road runs for a few meters through the Ngodwana River buffer zone.
- **Point 8.1:** Here the existing portion of #8 haul road crosses the Ngodwana catchment seep, and most of the water pass under the road, but there is an area where it seeps over the road.
- **Point 8.2:** Here the proposed portion of #8 haul will road cross the Ngodwana spillway drainage (Figure 48) by means of a low-level bridge that will not impede the flows of the spillway overflow.

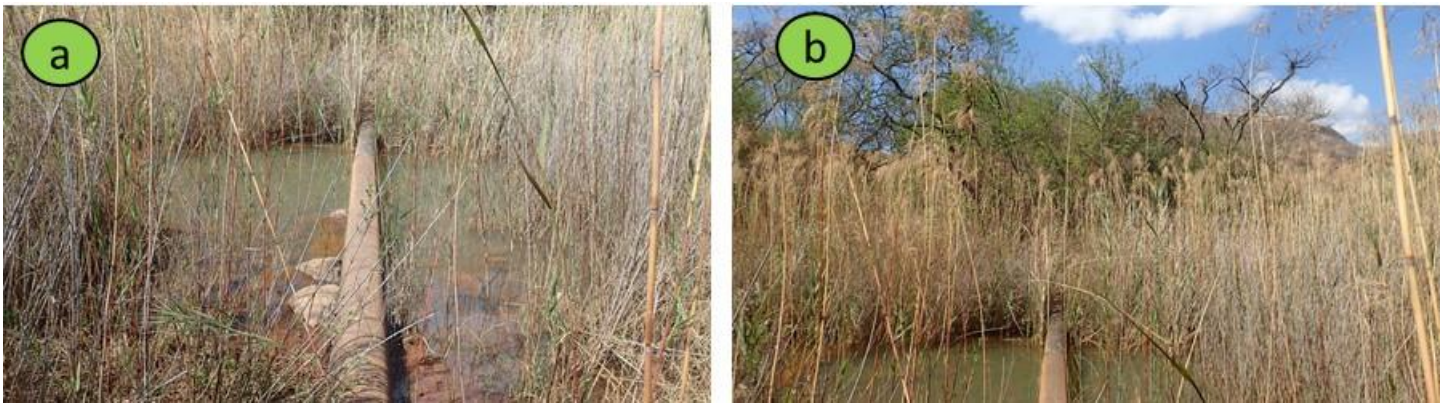


Figure 48: The area where the haul road will cross the Ngodwana spillway drainage by means of a low-level bridge.

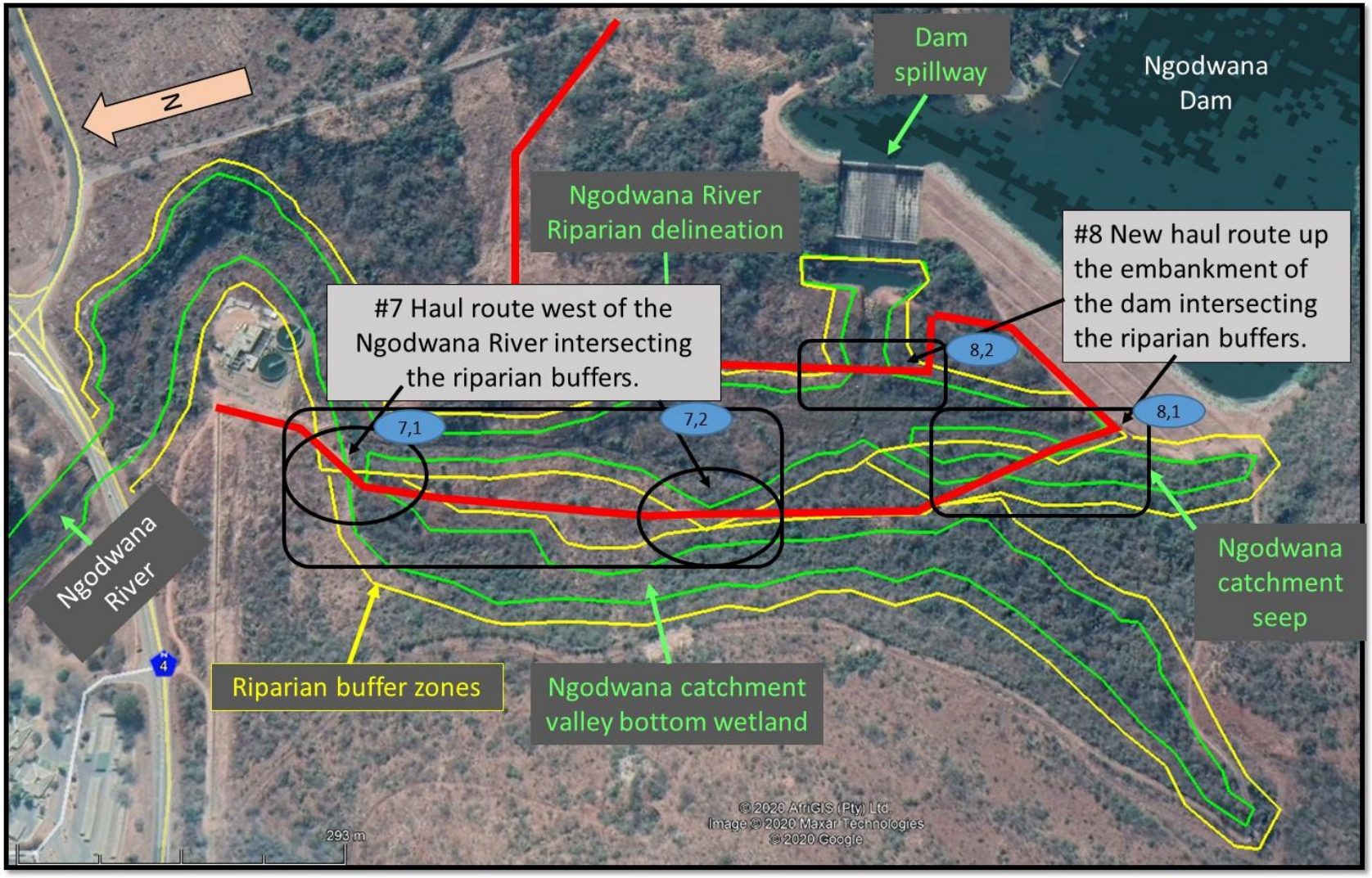


Figure 49: This figure illustrates the areas of the proposed haul routes intersecting with the riparian buffer zones.

Activity 5. Site establishment area and footbridge

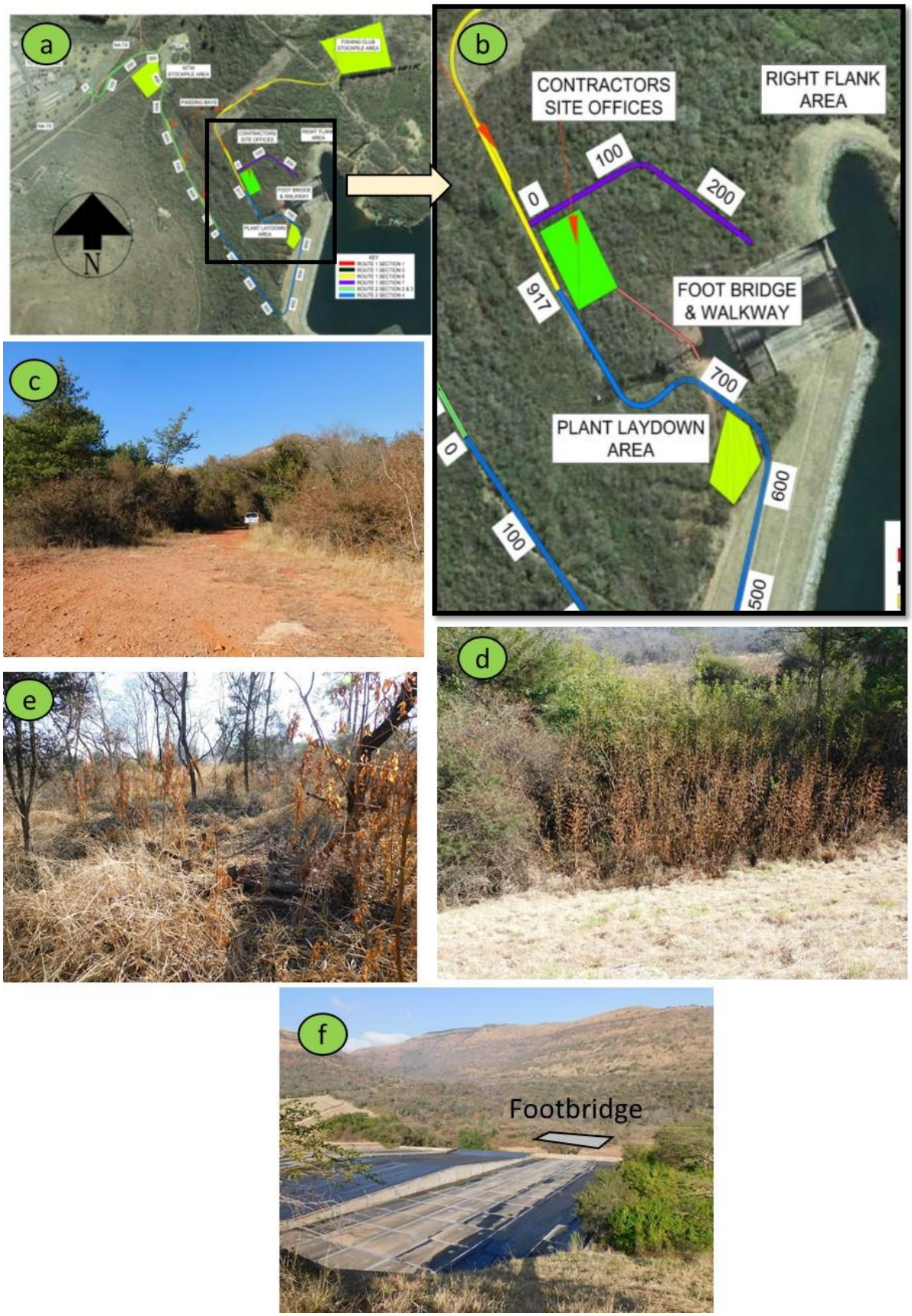


Figure 50:

50a. The proposed Ngodwana Dam rehabilitation infrastructure setup, highlighting haul road routes to areas (Figure 9).

50b. Plan of the proposed site establishment area and footbridge location.

50c. Existing road towards the footbridge location.

50d. A view of the current vegetation of the proposed contractor's laydown area, illustrating the mix of indigenous and alien vegetation on the site.

50e. A view of the current vegetation of the proposed contractor's site offices, illustrating the open woodland on the site.

50f. The proposed footbridge location as viewed from the top of the dam wall.

A foot bridge below the spillway will link the site office area with the contractor's laydown area. A pedestrian walkway and pedestrian bridge below the spillway will provide access to the construction site from here. This must be done in a way to conserve the area and to serve as an eco-recreation area after construction.

Alien invading vegetation

The spread of alien invasive species is an ongoing problem as alien plants in the surrounding landscape act as a long term source of seeds and future spread. Numerous alien invasive species were recorded in varying densities at the various sites, which reduces the ecological integrity of the riparian zone and its PES class. The high abundance of alien plant species within the site impacts adjacent plant communities and promote the invasion of alien species into the intact vegetation.

The disturbance to the vegetation and soils, during the clearing and preparation phase, could increase the risk of alien plant invasion, especially where soils are exposed. Loss of habitat adjacent to roads and pipelines may result in an increase in alien invasive plant species. Roads and traffic may facilitate the invasion of weeds and exotic plants as seeds attached to undercarriages in mud and dirt may bring seeds from a large potential catchment and move them across the landscape rapidly.

Inappropriate maintenance activities during the operational phase would also promote the invasion or dominance of alien plant species at the site. Alien species are already present in the area and will colonise any area of disturbance should they not be actively controlled.

Figure 51: The alien invader, yellow bells (*Tecoma stans*) is abundant in many places in the project area.

Following is an abstract from the Risk Assessment Matrix for the Ngodwana Dam project area relating to all current and expected impacts that the development will have on the system, the significance of these impacts, and mitigation through control measures.

Phase: Construction

Activity 1. Stabilizing the berm and toe drain.

Aspect 1.1 Vegetation clearing.

Potential Impact 1: Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: The area to be cleared as proposed for constructing the stabilizing berm and toe drain, was cleared completely during the dam construction in the early 1980s. The vegetation that returned after construction contained a large component of alien species (Table 7; Transect 2). This second round of clearing should be followed up by an alien plant control programme during rehabilitation of the construction footprint and replanting indigenous plants.

Potential Impact 2: Damage to riparian large trees or shrubs.

Risk rating after mitigation: Low (significance = 26; confidence 4).

Control measure: Removing large trees should be avoided as far as possible and unnecessary clearing of areas should also be avoided. Trees, such as indigenous Paperbark thorn (*Vachellia sieberana*) and Sweet thorn (*Vachellia karroo*) that grows vigorously, should be planted during rehabilitation and thus replace trees that have been removed.

Potential Impact 3: Fragmenting the riparian corridor by removing riparian bushes or river bank vegetation and thus compromise the function of riparian connectivity.

Risk rating after mitigation: Low (significance = 24; confidence 4).

Control measure: The Ngodwana River has been intercepted by the dam wall, thus fragmenting the riverine environment permanently. Other than covering an area of the original streambed (now not flowing, some seepage), no further fragmentation is foreseen due to the proposed construction activities.

Aspect 1.2: Disturbance - Altering the bed, banks, course of a watercourse.

Potential Impact 4: The covering of indigenous riverine vegetation will be associated with the construction of the berm and toe drain.

Risk rating after mitigation: Low (significance = 26 confidence 4).

Control measure: The area that will be covered by during construction of the stabilizing the berm and toe drain by material, currently consists of an area that has previously been cleared and now consists of some local indigenous plants and a large component of alien invading species. No indigenous plants of Special Concern are present in the area to be impacted and the covering of the vegetation will be permanent (Figure).

Potential Impact 5: Covering the marginal vegetation on the embankment will lead to loss of potential habitat and biodiversity.

Risk rating after mitigation: Low (significance = 28 confidence 4).

Control measure: The area that will be covered by stabilizing the berm and toe drain, consists of an area previously been cleared and now consists of low woodland and wetted areas created by seeping from the dam wall. No habitat of Special Concern are foreseen to be impacted.

Potential Impact 6: Erosion of cleared areas will lead to siltation of the downstream aquatic habitat.

Risk rating after mitigation: Low (significance = 33.7 confidence 4).

Control measure: Best Practice procedures should be implemented during construction and when the area is rehabilitated. Stringent mitigation measures must be imposed during construction to minimize runoff and stop possible silt run-off. The contamination of water leaving the site could be controlled by the use of silt-fencing, rows of hessian bags, mulch, brushwood and deflection berms (the choice depending on the situation).These mitigation measures are essential in all exposed areas.

Aspect 1.3: Disturbance - Noise and movement

Potential Impact 7: Vehicle and human movement and sounds will disturb riparian fauna in the vicinity of the construction activities.

Risk rating after mitigation: Low (significance = 31.5; confidence 4).

Control measure: The disturbance will be for a relative short period and the activities will be contained to the dam wall and roads leading tot the construction site. Workers should be forbidden to move around off the construction site.

Aspect 1.4: Impacting the Ngodwana catchment seep on the western slope.

Potential Impact 8: Impacting the flow and water quality of this near-pristine mountain stream due to construction activities.

Risk rating after mitigation: Low (significance = 31.5; confidence 4).

Control measure: This small wetland should be treated with care throughout the construction phase. Wherever possible, no covering of material or dumping of any rubble should be allowed into the wetland system. Personnel should refrain from accessing the forested wetland. The buffer must be respected and the water flow towards the Ngodwana River must not be obstructed.

Activity 2. Raising of the right flank embankment

Aspect 2.1: Vegetation clearing

Potential Impact 9: Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.

Risk rating after mitigation: Low (significance = 26; confidence 4).

Control measure: The area to be cleared for constructing in order to raise the right flank embankment, was cleared completely during the dam construction in the early 1980s. The vegetation that returned after construction contained a large component of alien species. This second round of clearing should be followed up by an alien plant control programme during rehabilitation of the construction footprint and replanting indigenous plants.

Aspect 2.2: Topping soil on the embankment

Potential Impact 10: Erosion of dumped soil will lead to siltation of the downstream aquatic habitat.

Risk rating after mitigation: Low (significance = 26; confidence 4).

Control measure: Best Practice procedures should be implemented during construction and when the area is rehabilitated. Stringent mitigation measures must be imposed during construction to minimize runoff and stop possible silt run-off. The contamination of water leaving the site could be controlled by the use of silt-fencing, rows of hessian bags, mulch, brushwood and deflection berms (the choice depending on the situation).These mitigation measures are essential in all exposed areas.

Activity 3. Haul route – both sides of the river

Aspect 3.1: Vegetation clearing.

Potential Impact 11: Removal of indigenous riparian vegetation, considering coves of White Stinkwood along the western haul route.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: About 90% of the planned haul routes will be on existing tracks or unpaved roads. Care must be taken not to impact on areas outside the demarcated route. Construction activities inside the riparian buffer zone must proceed with special care (Figure 49). Whenever tall white stinkwood trees are removed on the #8 new haul road, these trees must be replaced in order to mimic the natural habitat impacted on.

Aspect 3.2: Fragmentation or riparian corridor

Potential Impact 12: Impacting on indigenous riparian vegetation, fragmenting the riparian corridor.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: Corridors and buffers must be respected and the riparian zone must not be disturbed at all.

Aspect 3.3: Impacting stream flow of the Ngodwana catchment seep on the western slope.

Potential Impact 13: Impacting the flow and water quality of this near-pristine mountain stream due to construction activities.

Risk rating after mitigation: Low (significance = 26; confidence 4).

Control measure: Flow down the Ngodwana catchment seep must be allowed to flow unhindered to its confluence with the Ngodwana River.

Aspect 3.4: Erosion and siltation.

Potential Impact 14: Disturbing the soil during the construction of roads, clearing areas and create bare patches, channelling storm water and road run-off, etc. will cause erosion and siltation of the river.

Risk rating after mitigation: Low (significance = 30; confidence 4).

Control measure: If appropriate mitigation is carried out, including strict adherence to anti-erosion actions given in the EMP, this impact could be reduced to low significance. All areas susceptible to erosion must be identified and protection measures be implemented.

In any areas where the risk of erosion is evident, appropriate temporary or permanent works and water energy dispersion structures must be installed. Cleared or bare areas prone to erosion should be monitored and rehabilitation should be implemented wherever indications of potential erosion become evident. 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 development.

Activity 4. Site establishment area and footbridge.

Aspect 4.1: Vegetation clearing.

Potential Impact 15: Loss of riparian habitat and potential habitat for local biota, including corridors and buffers.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: Both the site establishment areas will be outside any buffer areas or riparian corridors, however the footbridge will cross the spillway-created stream where some riparian vegetation have established after dam construction. Any special habitat should be avoided such as rocky areas and outcrops.

Potential Impact 16: Damage to large trees or shrubs.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: During site clearing, large trees should be left intact as they can become incorporated as shade and garden features in the site establishment areas. Indigenous vegetation should be planted during rehabilitation of the cleared areas.

Potential Impact 17: Fragmenting the riparian corridor by removing riparian bushes or river bank vegetation and compromise the function of riparian continuity.

Risk rating after mitigation: Low (significance = 26; confidence 4).

Control measure: It is not foreseen that clearing the site establishment areas and footbridge will fragment the riparian corridor. Care should be taken during all construction phases not to impact on the riparian zone and remain in the demarcated footprint.

Aspect 4.2: Erosion and siltation

Potential Impact 18: Clearing of site establishment areas will create bare areas, channelling storm water and surface run-off, etc. which could cause erosion of sediment and resulting in the siltation of the river.

Risk rating after mitigation: Low (significance = 28; confidence 4).

Control measure: If appropriate mitigation is carried out, including strict adherence to anti-erosion actions given in the EMP, this impact could be reduced to low significance. All areas susceptible to erosion must be identified and protection measures be implemented. In any areas where the risk of erosion is evident, appropriate temporary or permanent works and water energy dispersion structures must be installed. Cleared or bare areas prone to erosion should be monitored and rehabilitation should be implemented wherever indications of potential erosion become evident. 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 development.

Activity 5. Alien invading vegetation

Aspect 5.1: Introduction of alien vegetation

Potential Impact 19: Alien plants are in competition with indigenous vegetation – the spreading of alien invasive plants will impact on indigenous plant communities in the area and spread further, therefore promote the invasion of alien species into the intact indigenous vegetation.

Risk rating after mitigation: Low (significance = 29.2; confidence 4).

Control measure: All aggressive alien species should be removed. In terms of the Conservation of Agricultural Resources Act (CARA, Act No. 43 of 1984), alien species need to be managed and controlled in terms of their respective categories, where category 1 must be removed. Species specific and area specific eradication recommendations: Footprint areas should be kept as small as possible when removing alien plant species. 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. Monitor all sites disturbed by construction activities for colonisation by exotics or invasive plants and control these as they emerge.

Phase Operational

Activity 6: Haul route – both sides of the river

Aspect 6.1: Dust

Potential Impact 20: Dust may affect photosynthesis, respiration, transpiration of plants along haul roads and therefore impact on the local ecology.

Risk rating after mitigation: Low (significance = 38.2; confidence 4).

Control measure: Vehicle-entrained particulate emissions from unpaved roads are significant sources of dust, especially where there are high traffic volumes on a road. Dust incidences can be treated by either watering, alternative material choices or using dust binders. If dust binders are used they should be used with care especially when they could affect the local groundwater. Moisture will act as a binding agent and reduce wind erosion emission by around 50%, depending on the amount of water applied. Alternatives include re-vegetation of temporarily exposed surfaces on which infrastructure will not be

constructed.

Activity 7: Alien invading vegetation.

Aspect 7.1: Spreading of alien vegetation.

Potential Impact 21: Alien species are already present in the valley and will colonise any area of disturbance should they not be actively controlled.

Risk rating after mitigation: Low (significance = 44; confidence 4).

Control measure: Invasive alien plant management plan. Invasive alien plant species pose the second largest threat to biodiversity after direct habitat destruction. The purpose of an Alien Plant and Open Space Management Plan is to provide a framework for the management of alien and invasive plant species during the construction and operation of infrastructure. The broad objectives of the plan include the following:

• Ensure alien plants do not become dominant in parts of the site, or the whole site, through the control and management of alien and invasive species presence, dispersal and encroachment.

• Develop and implement a monitoring and eradication programme for alien and invasive plant species.

• Promote the natural re-establishment and planting of indigenous species in order to retard erosion and alien plant invasion.

This plan should be updated throughout the life-cycle of the operation, as required in order to ensure that appropriate measures are in place to manage and control the establishment of alien and invasive plant species and to ensure compliance with relevant legislation.

Summary

All the risk ratings have been classified as “Low”. This rating indicates that the impacts of the proposed project on the ecology of both the project site drainage lines, will not be significant. The identified risk will thus not alter the PES of these reaches or the downstream ecology in any way should the prescribed control measures be adhered to.

4.4 Task 3.6 Monitoring and Compliance: Provide a detailed Biomonitoring programme for the Ngodwana Dam Project.

Aspects to be monitored:

Aspect 1: Project footprints

- Ensure that the construction activities are restricted to the demarcated project footprint;
- Vegetation cover should be monitored and areas devoid of cover should be planted with appropriate indigenous plant species;

- ensure that buffers and corridors are maintained;
- avoid sensitive habitats (wetlands, rocky areas, riparian woodland);
- monitor areas prone to erosion.

Aspect 2: Alien plants

- Initiate and oversee an alien plant control programme

4.5 Specialist report: Level of confidence

Table 47 indicates the levels of confidence for the different aspects of the specialist study, and the reasons for the ratings.

Table 47: Levels of confidence for the different aspects of the specialist study.

Aspect	**Level of confidence***	**Reason for rating**
Background information: Project description	4.0	Sufficient information were supplied during planning phase.
Background information: Biophysical	3.0	Sufficient information were available for the Ngodwana catchment area.
Flow and sediment regimes	2.0	Limited information on flows and sediment regimes were available.
Water quality	2.0	Limited information regarding water quality was available.
Riparian habitat	4.0	Surveys supplied good information.
Aquatic invertebrate assessment	3.5	Adequate macro-invertebrate habitat present in the system.
Fish Response Assessment	3.0	Adequate fish habitat present in the system.
Ecological Importance and Sensitivity (EIS) and Present Ecological State (PES) and impacts	4.0	Surveys and assessment tools supplied adequate data to assess the status.
Risk assessment	4.0	Background data, surveys and assessment tools supplied adequate data to assess risks.

*Levels of confidence: 1=Low; 3=Moderate; 5=High.

REFERENCES

Altus de Beer Consulting Engineer. 2019. Ngodwana Dam: Annual Dam safety report.

BGIS. 2019. BGIS Land Use Decision Support Report. Generated on the BGIS website: 05/01/2019.SANBI Biodiversity for Life.

Department of Water Affairs and Forestry, 1999. Ecoregional typing. Version 1.0: M:/f_rdm_october/rivers/version 1.0/riv_appR1_version1.0.doc.

Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetland and riparian areas. DWA&F, Pretoria. Republic of South Africa.

DMV Nelspruit Incorporated (2020). Preliminary assessment of haul roads for SAPPI, Ngodwana Dam Rehabilitation. Project 20828.

DWAF (2008). *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas,* prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs, South Africa, September 2013. The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area: Status Quo assessment, Integrated Unit of Analysis delineation and biophysical node identification. Prepared by: IWR Water Resources. Authored by: Mallory S, Louw D, Deacon A, Holland, M, Huggins G, Kotze P, Mackenzie J, Scherman P, Van Jaarsveld P, DWA Report, RDM/WMA05/00/CON/CLA/0213.

Department of Water and Sanitation (DWS). 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQIS-RDM: https://www.DWS.gov.za/iwqs/rhp/eco/peseismodel.aspx

Driver, A., JL Nel, K Snaddon, K Murray, DJ Roux, L Hill, ER Swartz, J Manuel & N Funke. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. (WRC Report No. 1801/1/11).

Ecoleges Environmental Consultants. 2020. Application for a General and Environmental Authorisation for the Sappi Dam Remediation, on Farm Ngodwana 1030 JT, Ngodwana, Mpumalanga Province. Notification & background information document (BID).

Hagen, DJ. 2019. Review of Dam Safety Risk and proposed remedial work associated with Category 3 Ngodwana Dam, Mbombela. SAPPI Letter Report 20191203.

KLEYNHANS, C. J. 1996. A preliminary assessment of the habitat integrity status of the Sabie River and some of its tributaries. In: Sabie Sand Workshop: Starter Document. Department of Water Affairs & Forestry.

Kleynhans, C.J. 1999. The development of a fish index to assess the biological integrity of South African rivers. *Water SA*. **25** 265-278.

Kleynhans, C.J., Louw, M.D., Thirion, C., Rossouw, N.J. & Rowntree, K. 2005. River EcoClassification: Manual for EcoStatus determination (Version 1). Joint Water Research

Commission and Department of Water Affairs and Forestry report. WRC Report No. KV 168/05.

Kleynhans CJ, Louw MD, Moolman J. 2007. Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans CJ, Louw MD, Graham M, 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08

Kotze, PJ. Mac Kenzie JA, Deacon AR. Louw, MD. Macfadyan, S. 2013. Review and update of the desktop Present Ecological State (PES) and Ecological Importance (ei) – Ecological Sensitivity (ES) of South African rivers according to sub-quaternary catchments: Inkomati Catchment (X). WRC Project Number: K5/2041. Deliverable 10: Inkomati, Crocodile and Sabie catchments (catchment X): Pes & EI-ES.

Macfarlane, D.M., Bredin IP., Adams, JB., Zungu, MM., Bate, GC. and Dickens, CWS. 2015. Preliminary guideline for the determination of Buffer Zones for rivers, wetlands and estuaries. Consolidated Report. To the Water Research Commission by the Institute of Natural Resources.

Macfarlane, D.M. and Bredin IP. 2017. Buffer Zone Guidelines for Rivers, Wetlands and Estuaries. Part 1: Technical Manual. WRC Report No. TT 715-1-17.

Macfarlane, D.M. and Bredin IP. 2017. Buffer Zone Guidelines for Rivers, Wetlands and Part 2: Practical Guide. WRC Report No. TT 715-2-17.

MacKenzie and Rountree, 2007. *Draft riparian delineation methods prepared for the Department of Water Affairs and Forestry, Version 1.0* (unpublished field notes).

Mpumalanga Biodiversity Sector Plan, 2014. Datasets from the Mpumalanga Biodiversity Sector Plan: Fish Support Areas, CBA, ESA, Strategic Water Source Areas, and Landcover. Includes the Mpumalanga Highveld Wetlands layer. BGIS.

Mucina, L. & Rutherford, M.C. (eds.) 2006. Vegetation of South Africa, Lesotho & Swaziland, Sterlizia 19. South African National Biodiversity Institute, Pretoria.

National Water Act (Act 36 of 1998), Republic of South Africa.

Nel J.L., Driver A., Strydom W., Maherry A., Petersen C., Roux D.J., Nienaber S., van Deventer H, Smith-Adao LB and Hill L. 2011. Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. WRC Report No. TT 500/11, Water Research Commission, Pretoria.

O'Brien, GC., Smit NJ., Wepener, V. 2014. Conservation of fishes in the Elands River, Mpumalanga, South Africa: Past, present and future. Koedoe vol.56 n.1 Pretoria Jan. 2014.

Ollis, D.J., Snaddon, C.D., Job, N.M. and Mbona, N. 2013. Classification System for Wetlands and other aquatic Ecosystems in South Africa. User manual: Inland systems. SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria.

Roux F., Selepe, M. Kleynhans CJ, Thirion, C. Diedericks G. Hoffmann AC, Marais, H. 2013. Ecostatus of the Crocodile River Catchment, Komati River System. Inkomati Usuthu Catchment Management Agency. Mpumalanga Tourism and Parks Agency (MTPA).

Roux F. Diedericks G. Hoffmann AC, Selepe, M. 2016. Mpumalanga Tourism and Parks Agency (MTPA). Ecostatus of the Elands River Catchment. www.iucma.co.za.

Skelton PH (2016): Name changes and additions to the southern African freshwater fish fauna, African Journal of Aquatic Science, DOI: 10.2989/16085914.2016.1186004

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

Appendix 3: RISK MATRIX methodology (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

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 listing of additional mitigation measures considered and listed in RED font.

					Severity								
No.	**Phases**	**Activity**	**Aspect**	**Impact**	**Flow Regime**		**Physico & Chemical (Water Quality)**		**Habitat (Geomorph + Vegetation)**		**Biota**		**Severity**
1		**EXAMPLE:** Clearing of vegetation in close proximity to or in a watercourse	Creating access roads for infrastructure										

Risk being posed to "resource quality" as defined in the Act must be scored according to the Risk Rating Table for Severity. A Severity score is then generated.

Severity	**Spatial scale**	**Duration**		**Consequence**		**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**		**Likelihood**	**Significance**	**Risk Rating**

Consequence, Likelihood and finally Significance scores are automatically calculated with the rest of parameters according to respective Risk Rating Tables.

Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE

RISK = CONSEQUENCE x LIKELIHOOD
CONSEQUENCE= SEVERITY + SPATIAL SCALE + DURATION
LIKELIHOOD = FREQUENCY OF THE ACTIVITY+ FREQUENCY OF THE IMPACT + LEGAL ISSUES + DETECTION

ONLY LOW RISK ACTIVITIES located within the regulated area of the watercourse will qualify for a GA according to this Notice. Medium and High risk activities will require a Section 21 (c) and (i) water use license.

RISK ASSESSMENT KEY (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

RISK ASSESSMENT KEY (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

Negative Rating

TABLE 1- SEVERITY

How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota and habitat)?

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 2 – SPATIAL SCALE

How big is the area that the aspect is impacting on?

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

TABLE 3 – DURATION

How long does the aspect impact on the resource quality?

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or	2

REC impacted but no change in status	
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 4 – FREQUENCY OF THE ACTIVITY

How often do you do the specific activity?

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

TABLE 5 – FREQUENCY OF THE INCIDENT/IMPACT

How often does the activity impact on the resource quality?

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

TABLE 6 – LEGAL ISSUES

How is the activity governed by

legislation?

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
Located within the regulated areas	

TABLE 7 – DETECTION

How quickly/easily can the impacts/risks of the activity be observed on the resource quality, people and property?

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

TABLE 8: RATING CLASSES

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.

170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

A low risk class must be obtained for all activities to be considered for a GA

TABLE 9: CALCULATIONS

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence X Likelihood

RISK ASSESSMENT MUST BE CONDUCTED BY A SACNASP REGISTERED PROFESSIONAL MEMBER AND THE ASSESSOR MUST:

1) CONSIDER BOTH CONSTRUCTION AND OPERATIONAL PHASES OF PROPOSED ACTIVITIES;

2) CONSIDER RISKS TO RESOURCE QUALITY POST MITIGATION CONSIDERING MITIGATION MEASURES LISTED IN TABLES PROVIDED;

3) CONSIDER THE SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS) AND STATUS (PRESENT ECOLOGICAL STATUS - PES) OF THE WATERCOURSE AS RECEPTOR OF RISKS POSED;

4) CONSIDER POSITIVE IMPACTS/RISKS REDUCTION AS A VERY LOW RISK IN THIS ASSESSMENT;

5) INDICATE CONFIDENCE LEVEL OF SCORES PROVIDED IN THE LAST COLUMN AS A PERCENTAGE FROM 0 - 100%.

ON THE EXCELL SPREADSHEET POP-UP COMMENTS ARE AVAILABLE FOR ALL COLUMNS IN THE HEADINGS WHICH EXPLAINS THE PURPOSE OF EACH COLUMN!