Ten Bosch:
Wetland and Riparian Zone Identification and Description

Submitted to:

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DECLARATION OF INDEPENDENCE

The specialist/s appointed in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010:

I/We, Anton Linström declare that:

General declaration

- I/We act as the independent specialist/s in this application;
- I/We do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010;
- I/We will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I/We declare that there are no circumstances that may compromise my/our objectivity in performing such work;
- I/We have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I/We will comply with the Act, regulations and all other applicable legislation;
- I/We have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I/We undertake to disclose to the applicant and the competent authority all material information in my/our possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself/ourselves for submission to the competent authority;
- All the particulars furnished by me/us in this form are true and correct; and
- I/We realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of Ecologist

Executive Summary

Wet-Earth Eco-Specs was appointed by NuLeaf Planning & Environmental to conduct a wetland / riparian survey for a Basic Assessment Report (BAR) on the Ten Bosch property North West of the small hamlet of Komatipoort. The land owner intends to develop a timeshare resort on the property consisting of the following: chalets, central complex with recreational facilities and a third of the existing water rights from the river will be converted to be used for the development.

The following activities were conducted:

- Identification of wetlands and riparian areas;
- Delineation of wetlands and riparian areas;
- Classification of the wetlands;
- Characterisation of wetlands and riparian areas,
- PES and EIS description of wetlands,
- PES evaluation of riparian areas,
- Buffer zone recommendations.
- Impact Assessment, and
- Mitigation measures.

The study area lies almost 6 km north of the N4, between Marloth Park and Komatipoort. It shares its northern border with the Kruger National Park, while the Mozambique border lies about 12 km to the east. It falls within the Ehlanzeni District Municipality, Nkomazi Local Municipality, Mpumalanga Province. The study area falls within the Tshokwane-Hlane Basalt Lowveld vegetation unit and occurs within land type Ea78. According to the MBSP terrestrial assessment, the study area is classified as 'Heavily Modified', 'Moderately Modified: Old lands' and 'Other Natural Areas'; it also borders on the Kruger National Park. It can be found within quaternary catchment X24H, which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area.

According to the MBSP freshwater assessment there are some ESA wetlands within the study area. The NFEPA project classifies these wetlands as channelled valley-bottom wetlands. According to the NBA 2011, all of the wetlands in the vicinity of the study area belong to wetland ecosystem types that are Critically Endangered. The sub-catchment within which the study area falls has been classified by the MBSP as an 'ESA Important Sub-catchment' owing to the presence of a fish species of conservation concern (Tiger Fish *Hydrocynus vittatus*). The study area also includes large sections of 'Heavily Modified' areas as well as a dam. It is associated with one perennial river (Crocodile) and several non-perennial rivers. According to NFEPA, the Crocodile River has a condition of 'D'.

The field survey revealed that only 3 water courses were identified and can be described as riverine areas. There are wetland areas which form part of these riparian areas. These wetland areas occur around the dam and upstream of road crossings and weirs. The delineated riparian areas are demarcated and indicated as T01, T02 and T03 for the purpose of this study.

According to the VEGRAI assessment the Site T01 Riparian Index of Habitat Integrity (RIHI) is a C/D (57.7%). The main impacts are road crossings, orchard footprint (extending into riparian areas in places), a dam that destroyed approximately 71% of the original riparian area, felling of riparian vegetation, a weir in the active channel and the extensive presence of exotic vegetation.

Site T02 Riparian Index of Habitat Integrity (RIHI) is a D (53.8%). The main impacts are roads traversing the riparian zone, dumping, agriculture, vegetation clearing and further water quality problems (due to the presence of orchards, exotic infestation and the damming effect of a road crossing with only one culvert).

Site T03 the Crocodile River Riparian Index of Habitat Integrity (RIHI) is a C/D (57.9%), with the main impacts being flood events, grazing and trampling, water abstraction and the presence of exotic species. The exotic tree *Spathodea campanulata*, a tall tree native to the dry tropical forests of tropical Africa. It has been nominated as among the top 100 of the "World's Worst" invaders.

The edge of the water resources (T01-03) in the study area have been delineated, with the starting point for delineation of the aquatic impact buffer zones for Rivers and streams, being on the outer edge of the active channel. A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP. However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows:

- T01 : 16 m
- T02 : 15 m
- T03 : 67 m

The following is recommended:

- All activities should stay out of the 1:100 year flood line area;
- All activities should stay out of the riparian areas area and its recommended buffer zones;
- All storm water should be diverted to a point from where the water must be released in a controlled manner that will not initiate or enhance any erosion, the way storm water enters a natural waterway is important because high-energy flows can cause serious damage (especially to riparian zones);
- Energy dissipaters and smaller permeable gabion-structures covered with reeds can be constructed at the effluent points of all stormwater; and
- To cater for the present and the proposed developments in above mentioned riparian areas on site and off site mitigation is recommended to mitigate the negative effects thereof.

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GLOSSARY

Anaerobic	Without air.
Biodiversity	The variety of life: the different plants, animals and micro-organisms, their genes and the ecosystems which they form part of.
Catchment	Area from which rainfall flows into river.
Connectivity	In this context, referring to either the upstream-downstream or lateral (between the channel and the adjacent floodplain) connectivity of a drainage line. Upstream-downstream connectivity is an important consideration for the movement of sediment as well as migratory aquatic biota. Lateral connectivity is important for the floodplain species dependent on the wetting and nutrients associated with overbank flooding.
Exotic	From another part of the world; foreign and/or alien.
Geology	The study of the composition, structure, physical properties, dynamics, and history of earth materials, and the processes by which they are formed, moved, and changed.
Gleyed soil	A material that has been or is subject to intense reduction as a result of prolonged saturation with water. Grey colours are due to an absence of iron compounds.
Hydro-geomorphic	Refers to the water source and geology forms.
Invasive	Any alien species of insect, animal, plant or pathogen, including its seeds, eggs, spores, or other biological material capable of propagating that species.
Palustrine	Relating to a system of inland, non-tidal wetlands characterized by the presence of trees, shrubs and emergent vegetation.
Pedology	The branch of soil science that treats soils and all their properties as natural phenomena.
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 characterises the hydrodynamic nature of these units."*** According to the classification system, channels generally refer to rivers or streams (including those that have been canalised) 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.
Riparian Zone	Area of land directly adjacent to the active channel of a river, which is influenced by river-induced or river-related processes.

Seep	A wetland area located on gently to steeply sloping land and dominated by the colluvial unidirectional movement of water and material down-slope. Water inputs are primarily via subsurface flows from an up-slope direction.
Soils	Dynamic natural body composed of mineral and organic materials (as well as living organisms) in which plants grow. It can also be described as the collection of natural bodies occupying parts of the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.
Topographical maps	Detailed depiction of land features shown on a map.
Topography	Detailed description of land features.
Unchannelled valley bottom	Linear fluvial, net depositional valley bottom surfaces that do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas.

Abbreviations

DWA(F)	Department of Water Affairs (and Forestry, i.e. prior to 2009)
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMC	Ecological Management Class
FEPA	Freshwater Ecosystem Priority Area
GIS	Geographic Information System
HGM	Hydro-geomorphic
MBSP	Mpumalanga Biodiversity Sector Plan
MPRDA	Mineral and Petroleum Resources Development Act
NEMA	National Environmental Management Act
NWA	National Water Act (Act No. 36 of 1998)
PES	Present Ecological Status
SAM	Significance after mitigation
SANBI	South African National Biodiversity Institute
SBM	Significance before mitigation
TDS	Total Dissolved Solids
VEGRAI	Vegetation Response Assessment Index

1 INTRODUCTION

Wet-Earth Eco-Specs was appointed by NuLeaf Planning & Environmental to conduct a wetland / riparian survey for a Basic Assessment Report (BAR) on the Ten Bosch property North West of the small hamlet of Komatipoort. The study entail the identification and delineation of possible wetland / riparian areas and its integrity assessments.

The land owner intends to develop a timeshare resort on the property consisting of the following:

- 60 -100 chalets
- Central complex with recreational facilities
- A third of the existing water rights from the river will be converted to be used for the development.

2 SCOPE OF WORK

The following activities were conducted:

- Identification of wetlands and riparian areas;
- Delineation of wetlands and riparian areas;
- Classification of the wetlands;
- Characterisation of wetlands and riparian areas,
- PES and EIS description of wetlands,
- PES evaluation of riparian areas,
- Buffer zone recommendations.
- Impact Assessment, and
- Mitigation measures.

3 LIMITATIONS OF THIS INVESTIGATION

The following limitations were placed on the wetland ecosystem and biodiversity study of this project:

- A single baseline assessment was conducted, thus limiting the amount of biota identified at the site;
- Accuracy of the maps, aquatic ecosystems, routes and desktop assessments was limited to the current 1:50 000 topographical map series of South Africa;
- Accuracy of Global Positioning System (GPS) coordinates was limited to 15 m accuracy in the field;
- Delineations and related spatial data generated will be supplied in GIS (shape file) format only and will be for the purpose of conceptual planning only and not detailed design. If the client requires that data be accurate to detailed design level, this can be negotiated and budgeted for separately;
- This survey was conducted in the autumn season, which is not optimal: surveys of this nature should take place in the summer months;
- The assessment of the impact of past activities on the wetlands was based on professional judgement, since no data (to our knowledge) exists prior to the developments that have already taken place on the site, to which the current status can be compared;
- Time and costs related to surveys have been calculated based on the proposed area (route) as indicated by the client;
- Whilst every care is taken to ensure that the data presented is qualitatively adequate, inevitably conditions are never such that that is entirely possible. Under the circumstances, it must be pointed out that the nature of the vegetation, the time of year, human intervention and the like, limit the veracity of the material presented.

4 METHODOLOGY

4.1 Characterization of the flora

The area was traversed on foot and all indications of plant species observed were recorded. Background literature surveys were also conducted to assess which species have been recorded in the general area.

4.2 Riparian Vegetation Response Assessment Index (VEGRAI)

The assessment of the riparian vegetation was done according to the Level 3: Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al. 2007). According to this index, the following components were assessed:

Site extent determination

Flow, geomorphology, substrata, elevation, vegetation structure and species diversity, as well as the importance of these, were recorded, as they play an important role in determining riparian vegetation distribution. General characteristics were described.

Site delineation

In order to cover a representative area of the riparian zone in the study area, several transect surveys were necessary. Areas in between these transects were also traversed on foot, and spot surveys contributed to a more complete survey.

Zone determination

The following zones within the riparian vegetation were identified for a Level 3 assessment and were assessed at each site:

- Marginal zone: starts at the water's edge and extends a few metres up the bank, along a lateral gradient.
- Non-Marginal zone: Starts at the end of the marginal zone and extends away from the river to a point where there is a significant decrease in lateral slope or where vegetation species composition changes from riparian to non-riparian vegetation species.

Species list

Key/dominant/easily identifiable vegetation species were listed and indicated as woody or non-*woody* species and the zones where they occur were recorded.

Land use and impact evaluation

The surrounding and upstream land uses that could have an impact on the site were identified. Vegetation removal, changes to water quality and changes to water quantity were the three impacts that were considered for intensity and extent. The impacts were assessed on a scale from 0–5 (where 0 = no impact and 5 = extreme impact).

Exotic vegetation and invasion

Exotic vegetation has an impact on indigenous riparian vegetation. The impact is measured using the cover percentage of exotic species. A list of exotic species and the zones in which they are found was recorded at each of the sites.

Reference condition reconstruction

Reference conditions can be reconstructed in one of two ways:

- By using an unaffected river in the same eco-region to reconstruct the reference state, or
- By eliminating impacts to reconstruct the reference conditions.

Response metrics rating

For Level 3 VEGRAI assessments, only abundance and cover were rated. Using the guideline illustrations provided by the index, the abundance and cover for woody and non-woody species were rated separately for each of the zones. The abundance and cover rating was based on indigenous species density and percentage aerial cover.

Ecological Category

Field data was transferred to the VEGRAI Excel spreadsheet. The Ecological Category was calculated from the results obtained.

Metric groups and the calculation of the Ecological Category

The following procedure was followed to integrate the conditions of metric groups and to provide an estimated Ecological Category for the riparian vegetation:

- The degree to which a metric group has changed from the natural state is subtracted from 100 to provide the degree to which the metric group is still intact.
- Each metric group (vegetation zone) is ranked and weighted according to its relative importance to the functioning of the river under natural conditions (cf. above). The focus is on the in-stream aspect of the river in particular.
- These weights are summed and the weight for each metric group is expressed as a proportion of this total.
- This proportional weight is multiplied by the percentage of the metric group in a natural condition and summed for all metric groups. This provides an integrated value that relates to the Ecological Category for the riparian vegetation that ranges from A to F (Table 1).

Table 1. 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 habitat and biota may have taken place, but the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. Loss and change of natural habitat 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

4.3 Buffer Zone

The literature review revealed that international approaches used to determine required buffer zone widths varied considerably from simple one-size-fits-all approaches to others that rely on extensive site-

specific information to inform buffer width requirements (Macfarlane, 2014). Three generic approaches were identified in the literature, and are briefly outlined below:

- Fixed-width: The fixed width approach typically applies a standard buffer width to a particular water resource type. In some instances, a generic width is applied regardless of any characteristics of the water resource. However, this approach is more typically applied to a class of wetland or river type, or a specific landuse type / activity.
- Modified fixed-width: In this approach, a matrix of factors is typically used to categorize wetlands and / land-uses with category-specific standard buffer widths being applied to the resource. These widths may, however be modified based on relevant on-site factors where more detailed information is available.
- Variable-width: This approach usually requires the development of a detailed formula and methodology for considering site-specific factors such as wetland type, adjacent land-use, vegetation, soils, wildlife habitats, slope, desired function and other special site-specific characteristics to calculate buffer widths.

While each approach has a number of advantages and disadvantages, the modified fixed-width approach was regarded as most appropriate for the South African context. This was principally due to the need to develop a tool that could be applied across different levels (i.e. desktop and site-based), while maintaining a level of predictability and consistency between approaches. The method outlined in this document therefore proposes highly conservative buffer widths based on generic relationships for broad-scale assessments, but allows these to be modified based on more detailed site-level information. Resultant buffers therefore range from highly conservative, fixed-widths for different land-uses at a desktop level, to buffers that are modified based on a more thorough understanding of the water resource and specific site characteristics (Macfarlane, 2014).

4.3.1 Impact Assessment and Mitigation

In order to assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of impact associated with the proposed project;
- The assessment of the impacts of the proposed project on the aquatic ecosystems;
- The recommendation of mitigation and management measures to deal with significant impacts;
- The identification of aspects which may require further study.

The impacts of the proposed project were assessed in terms of impact significance and recommended mitigation measures. The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT, 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). The following criteria have been proposed by the Department of Environmental Affairs for the description of the magnitude and significance of impact (DEAT, 2002):

This section of the report describes and evaluates the potential impact of the development on the receiving wetland environment. The significance of the impact was determined using the criteria given in Table 2 in accordance with the rating contained.

Table 2: Criteria for Assessment of Impacts

Severity (Magnitude)	
The severity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the affected environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as:	
(I)nsignificant	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
(M)oderate	The affected environment is altered, but functions and processes continue, albeit in a modified way.
(V)ery High	The function or process of the affected environment is disturbed to the extent that it temporarily or permanently ceases.
Duration	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development.	
(T)emporary	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
(S)hort term	The impact will be relevant through to the end of a construction phase (1.5 – 2 years).
(M)edium term	The impact will last up to the end of the development phases, after which it will be entirely negated.
(L)ong term	The impact will continue for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter.
(P)ermanent	This is the only class of impact that will be non-transitory. Mitigation either by man-made or natural processes will not occur in such a way or in such a time span that the impact is considered transient.
Spatial scale	
Classification of the physical and spatial scale of the impact.	
(F)ootprint	The impacted area extends only as far as the activity, such as the footprint occurring within the total site area.
(S)ite	The impact could affect the whole, or a significant portion of the site.
(R)egional	The impact could affect the area, including the neighbouring farms, the transport routes and the adjoining towns.
(N)ational	The impact could have an effect on the whole country (South Africa).
(I)nternational	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
Probability	
This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
(I)improbable	The possibility of the impact occurring is nil, due either to the circumstances, design or experience. The chance of this impact occurring is defined as0%.
(P)ossible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chance of this impact occurring is defined as 25%.
(L)ikely	There is a possibility that the impact will occur to the extent that provisions for mitigation must therefore be made. The chance of this impact occurring is defined as 50%.
(H)ighly Likely	It is most likely that the impact will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chance of this impact occurring is defined as 75%.
(D)efinite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100%.

In order to assess each of these factors for each impact, the following ranking scales will be used (**Table 3**).

Table 3: Assessment Criteria: Ranking Scales

PROBABILITY		MAGNITUDE	
Description / Meaning	Score	Description / Meaning	Score
Definite/don't know	5	Very high/don't know	10
Highly likely	4	High	8
Likely	3	Moderate	6
Possible	2	Low	4
Improbable	1	Insignificant	2
DURATION		**SPATIAL SCALE**	
Description / Meaning	Score	Description / Meaning	Score
Permanent	5	International	5
Long term	4	National	4
Medium term	3	Regional	3
Short term	2	Local	2
Temporary	1	Footprint	1/0

Details of the significance of the various impacts identified are presented in Table 4 and Table 5.

Determination of Significance – With Mitigation
Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. The Significance Rating (SR) is determined as follows:

Equation 1:

Significance Rating (SR) = (Extent + Intensity + Duration) x Probability

Identifying the Potential Impact without Mitigation Measures (WOM)
Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a value for each impact (prior to the implementation of mitigation measures). Significance without mitigation is rated on the following scale:

Table 4: Significance Rating Scales without mitigation

SR < 30	Low (L)	Impacts with little real effect and which should not have an influence on or require modification of the project design or alternative mitigation. No mitigation is required.
30 < SR < 60	Medium (M)	Where it could have an influence on the decision unless it is mitigated. An impact or benefit that is sufficiently important to require management. Of moderate significance - could influence the decisions about the project if left unmanaged.
SR > 60	High (H)	Impact is significant, mitigation is critical to reduce impact or risk. Resulting impact could influence the decision depending on the possible mitigation. An impact that could influence the decision about whether or not to proceed with the project.

Identifying the Potential Impacts with Mitigation Measures (WM)
In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it will be necessary to re-evaluate the impact. Significance with mitigation is rated on the following scale as contemplated in Table 5.

Table 5: Significance Rating Scales with mitigation

SR < 30	Low (L)	The impact is mitigated to the point where it is of limited importance.
30 < SR < 60	Medium (M)	Notwithstanding the successful implementation of the mitigation measures to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
SR > 60	High (H)	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and, taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance after mitigation could render the entire development option or entire project proposal unacceptable.

5 RESULTS AND DISCUSSION

5.1 Study Area

5.1.1 Location

The study area lies almost 6 km north of the N4, between Marloth Park and Komatipoort (Figure 1). It shares its northern border with the Kruger National Park, while the Mozambique border lies about 12 km to the east (Figure 1). It falls within the Ehlanzeni District Municipality, Nkomazi Local Municipality, Mpumalanga Province and is situated on the farm Tenbosch 162 JU.

Figure 1: Google Earth image showing the study area in relation to the surrounding places and roads

5.1.2 Land-use

The land-uses within the study area, as per the 2010 land-cover data, comprise cultivation, old lands, urban development and a dam (Figure 2). The land-uses surrounding the study area are similar. There are also natural areas within and surrounding the study area (Figure 2).

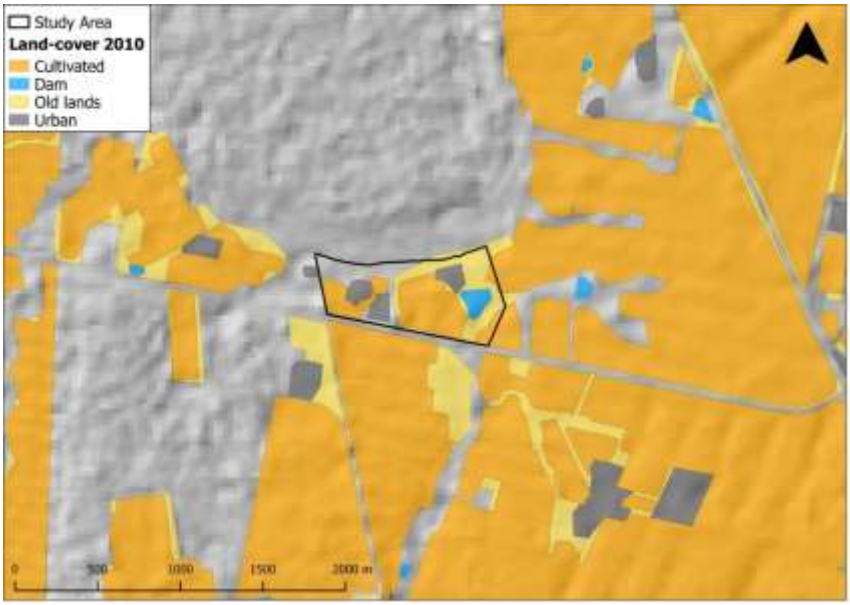

Figure 2: The 2010 land-cover data (which only indicates transformed areas) showing the different land-uses within and surrounding the study area. The light grey areas indicate untransformed (natural) areas.

5.1.3 Vegetation Units

According to Mucina & Rutherford (2006), the study area falls within the Tshokwane-Hlane Basalt Lowveld vegetation unit (SVl5, Figure 3). The following description applies to the unit as a whole and is taken from Mucina & Rutherford (2006).

Tshokwane-Hlane Basalt Lowveld has an altitude range of 180–400 m. It usually comprises fairly flat plains with open tree savanna, often dominated by tall *Sclerocarya birrea* and *Acacia nigrescens*, with a moderately developed shrub layer and a dense herbaceous layer. On some sloping areas with shallower soils, trees are stunted (e.g. *A. nigrescens*). It is a summer rainfall region with dry winters. The unit has a conservation target of 19%. About 64% is statutorily conserved mainly in the Kruger National Park, but also in the Mlawula Nature Reserve. In addition, over 3% is conserved mainly in the Hlane Game Sanctuary. About 17% is transformed, almost all by cultivation.

Mean monthly minimum and maximum temperatures at the study site itself are 9˚C and 32.6˚C in July and December respectively, while the annual average is 22.8˚C; the mean annual precipitation is 634 mm (WorldClim database, Hijmans et al., 2005).

Figure 3: The position of the study area in relation to the surrounding vegetation units

5.1.4 Land Types

The study area falls entirely within land type Ea78 (Figure 4). The geology is described as “Basalt of the Letaba Formation, Karoo Sequence”, while the soils are described as “One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated” (Land Type Survey Staff, 1972–2006).

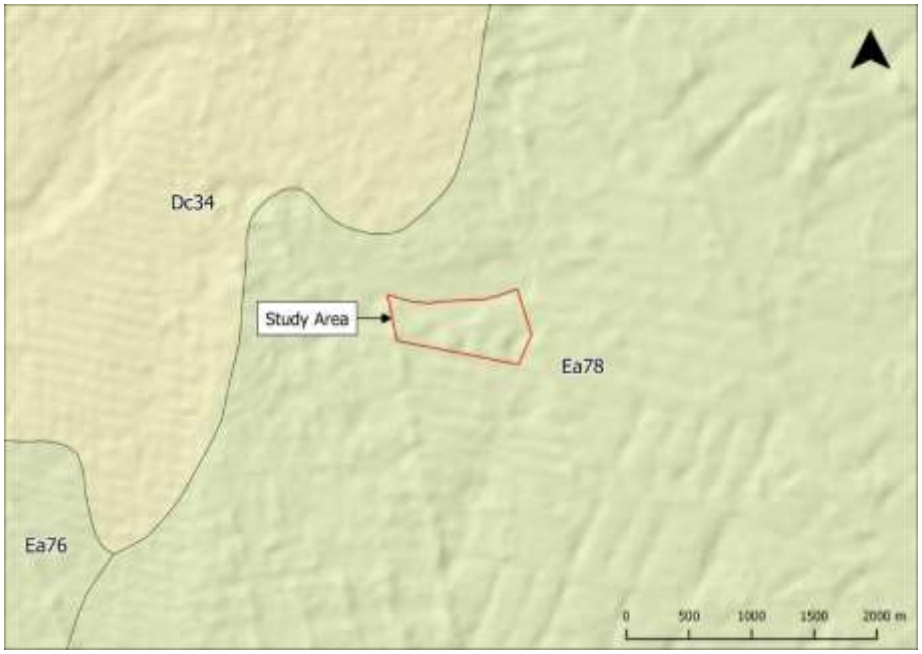

Figure 4: Study area in relation to the land types in the vicinity

5.1.5 Mpumalanga Biodiversity Sector Plan (Terrestrial Assessment)

The Mpumalanga Biodiversity Sector Plan (MBSP) identifies terrestrial and freshwater areas that are important for conserving biodiversity pattern and ecological processes (MTPA, 2014). According to the MBSP terrestrial assessment, the study area is classified as ‘Heavily Modified’, ‘Moderately Modified: Old lands’ and ‘Other Natural Areas’; it also borders on a Protected Area (Kruger National Park; Figure 5). Definitions of these categories can be found in Table 6.

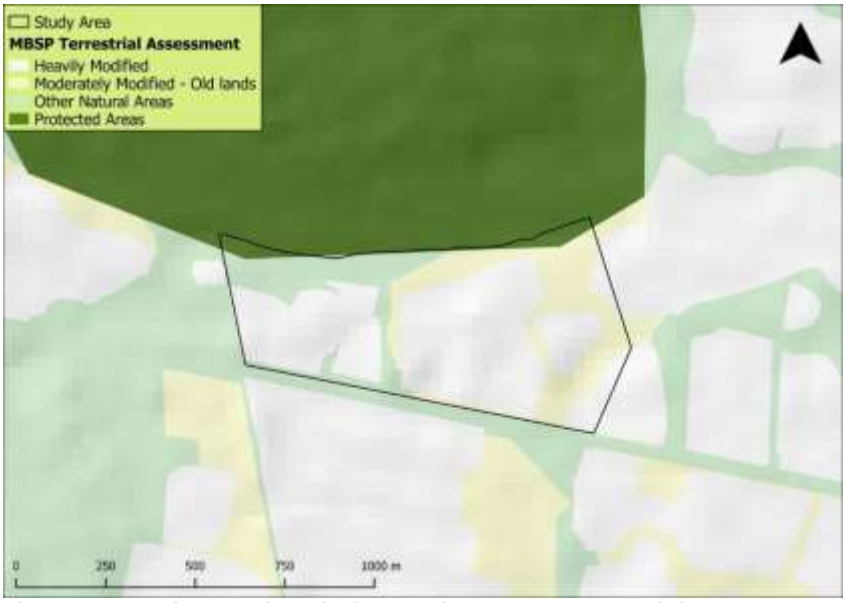

Figure 5: Study area in relation to the MBSP terrestrial assessment

Table 6: Descriptions of the relevant map categories for the MBSP terrestrial assessment, taken from MTPA (2014).

Map Category	Description	Sub-category	Description
Protected Areas (PA)	Areas that are formally protected by law and recognised in terms of the Protected Areas Act, including contract protected areas declared through the biodiversity stewardship programme.	National Parks & Nature Reserves	Includes formally proclaimed National Parks, Nature Reserves, Special Nature Reserve, and Forest Nature Reserves.
Other Natural Areas (ONA)	Areas that have not been identified as a priority in the current systematic biodiversity plan but retain most of their natural character and perform a range of biodiversity and ecological infrastructural functions.		
Moderately or Heavily Modified Areas	Areas in which significant or complete loss of natural habitat and ecological function has taken place due to activities such as ploughing, hardening of surfaces, open-cast mining, and cultivation.	Heavily Modified	All areas currently modified to such an extent that any valuable biodiversity and ecological functions have been lost.
		Moderately Modified: Old lands	Old cultivated lands that have been allowed to recover, and support some natural vegetation. Although biodiversity pattern and ecological functioning may have been compromised, the areas may still play a role in supporting biodiversity and providing ecosystem services.

5.1.6 Quaternary Catchments, Wetlands and Rivers (desktop assessment)

This desktop assessment is based on a combination of the MBSP freshwater assessment, the NFEPA project (National Freshwater Ecosystem Priority Areas) and the NBA 2011 (National Biodiversity Assessment). The MBSP freshwater assessment relied heavily on the NFEPA project but was improved for Mpumalanga (Lötter, 2015). The NFEPA project identifies FEPAs (Freshwater Ecosystem Priority Areas), which are rivers, wetlands and estuaries that need to remain in a good condition to conserve freshwater ecosystems and protect water resources for human use (Nel et al.,

2011). The NBA provides an assessment of the state of South Africa's biodiversity, including ecosystem threat status (Driver et al., 2012).

The study area lies within quaternary catchment X24H, which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area (Figure 6).

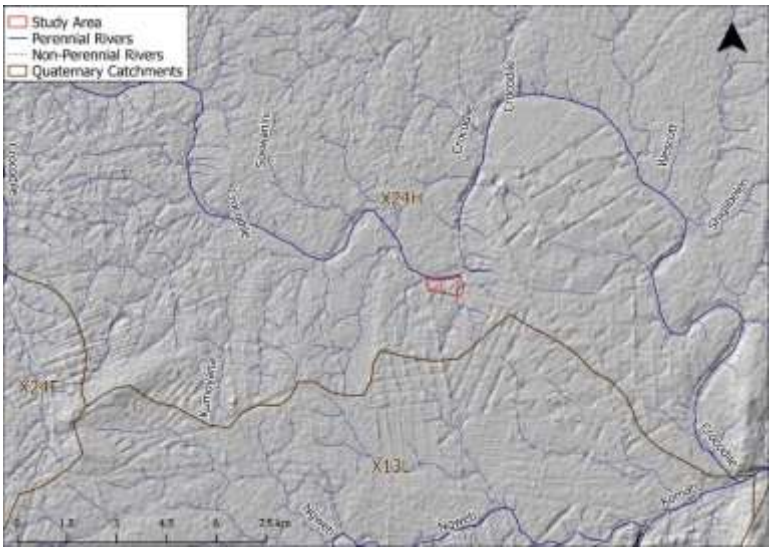

Figure 6: The study area in relation to quaternary catchments and rivers

According to the MBSP freshwater assessment there are some ESA wetlands within the study area (Figure 7 and Table 7). These are associated with the dam occurring within the study area as well as with the Crocodile River, which lies on the northern border of the study area (see Figure 7). The NFEPA project classifies the wetlands within the study area as channelled valley-bottom wetlands.

According to the NBA 2011, all of the wetlands in the vicinity of the study area belong to wetland ecosystem types that are Critically Endangered. A Critically Endangered ecosystem type is one in which most of the ecosystem type has been severely or moderately modified from its natural state and few natural or near-natural examples of this ecosystem remain; these remaining healthy examples should be the focus of urgent conservation action (Driver *et al.*, 2012).

The sub-catchment within which the study area falls has been classified by the MBSP as an 'ESA Important Sub-catchment', but does include large sections of 'Heavily Modified' areas as well as a dam (Figure 7; Table 7). The sub-catchment is important as it is a Fish Support Area. This is owing to the presence of a fish species of conservation concern (Tiger Fish *Hydrocynus vittatus*).

The study area is associated with one perennial river (Crocodile) and several non-perennial rivers (Figure 7). The extent to which a river has been modified by human activity is referred to as the river condition (Nel *et al.*, 2011). According to NFEPA, the Crocodile River has a condition of 'D', which means that it is largely modified such that a large loss of natural habitat, biota and basic ecosystem functions have occurred (Nel *et al.*, 2011).

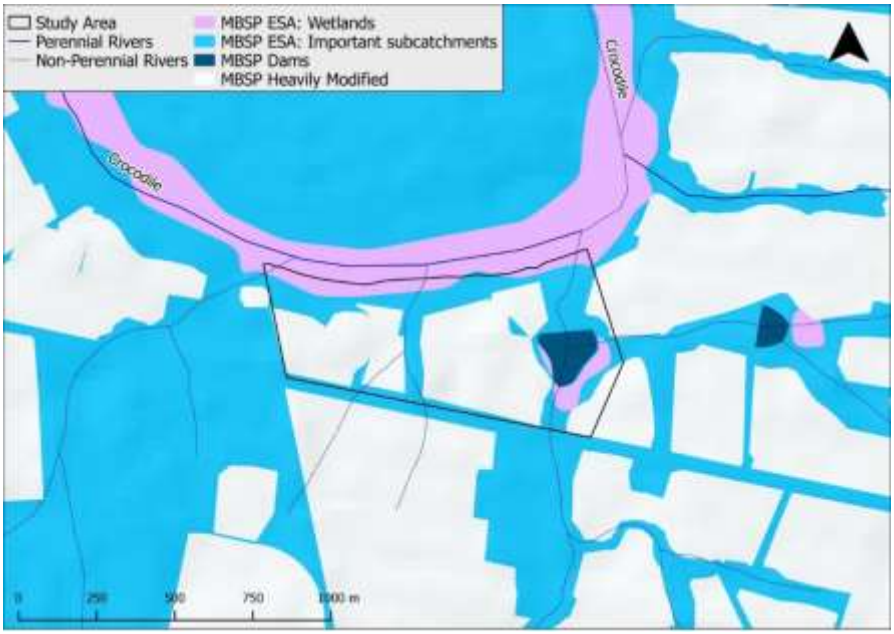

Figure 7: **The study area in relation to rivers and the MBSP freshwater assessment; ESA = Ecological Support Area**

Table 7: Descriptions of the relevant map categories for the MBSP freshwater assessment, taken from MTPA (2014).

Map Category	Description	Sub-category	Description
Ecological Support Areas (ESA)	Areas that are not essential for meeting targets, but that play an important role in supporting the functioning of CBAs and that deliver important ecosystem services.	ESA: Wetlands	All non-FEPA wetlands. Although not classed as FEPAs, these wetlands support the hydrological functioning of rivers, water tables and freshwater biodiversity, as well as providing a host of ecosystem services through the ecological infrastructure that they provide.
		ESA: Important Sub-catchments	Sub-catchments that either contain river FEPAs and/or Fish Support Areas.
Heavily Modified Areas	Areas in which significant or complete loss of natural habitat and ecological function has taken place due to activities such as ploughing, building of dams, hardening of surfaces, open-cast mining, cultivation, and so on.	Heavily Modified	All areas currently modified to such an extent that any valuable biodiversity and ecological functions have been lost.
		Heavily Modified: Dams	Artificial water bodies that have impacted on wetland or river ecosystems. These areas may still have a recharge effect on wetlands, groundwater and river systems and may support river- or water-dependent fauna and flora, such as water birds and wetland vegetation.

5.2 Riparian Area Identification and Delineation

In order to cover a representative area of the wetlands in the study area, several surveys were necessary. It should be noted that only the riparian areas in the study area were identified and surveyed.

The riparian areas identified in the study area were delineated in accordance with the guidelines for delineating the boundaries of a wetland, set out by the Department of Water Affairs and Forestry (DWAF) (DWAF, 2005). These delineated riparian areas are demarcated and indicated as per the map shown in Figure 8.

Figure 8: Delineated riparian areas on the Ten Bosch study area adjacent to the Crocodile River

5.3 Wetland and Riparian Characterization and Integrity Study

In order to cover a representative area of the riparian area in the study area, several transect surveys were necessary. The riparian areas and drainage lines identified in the study area were delineated in accordance with the guidelines for delineating the boundaries set out by the then Department of Water Affairs and Forestry (DWAF, 2005).

3 water courses were identified and can be described as riverine areas. There are wetland areas which form part of these riparian areas. These wetland areas occur around the dam and upstream of road crossings and weirs. The delineated riparian areas are demarcated and indicated as per the map showed in Figure 9.

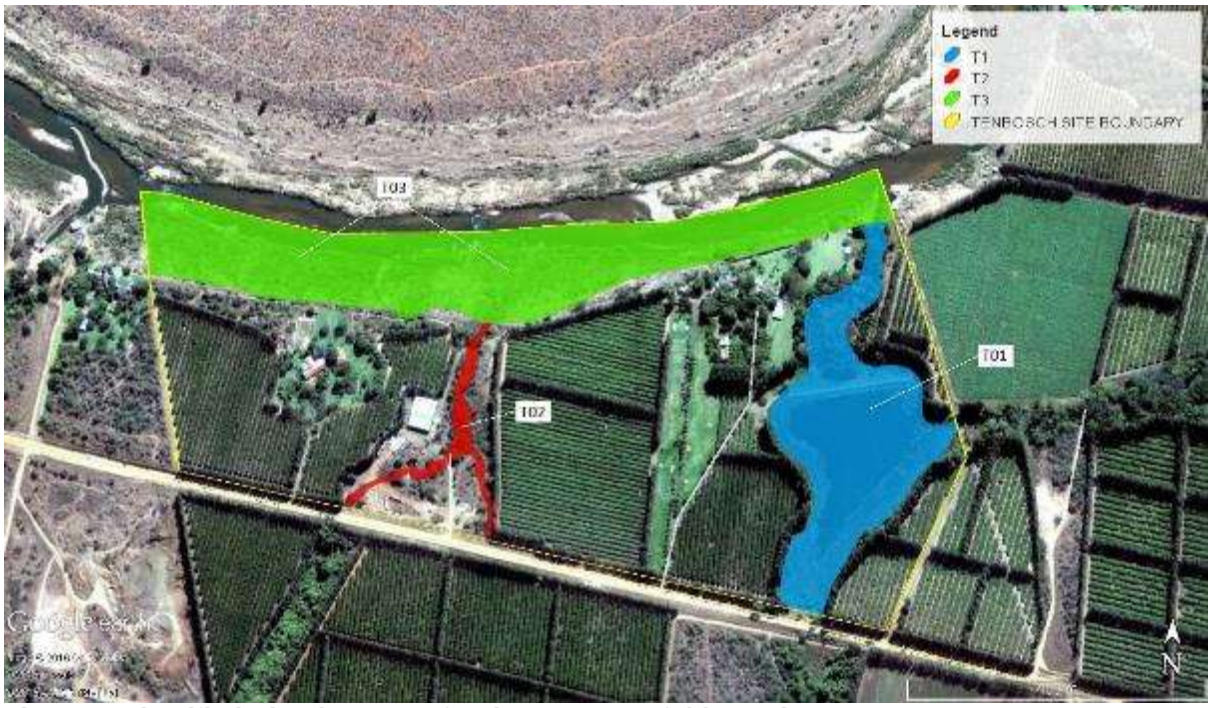

Figure 9: Identified Riparian areas for the purpose of this study

5.3.1 Site T01

SITE DESCRIPTION

This site is located at 25°23'09.51 S, 31°53'31.57 E. The riparian zone extends upstream from the edge of the property and downstream where it joins the Crocodile River (Figure 10 and Figure 11).

Dam in upstream portion of riparian area

Riparian forest in lower downstream portion of river

Figure 10: Views of Site T01 Riparian Area

Figure 11: Google image of the delineated T01 Riparian Area within the study area

Marginal zone (Figure 12)**:**
The presence of a dam indicates a disturbed environment with the result that a large portion of this zone is dominated by reeds, grasses and sedges. The section downstream of the dam is dominated by trees and scattered clumps of grass and sedge. The substrate consists of soil with rocky features occurring in places. The dominant tree species are *Ficus sycomorus* and *Trichilia emetica.* The following grass and sedge species occur in this zone: *Phragmites* australis, Typha capensis, Cyperus dives, Cyperus sexangularis, etc. Exotic vegetation, such as: *Melia azedarach, Tecoma stans, Verbena bonariensis, Tagetes minuta, Ricinus communis, Lantana camara*, etc. occurs.

Non-marginal zone (Figure 12)**:**
A reed and tree dominated state exists along the edges of the dam. Downstream of the dam the dominant vegetation is mostly trees and herbs. The substrate consists mainly of soil material and rocky habitat in places. The banks are steep in places. The following woody species occur: *Bridelia micrantha, Acacia xanthophloea, Philenoptera violacea, Phyllanthus reticulatus, Ficus sycomorus, Syzygium cordatum, Celtis africana, Sclerocarya birrea* subsp*. caffra*, *Bridelia micrantha, Rauvolfia caffra, Grewia monticola, Bridelia cathartica, Phyllanthus reticulatus, Gymnosporia senegalensis, Pluchea dioscoridis and Gymnanthemum coloratum,* etc. Understory plants such as: *Setaria megaphylla, Hypoestes forskaolii, Cucumis zeyheri*, *Jasminum fluminense*, and *Panicum maximum* occur. Some exotic

vegetation such as: *Melia azedarach, Solanum mauritianum, Lantana camara, Ageratum conyzoides,* etc. were also found.

View of the marginal zone

View of the non-marginal zone

Figure 12: Photos of selected VEGRAI site

Reference Condition

The reference condition for the components are summarised in Table 8.

Table 8: Reference conditions

Component	Reference conditions	Confidence
Riparian vegetation	**Marginal zone:** Reed and sedge-dominated state with pockets of grass. Sedges such as *Cyperus dives, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. can occur. Without the habitat destruction caused by the dam, weir and river bank undercutting, a more woody- and shrub vegetated state, with a better species composition and abundance is expected. **Non-marginal zone:** A more tree, sedge and grass-dominated state is expected. More trees and shrubs are expected, especially along the edges of the macro-channel. Species such as Ficus sycomorus, F. sur, Acacia sieberiana, Ziziphus mucronata, Gymnosporia buxifolia, etc. could also occur. With less slashing and cutting of undergrowth more grass cover and abundance is expected.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a C/D (57.7%). The main impacts are the road crossings, orchard footprint (extending into riparian areas in places), a dam that destroyed approximately 71% of the original riparian area, felling of riparian vegetation, a weir in the active channel and the extensive presence of exotic vegetation (Figure 13). Water quality is degraded further as a result of agriculture, human settlement, and a golf course adjacent to the riparian area. Due to the influence of the dam, less alluvial material is released to the downstream areas which has resulted in the degradation of the riverbank, referred to as bed-armouring. The result of this can be seen in bank collapse and under-cutting of the bank which is taking place. There is also extensive vegetation clearing in the riparian areas' catchment which reduces the vegetation roughness coefficient (Figure 13).

One culvert connecting upper stream area with lower stream area

Dam in drainage line

Road crossing

Exotic vegetation
(*Hedychium gardnerianum*)

Weir in river creates open water area

Felling of undergrowth vegetation

Bank scouring resulting in bank collapse

Vegetation clearing in catchment area

Figure 13: Activities that contribute towards the degradation of the T01 riparian zones integrity

PES causes and sources

The PES for the components, as well as the reasons for the PES are summarised in Table 9.

CAUSE: A stressor that occurs at an intensity, duration and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 9: Causes and sources

	PES	Conf.	Causes	Sources	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	D/E	2.8	Road traversing area	Restricted hydrology	Non-Flow related NF	2.8
			Orchards	Extend into riparian areas		
			Increased flows	Increased stormwater flows due to catchment being under orchards.		
			Dam, habitat destruction	Constructed in wetland		
			Exotic invasion	*Melia azedarach, Arundo donax* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication program in place.		
			Water quality	Orchards, golf course, farming activities, etc. with many point and non-point source pollution occurring.	Flow related F	
			Water quantity	Dam upstream.		

[1] Flow related [2] Non Flow related

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable, or still changing). The results are summarised in Table 10.

Table 10: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	D/E	Stable	D/E	The presence of the road crossing and the extent of the dam area will always have an impact on the habitat availability and integrity of this site. Orchards, slashing and the presence of exotic vegetation species impacts on the vegetation composition, cover and abundance. If these impacts are not managed their impact will stay the same.	3

PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence is included in the EcoStatus assessment index (Table 11). The EcoStatus EC is a D/E (39.3%).

Table 11: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	39.3	D/E	
ECOSTATUS	Confidence rating		
Confidence rating for riparian vegetation zone information	2.8		
ECOSTATUS	EC		D/E

5.3.2 Site T02

SITE DESCRIPTION

This site is located at 25°23'11.64 S, 31°53'12.68 E (Figure 14). The riparian zone extends from the edge of the property upstream to where it joins with the Crocodile River downstream (Figure 15 and Figure 16).

Figure 14: Dense vegetation evident in this image of site T02

Figure 15: Google image of the T02 delineated riparian zone

Marginal zone (Figure 16)**:**
The dominate vegetation consists of shrub species with scattered grass and herbs. Within the riparian section adjacent to the storage facilities, upstream of the road crossing, the understory has been cleared and is dominated by trees and scattered clumps of grass and sedges. The substrate consists mainly of soil with rocky banks in places. Dominant woody species present include: *Ficus sycomorus, Rauvolfia caffra, Phyllanthus reticulatus and Trichilia emetica.* The following grass and sedge species occur: *Persicaria decipiens, Commelina diffusa* subsp. *scandens, Phragmites* australis, *Typha capensis, Cyperus dives, Cyperus sexangularis*, etc. In the area between the two road crossings the grass *Leersia hexandra* dominates. Exotic vegetation such as *Melia azedarach, Tecoma stans, Verbena bonariensis, Tagetes minuta, Ricinus communis, Lantana camara*, etc. occurs.

Non-marginal zone (Figure 16)**:**
A tree and grass-dominated state occurs upstream of the road-crossing. In this area the groundcover and some shrubs have been felled to clear the space. The substrate consists mainly of soil and rocky material. The downstream section is dominated by a woodier component. Upstream of the lower road crossing the dominant vegetation consists of grass and sedges. The following woody species occur: *Rhoicissus tridentata* subsp. *cuneifolia*, *Bridelia micrantha, Acacia nigrescens, Acacia xanthophloea, Philenoptera violacea, Phyllanthus reticulatus, Ficus sycomorus, Ziziphus mucronata, Syzygium cordatum, Celtis africana, Sclerocarya birrea* subsp*. caffra*, *Rauvolfia caffra, Grewia monticola, Grewia flavescens, Phyllanthus reticulatus, Gymnosporia senegalensis, Pluchea dioscoridis and Gymnanthemum coloratum,* etc. Understory plants such as *Setaria megaphylla* and *Panicum maximum* are present. Some exotic vegetation such as, *Melia azedarach, Solanum mauritianum, Lantana camara, Ageratum conyzoides,* etc. were also found. The climber *Ipomoea purpurea* occurs abundantly and has a smothering effect on the vegetation.

View of the marginal zone

View of the non-marginal zone

Figure 16: Photos of selected marginal and non-marginal zones of the T02 riparian

REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 12.

Table 12: Reference conditions

Component	Reference conditions	Conf.
Riparian vegetation	Marginal zone: Grass and sedge-dominated state, with pockets of reeds. Sedges such as *Cyperus dives, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. can occur. Without the influence of road crossings and presence of exotic vegetation, more woody- and shrub vegetation is expected. A better species composition and abundance is also anticipated. Non-marginal zone: A more woody, sedge and grass-dominated state is expected. Denser trees and shrubs should occur. Species such as *Ficus sycomorus, F. sur, Acacia sieberiana, Ziziphus mucronata, Gymnosporia buxifolia*, etc. would be more prevalent. Graminoids such as *Bothriochloa insculpta, Panicum maximum, Setaria sphacelata, Sporobolus africanus*, etc. are expected in greater numbers. With less slashing and cutting of undergrowth, more grass cover and abundance is expected in places.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a D (53.8%). The main impacts are roads traversing the riparian zone, dumping, agriculture, vegetation clearing and further water quality problems (due to the presence of orchards, exotic infestation and the damming effect of a road crossing with only one culvert) (Figure 17).

Road crossing with one culvert

Road crossing resulted in the build-up of sediment, providing habitat for various exotic vegetation such as *Ipomoea purpurea, Cocculus hirsutus, Passiflora subpeltata, Cardiospermum grandiflorum, Melia azadarach*, etc.

Road crossing with one culvert

Artificial channel in riparian zone

Cleared catchment area

Figure 17: Impacts that result in the degradation of the wetland area

PES causes and sources

The PES for the components, as well as the reasons for the PES are summarised in Table 13.

CAUSE: A stressor that occurs at an intensity, duration and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 13: Causes and sources

	PES	Conf.	Causes	Sources	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	D	2.9	Roads traversing riparian area	No maintenance and too few culverts.	Non-Flow related NF	2.9
			Orchards	Little to no management to protect the riverine area.		
			Exotic infestation	*Melia azedarach, Solanum mauritianum, Lantana camara* and non-woody weeds such as, *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication program in place.		
			Hardened surfaces	Road areas, parking areas and cleared areas close to storage facilities, etc.	Flow related F	
			Water quality	Orchards, workshop area, etc. with possible point and non-point source pollution occurring.		
			Water quantity	Orchards, irrigation, etc. can impact on hydrology.		

[1] Flow related [2] Non Flow related

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarised in Table 14.

Table 14: Trend

	PES	Trend	Trend PES	Reasons	Conf
Rip veg	D	Stable	D	The presence of road crossings and the extent of orchards, workshop area, storage facilities, parking areas, etc. will always have an impact on the habitat availability and integrity of this site. Exotic vegetation infestation impacts on the vegetation composition, cover and abundance. Without a rehabilitation plan, it is expected that the situation will not change and that the current EC will remain the same.	2.9

PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence is included in the EcoStatus assessment index (Table 15). The EcoStatus EC is a D (53.8%).

Table 15: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	53.8	D	
ECOSTATUS	Confidence rating		
Confidence rating for riparian vegetation zone information	2.9		
ECOSTATUS	EC		D

5.3.3 Site T03

SITE DESCRIPTION

The Crocodile River site is located at 25°31'50.21 S, 31°23'01.25 E. A panoramic view of the study area can be seen in Figure 18. Figure 19 is a Google aerial photo indicating the extent of this riparian zone.

Figure 18: Panoramic view of the riparian area T03

Figure 19: Google image of the delineated riparian zone, T03, in the study area

Marginal zone: (Figure 20)
Reeds and sedges are the dominate vegetation type. The substrate consist mainly of alluvial sand. The following grass and sedge species occur: *Cynodon dactylon, Persicaria decipiens, Commelina diffusa* subsp. *scandens, Phragmites* australis, *Typha capensis, Cyperus dives, Cyperus sexangularis*, *Leersia hexandra* etc. Exotic vegetation such as: macrophyte *Eichhornia crassipes* occurs along the edge of

the active channel. Other exotic species, such as *Ricinus communis, Centella asiatica, Sesbania bispinosa*, etc. occur.

Non-marginal zone: (Figure 20)
Reeds with scattered trees and shrub species are the dominate vegetation type. Continuous grazing and trampling has resulted in the reeds and trees being stunted. The woody species are obviously recovering after major flood destruction in the not-too-distant past. The substrate consists mainly of alluvial material and rocky dykes crossing the riverine area. The following woody species are dominant: *Dichrostachys cinerea*, *Gymnosporia senegalensis, Ziziphus mucronata*, *Lippia javanica*, *Bridelia micrantha, Acacia nigrescens, Philenoptera violacea, Phyllanthus reticulatus, Pluchea dioscoridis, Gomphocarpus physocarpus, Asparagus cooperi,* etc. Grass species such as *Cynodon dactylon*, *Setaria sphacelata* and *Panicum maximum,* are also present. Cyperus sexangularis and *Schoenoplectus* spp. are the dominant sedges. Some exotic vegetation such as, Centella asiatica, *Spathodea campanulata, Melia azedarach, Solanum mauritianum, Lantana camara, Parthenium hysterophorus, Ageratum conyzoides,* etc. were also identified.

View of the marginal zone

View of the non-marginal zone

Figure 20: Photos of selected VEGRAI site

REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 16.

Table 16: Reference conditions

Component	Reference conditions	Conf
Riparian vegetation	**Marginal zone:** Grass and sedge-dominated state, with pockets of reeds. Little to no woody species is expected in this alluvial system. Sedges such as *Cyperus dives, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. can occur. More grass cover and abundance is expected. **Non-marginal zone:** It is expected that reeds, with scattered trees and shrubs, should dominate this zone. Species such as *Ficus sycomorus, F. sur, Trichilia emetica, Nuxia oppositifolia, Ziziphus mucronata, senegalensis*, etc. could occur at a higher frequency. Graminoids such as *Bothriochloa insculpta, Panicum maximum, Setaria sphacelata, Sporobolus africanus*, etc. are expected to occur in greater numbers. Indications are that with time more trees and shrubs should survive, resulting in denser riparian vegetation habitat.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a C/D (57.9%), with the main impacts being flood events, grazing and trampling, water abstraction and the presence of exotic species. The exotic tree *Spathodea campanulata*, a tall tree native to the dry tropical forests of tropical Africa. It has been nominated as among the top 100 of the "World's Worst" invaders (Figure 21).

The exotic *Eichhornia crassipes* (Water hyacinth)

Grazing and trampling

Spathodea campanulata (Fountain Tree)

Centella asiatica

Water abstraction with direct impact on the system

Figure 21: Impacts identified in the Crocodile River Riparian zone

PES causes and sources

The PES for the components, as well as the reasons for the PES are summarised in Table 17.

.**CAUSE:** A stressor that occurs at an intensity, duration and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 17: Causes and sources

	PES	Conf.	Causes	Sources	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	C/D	3.1	Housing development footprint	Extends in places into the riparian areas	Non-Flow related NF	3.1
			Orchards	Little management to protect the riverine area.		
			Exotic infestation	*Melia azedarach, Spathodea campanulata Lantana camara,* and non-woody weeds, such as *Ageratum houstonianum, Verbena bonariensis*, *Centella asiatica*, *Ipomoea alba,* etc.		
			Flood events	Flood events can be extreme due to catchment-related mismanagement.	Flow related F	
			Water quality	Orchards, housing developments, etc. with point and non-point source pollution occurring.		
			Water quantity	Water abstraction points at various points along the river. Many of the tributaries have in-stream dams for irrigation purposes.		

[1] Flow related [2] Non Flow related

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarised in Table 18.

Table 18: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	C/D	Stable	C/D	The presence of orchards, housing or lodge developments etc. will always have an impact on the habitat availability and integrity of this site. Grazing and trampling will always occur and the presence of exotic vegetation species will not change. No management is in place to eradicate these species. This continues to have an impact on the vegetation composition, cover and abundance. It is unlikely that these impacts will improve and therefore the current situation should remain the same.	3.1

PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence is included in the EcoStatus assessment index (Table 19). The EcoStatus EC is a C/D (57.9%).

Table 19: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	57.9	C/D	
ECOSTATUS	Confidence rating		
Confidence rating for riparian vegetation zone information	3.1		
ECOSTATUS	EC		C/D

5.4 BUFFER ZONE

Buffer zones are strips of undeveloped, typically vegetated land (composed in many cases of riparian habitat or terrestrial plant communities) which separate development or adjacent land uses from aquatic ecosystems (rivers and wetlands). The primary purpose for establishing buffers in this case would be to reduce the impact of adjacent land use on water quality and to provide habitat for aquatic and semi-aquatic species. The hydrology and the water quality of the riparian zones in the study area could change both during the construction period and after development.

In order to assess and apply the width of any buffer it is important to understand the role that buffer zones play in protecting aquatic resources with their associated biota and in mitigating impacts from anthropogenic impacts. Thus, the proposed buffer will serve to provide a wide range of buffer functions and values including (Macfarlane, *et al.*, 2014):

- Sediment removal;
- Nutrient removal;
- Toxic removal;
- Control of microclimate and water temperature;
- Provision of habitat for wildlife;
- Screening of adjacent disturbances;
- Habitat connectivity;
- Channel stability and flood attenuation;
- Groundwater recharge; and
- Aesthetic appeal.

Despite the range of functions potentially provided by buffer zones, they are far from being a 'silver bullet' that addresses all water resource related problems. Indeed, buffers can do little to address some impacts such as hydrological changes caused by stream flow reduction activities (i.e. changes in flow brought about by abstractions or upstream impoundments). Buffer zones are also not the appropriate tool for mitigating against point-source discharges (e.g. sewage outflows), which can be more effectively managed by targeting these areas through specific source-directed controls. Contamination or use of groundwater is also not well addressed by buffer zones and requires complementary approaches such as controlling activities in sensitive groundwater zones (Macfarlane, *et al.*, 2014).

Anthropogenic impacts (dams, orchards, roads, bush clearing, housing, artificial channels, etc.) in and around these water courses, emphasises the already increased impact from the larger catchment. To support the water courses' integrity in an already disturbed environment and with the proposed development still to come, an aquatic buffer will be a necessity. However, it should be noted that an aquatic surface buffer of 20-30 m is highly unlikely to protect catchment-related hydrology support such as groundwater recharge. Therefore, the identification of mitigation and management measures of the proposed development in the greater catchment should compensate for the possible loss of catchment support.

The edge of the water resources (T01-03) in the study area have been delineated, with the starting point for delineation of the aquatic impact buffer zones for Rivers and streams, being on the outer edge of the active channel as visualised in Figure 22 (Macfarlane *et al.,* 2014).

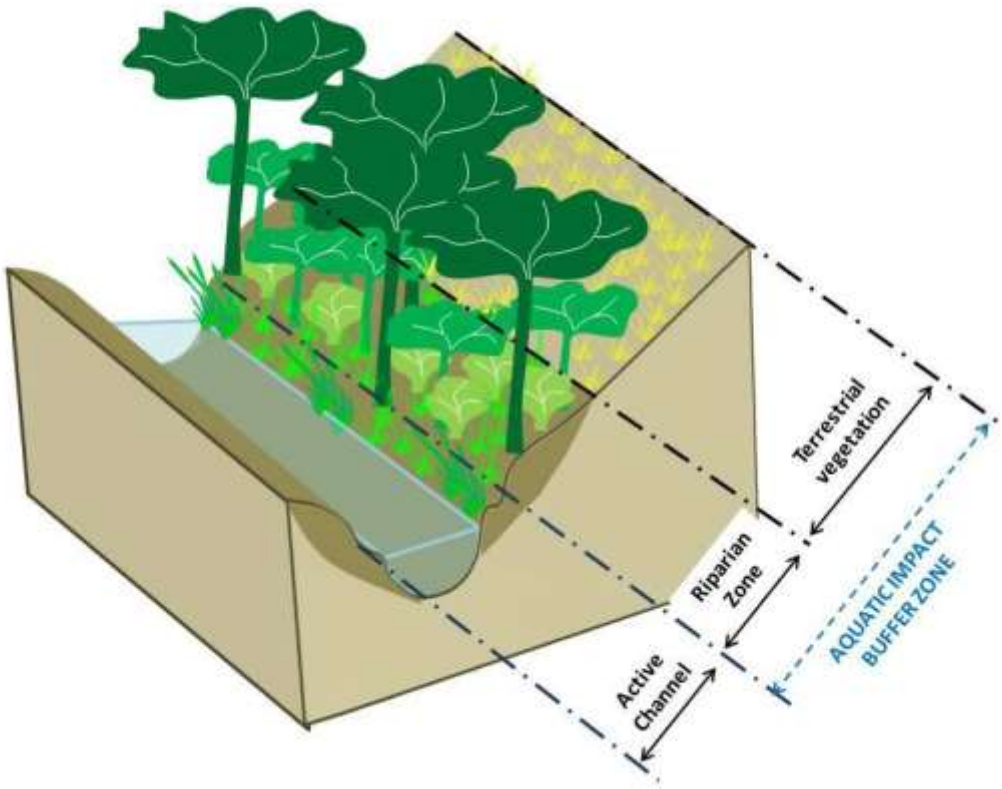

Figure 22: Schematic diagram indicating the boundary of the active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone.

Due to their position 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 linked to 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. 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. There may however be instances in which the riparian zone extends beyond the aquatic impact buffer zone. In such instances, setback requirements include the full extent of the riparian zone and any additional requirements that may apply to managing this area.

A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows (Figure 23, Figure 24 and Figure 25):

- T01 : 16 m
- T02 : 15 m
- T03 : 67 m

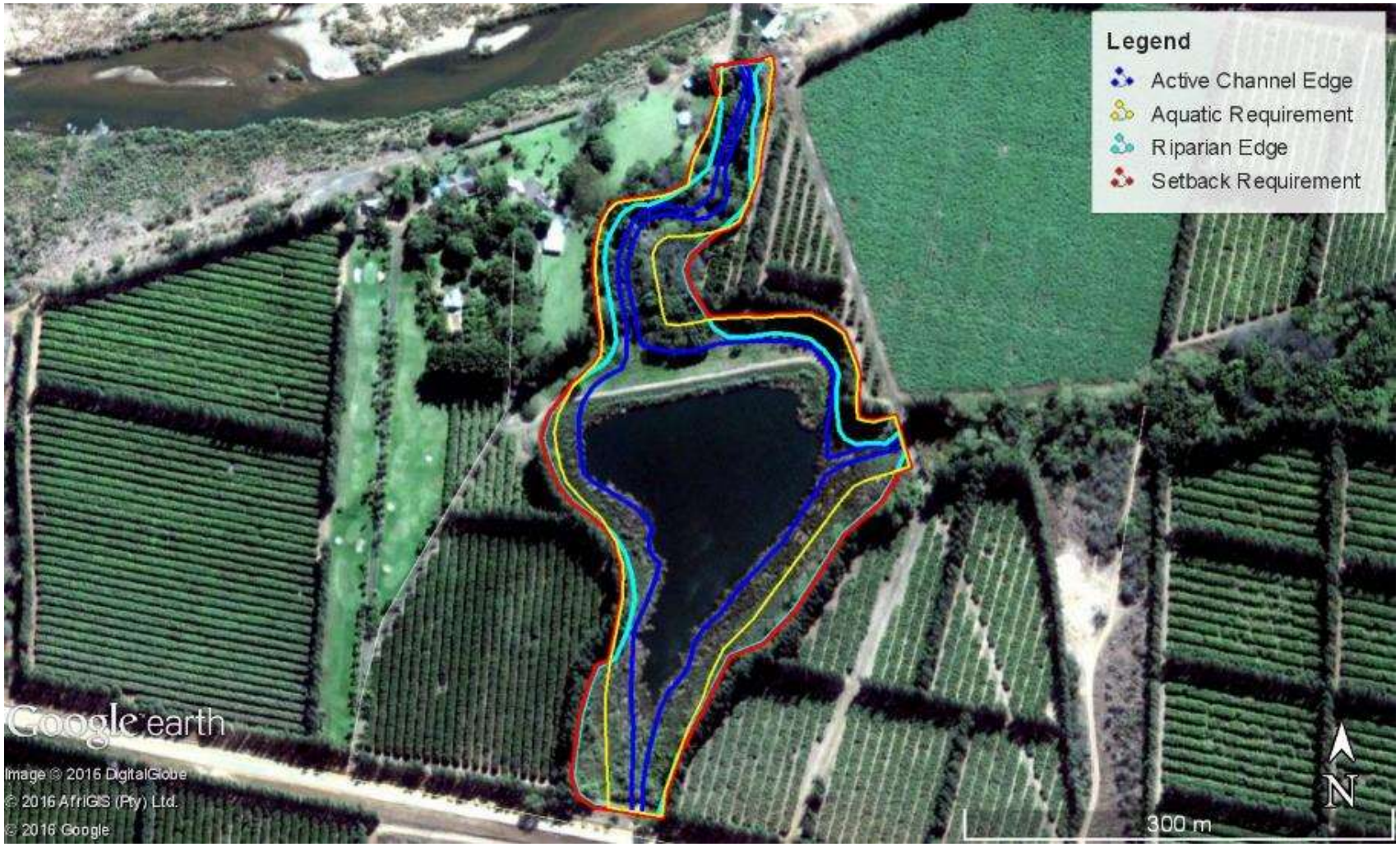

Figure 23: Delineation of the T01-Riparian site's active channel edge, aquatic requirement, riparian edge and then the final setback requirement

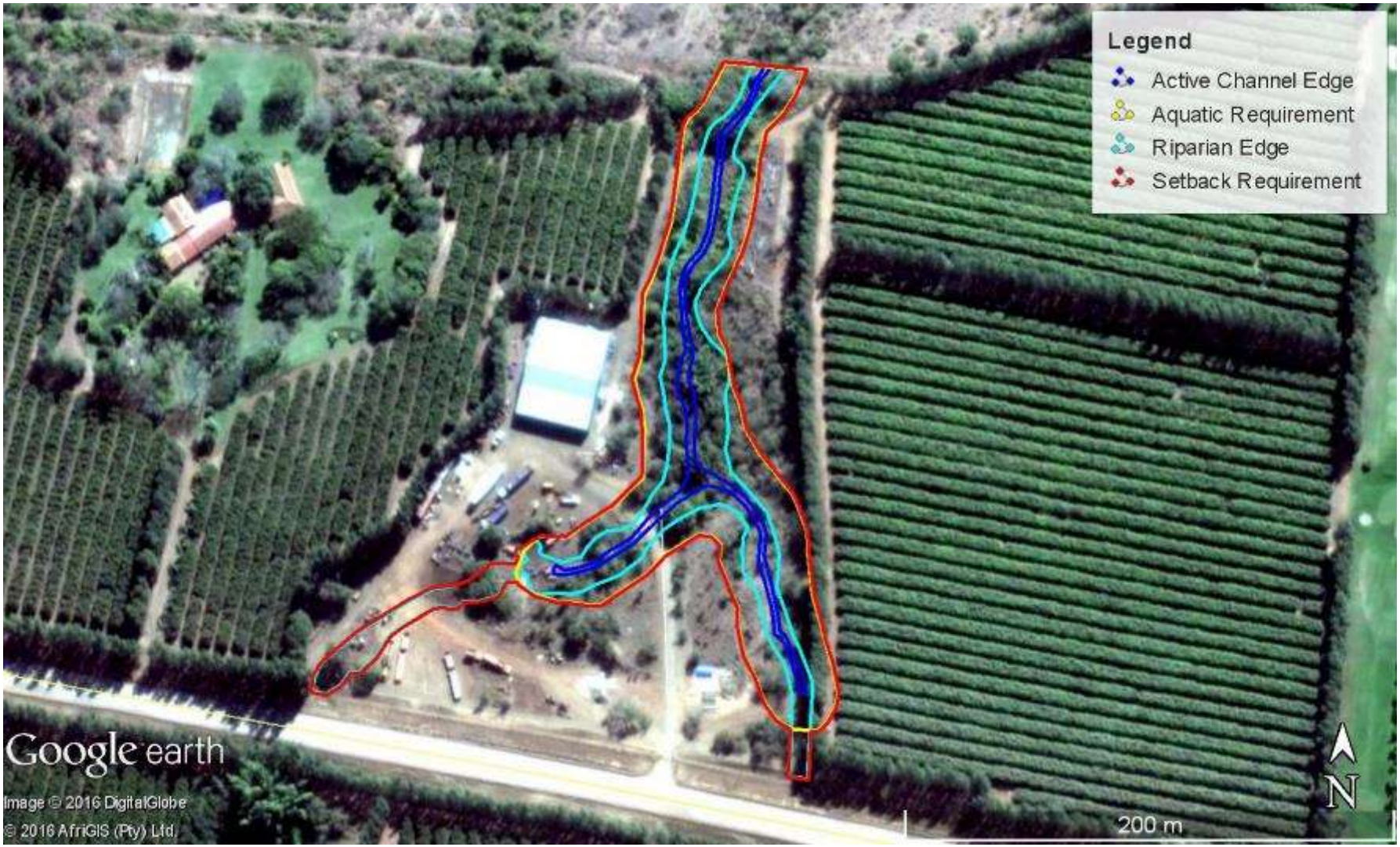

Figure 24: Delineation of the T02-Riparian site's active channel edge, aquatic requirement, riparian edge and then the final setback requirement

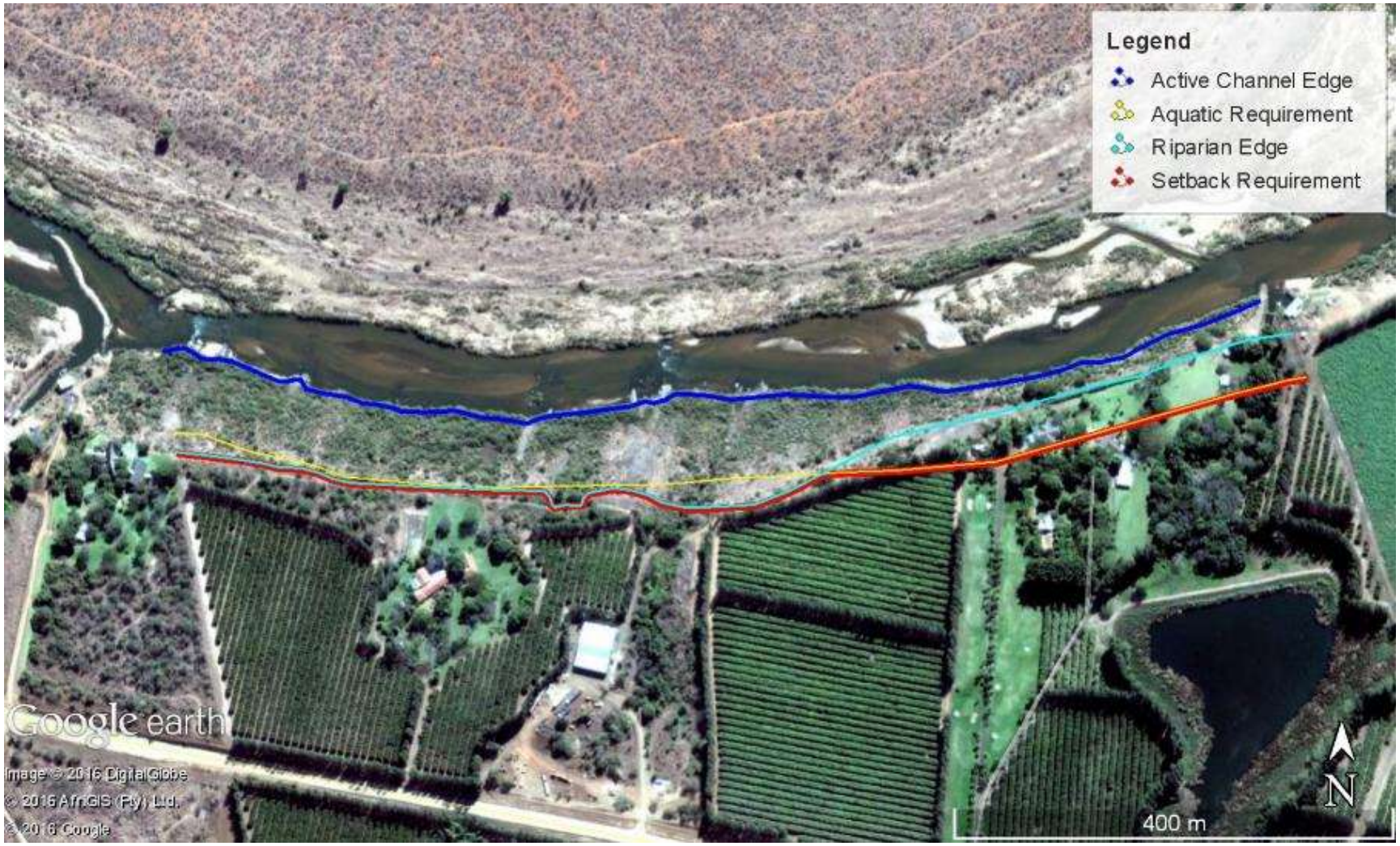

Figure 25: Delineation of the T03-Riparian site's active channel edge, aquatic requirement, riparian edge and then the final setback requirement

6 IMPACT ASSESSMENT AND MITIGATION

Any development in a natural system will have an impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective, the focus of an impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT, 2002). Alterations of the natural variation of water flow through decreasing or increasing can only have an influence upon almost every aspect of the wetland's ecological functioning (Davies & Day, 1998).

Current South African legislation, as indicated at the beginning of this report, requires that the necessary aquatic ecosystem impact assessment be conducted and mitigation measures assessed, so as to reduce or prevent the degradation of aquatic habitats and biotic populations due to alterations in the wetland that may have an impact on migration and ecosystem functioning.

This assessment was made after one visit to the study area. A single visit makes it difficult to identify and assess all species and/or species composition. Further assessment on the presence of threatened or protected species is thus handicapped. Thus, for this assessment, the riparian areas should be regarded as sensitive from a biodiversity aspect.

6.1 Impacts

Based on evaluation tables (Table 2 and Table 3), the impact magnitude and significance of the development will depend on where it will take place. If the footprint extends into the riparian areas, the impact can be significant due to the loss of a riparian area (and habitat) that is host to certain wetland services.

The most significant impact of development in riparian areas can have the following effects:

- Destruction of riparian habitat that leading to habitat loss (and biodiversity loss)
- Initiation of erosion (increased flow volumes due to hardened surfaces)
- Increase in sediment due to the construction of buildings that can smother riparian habitat downstream
- Change in water quality.

Only some of the negative impacts of a development in a riparian can be mitigated by controlling flow-rates by means of the following:

- Some erosion is already evident in the area and storm-water run-off into the riparian area should make use of energy dissipaters
- Remove all dumped and refuse material in riparian area
- Remove invasive alien vegetation to establish and recreate riparian habitat
- Stay clear of the 1:100 flood lines and buffer zones.

Because roads and/or pathways can be one of the biggest destroyers of riparian areas, care should be taken to construct adequate numbers of large culverts to cover the area of a riparian area. However, culverts and/or storm-water pipes can initiate erosion capable of destroying riparian areas, therefore sufficient numbers of energy dissipaters should be put in place.

Most of the impacts identified relate to water quality, wetland habitat and wetland biotic components:

Water quality impacts

Fluctuations in the *in situ* water quality parameters (pH, Electrical Conductivity (EC), TDS, DO, and temperature) may occur during the construction phase, the operational phase as well as during the decommissioning and closure phase. These will have impacts on the wetland's ecosystem, biotic communities and vegetation.

Water quality may be adversely affected due to the fact that the following proposed activities will impact the riparian area:

- Dust generation and transportation due to the clearing of vegetation prior to construction, the construction phase, and the decommission and closure phase, which will settle on the riparian habitats, leading to:
    - Reduced photosynthesis and transpiration in flora;
    - An increase in fine-particulate sediments in the water;
    - A decrease in visibility and light penetration;
    - An increase in potential EC and TDS;
    - Fluctuations in the pH values; as well as
    - Fluctuations in the surface water quality monitoring parameters.

  This impact will be greatly increased during the drier months of April through to September;

Increased soil sediment loads via surface water run-off into the adjacent riparian areas owing to the clearing of vegetation prior to construction, the construction activities and the removal of topsoil, can lead to:

- Reduced photosynthesis and transpiration in the in-stream aquatic macrophytes;
- An increase in fine-particulate sediments in the water;
- A decrease in visibility and light penetration;
- An increase in potential EC and TDS;
- Fluctuations in the pH values; as well as
- Fluctuations in the surface water quality monitoring parameters.

This impact will be greatly increased in the wet months of October to March and during high flow events.

Habitat disturbances, resulting in increased sediment input from erosion; and

Cumulative impact from existing surrounding activities as well as the proposed development project, leading to;

- Increased erosion, flooding, sedimentation and bank instability;
- Fluctuations in *in situ* water quality parameters; and
- Fluctuations in biodiversity parameters.

Habitat impacts

The habitat may be affected due to the fact that the following proposed activities may impact the riparian areas:

Habitat loss or alteration

If construction is going to take place in or on the edge of a riparian area, the largest impact is expected to occur during this period. The following activities can have an impact:

- Removal/destruction of riparian ecosystem habitat;
- Vegetation removal;
- Wetland edge disturbances; and
- Drainage pattern changes.

These activities may result in possible destabilization, increased erosion potential and exotic vegetation encroachment.

Dust that enters the riparian area can have the following impact:

- Decreased visibility due to clouding of water column;
- Decreased light penetration;
- Siltation of fine sediment substrates, gravel substrates and inter-substrate spaces; and
- Decrease in habitat availability.

This impact will be greatly increased during the drier months of April through to September.

Soil sediment loads entering the riparian ecosystems via surface water will lead to:

- An increase in fine-particulate sediments in the water;
- A decrease in visibility;
- A decrease in light penetration;
- Increased siltation; and
- Decreased habitat availability.

This impact will be greatly increased in the wet months of October to March and during flood events.

Cumulative impact from existing surrounding activities as well as the proposed project, will lead to:

- Increased erosion, flooding, sedimentation and bank instability;
- Fluctuations in *in situ* water quality parameters; and
- Fluctuations in biodiversity parameters.

Biotic changes

Vegetation

Changes to the vegetation community structure of the riparian ecosystem may take place due to the likelihood that the following may occur as a result of the above-mentioned impacts:

- Fluctuations in water chemistry may directly impact on the ability of certain plant species to survive;
- Toxicity of water may be lethal to sensitive vegetation;
- Increased possibility for microbial growth and algal blooms;
- Sedimentation of marginal vegetation habitats; and
- Exotic riparian vegetation encroachment.

6.2 Mitigation

The construction, operation and maintenance of this development have the potential to cause some environmental damage to the physical, biological and chemical components of riparian areas ecosystems. The construction activities should therefore apply methods and management practices that minimize and avoid the following impacts:

- Loss and disturbance of vegetation and habitat within its footprint;
- Soil compaction and increased risk of sediment transport and soil erosion during construction and routine maintenance in the operational phase;
- Flow modification due to concentrating flows and storm-water run-off from the road surfaces. This can lead to erosion and channel incision, and change in the in-stream habitat;
- Water quality deterioration due to chemical spills during the construction and operation phases, and
- Riparian area habitat fragmentation.

Riparian areas in particular can be very sensitive. This is due to the fact that riparian areas are low energy drainage lines in the landscape that are generally dependent on locally high water tables. These locally high water tables create the hydrological conditions of near-surface soil saturation that allows riparian areas to develop.

Hardened surfaces, and increased flow rates and volumes, can lead to the creation of preferential flow paths and possible concentration of flows into channels, which may cause further erosion and donga formation. That could result in a degradation of the environmental resource, as well as effectively draining the riparian areas through a lowering of the local water table and subsequent desiccation of the riparian areas. Eroded riparian areas are very difficult to rehabilitate to reference conditions due to the fact that both the water and soil required to support the riparian areas would then need to be reinstated.

To maintain the integrity of the riparian areas concerned, the following actions are recommended:

- Plan and develop outside riparian areas;
- Create the recommended buffer around riparian areas (it is likely that a buffer of <20 m may adequately fulfil a number of functions and values such as biotic movement, protecting the edge of the riparian areas, and some water quality functions, etc.) (MacFarlane, Dickens, & Von Hase, 2009);
- Minimize the removal/damage to vegetation in riparian areas;
- The construction of pathways (disturbance zones) in or adjacent to the riparian areas is to be closely managed and strictly controlled to minimize damage to riparian areas;
- Operation and storage of equipment in the riparian areas to be prevented;
- If the riparian areas is disturbed during construction it should be re-vegetated using site-appropriate indigenous vegetation and/or seed mixes;
- Alien vegetation should not be allowed to colonize the disturbed riparian areas;
- Rehabilitation of disturbed riparian areas habitat should commence immediately after construction is completed;
- No construction camps should be allowed in or within 20 m of a riparian areas;
- No stockpile areas should be located in or within 20 m of a riparian areas;
- Construction should preferably take place during the low flow/winter months in order to minimize the risk of sediment and debris being washed into riparian areas;
- Stockpiling of soil and of supplies for the construction camps must take place clearly away (at least 20 m where possible) from the edge of riparian areas to prevent soil being washed into the riparian areas habitat;
- During the construction and operation phases erosion and siltation measures should be implemented (e.g. the use of temporary silt traps downstream of construction areas);
- Slope/bank stabilization measures should be implemented where necessary to prevent erosion during the operation;
- Debris and sediment trapping, as well as energy dissipation control structures, should be put in place where storm-water may enter riparian areas;
- Turbidity, sedimentation and chemical changes to the composition of the water must be limited; and
- Where vegetation removal has occurred adjacent to the pathways, monitoring should take place to ensure successful re-establishment of natural vegetation. Alien vegetation should be removed from these disturbed areas on an ongoing basis to ensure successful re-vegetation by indigenous species.

7 CONCLUSION

According to the MBSP freshwater assessment there are some ESA riparian areas within the study area. The NFEPA project classifies these riparian areas as channelled valley-bottom riparian areas. According to the NBA 2011, all of the riparian areas in the vicinity of the study area belong to riparian areas ecosystem types that are Critically Endangered. The sub-catchment within which the study area falls has been classified by the MBSP as an ‘ESA Important Sub-catchment’ owing to the presence of a fish species of conservation concern (Tiger Fish *Hydrocynus vittatus*). The study area also includes large sections of ‘Heavily Modified’ areas as well as a dam. It is associated with one perennial river (Crocodile) and several non-perennial rivers. According to NFEPA, the Crocodile River has a condition of ‘D’.

3 water courses were identified and can be described as riverine areas. There are riparian areas which form part of these riparian areas. These riparian areas occur around the dam and upstream of road crossings and weirs. The delineated riparian areas are demarcated and indicated as T01, T02 and T03.

Site T01 Riparian Index of Habitat Integrity (RIHI) is a C/D (57.7%). The main impacts are road crossings, orchard footprint (extending into riparian areas in places), a dam that destroyed approximately 71% of the original riparian area, felling of riparian vegetation, a weir in the active channel and the extensive presence of exotic vegetation.

Site T02 Riparian Index of Habitat Integrity (RIHI) is a D (53.8%). The main impacts are roads traversing the riparian zone, dumping, agriculture, vegetation clearing and further water quality problems (due to the presence of orchards, exotic infestation and the damming effect of a road crossing with only one culvert).

Site T03 the Crocodile River Riparian Index of Habitat Integrity (RIHI) is a C/D (57.9%), with the main impacts being flood events, grazing and trampling, water abstraction and the presence of exotic species. The exotic tree *Spathodea campanulata*, a tall tree native to the dry tropical forests of tropical Africa. It has been nominated as among the top 100 of the "World's Worst" invaders.

The edge of the water resources (T01-03) in the study area have been delineated, with the starting point for delineation of the aquatic impact buffer zones for Rivers and streams, being on the outer edge of the active channel. A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows:

- T01 : 16 m
- T02 : 15 m
- T03 : 67 m

The proposed development can result in the increase of hardened surfaces and subsequent storm water runoff. Any hardening of surfaces will reduce the infiltration and ultimately reduce the yield of the seep zones they are feeding into the greater riparian areas systems.

The following is recommended:

- All activities should stay out of the 1:100 year flood line area;
- All activities should stay out of the riparian areas area and its recommended buffer zones;
- All storm water should be diverted to a point from where the water must be released in a controlled manner that will not initiate or enhance any erosion, the way storm water enters a natural waterway is important because high-energy flows can cause serious damage (especially to riparian zones); and
- Energy dissipaters and smaller permeable gabion-structures covered with reeds can be constructed at the effluent points of all stormwater.
- To cater for the present and the proposed developments in above mentioned riparian areas on site and off site mitigation is recommended to mitigate the negative effects thereof.

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Appendix A

Riparian areas vegetation species observed during the field trip

Species	Family	Sites		
		T01	T02	T03
Acacia ataxacantha	Fabaceae		X	
Acacia karroo	Fabaceae		X	X
Acacia nigrescens	Fabaceae	X	X	X
Acacia robusta subsp. *clavigera*	Fabaceae		X	
Acacia schweinfurthii	Fabaceae		X	
Acacia sieberiana var. *woodii*	Fabaceae	X	X	X
Acacia xanthophloea	Fabaceae	X	X	X
Acalypha glabrata	Euphorbiaceae		X	
*Ageratum houstonianum**	Asteraceae	X	X	X
Ampelopteris prolifera	Thelypteridaceae	X		
Annona senegalensis	Annonaceae			X
Andropogon huillensis	Poaceae	X		
Antidesma venosum	Aphyllanthaceae	X		
*Arundo donax**	Poaceae	X	X	X
Asparagus setaceus	Asparagaceae	X	X	X
Bauhinia galpinii	Caesalpiniaceous	X	X	
*Bauhinia variegata**	Caesalpiniaceous	X	X	
Berchemia zeyheri	Rhamnaceae			X
*Bidens pilosa **	Asteraceae	X	X	X
Bothriochloa bladhii	Poaceae		X	
Brachiaria brizantha	Poaceae	X		
Breonadia salicina	Rubiaceae	X		
*Caesalpinia decapetala**	Fabaceae		X	
*Canna indica**	Cannaceae	X		
*Cardiospermum grandiflorum**	Sapindaceae		X	X
*Casuarina cunninghamiana**	Casuarinaceae	X	X	X
Celtis africana	Celtidaceae	X	X	X
Combretum hereroense	Combretaceae		X	

Combretum imberbe	Combretaceae		X	X
Combretum molle	Combretaceae		X	
Commelina benghalensis	Commelinaceae	X	X	X
*Conyza canadensis**	Asteraceae	X	X	
Croton gratissimus	Euphorbiaceae		X	
*Cuscuta campestris**	Convolvulaceae		X	X
Cynodon dactylon	Poaceae	X	X	X
Cyperus dives	Cyperaceae	X	X	
Cyperus sexangularis	Cyperaceae	X	X	X
Dalbergia melanoxylon	Fabaceae	X	X	X
*Datura stramonium**	Solanaceae	X	X	X
Dichrostachys cinerea	Mimosaceae	X	X	X
Diospyros mespiliformis	Ebenaceae	X	X	X
Dodonaea angustifolia	Sapindaceae		X	
Eragrostis rotifer	Poaceae	X	X	
Eriochloa meyeriana	Poaceae			X
Eucalyptus sp.*	Myrtaceae	X	X	
Euclea natalensis	Ebenaceae	X	X	X
Ficus sur	Moraceae	X	X	X
Ficus sycomorus	Moraceae	X	X	X
Gymnosporia senegalensis	Celastraceae	X	X	X
Hippobromus pauciflorus	Sapindaceae		X	
Hyparrhenia hirta	Poaceae	X	X	
Imperata cylindrica	Poaceae	X	X	X
Indigofera colutea	Fabaceae	X		
*Ipomoea alba**	Convolvulaceae		X	X
*Jacaranda mimosifolia **	Bignoniaceae		X	X
*Lantana camara**	Verbenaceae	X	X	X
Leonotis intermedia	Lamiaceae		X	
Lippia javanica	Verbenaceae	X	X	X
*Melia azedarach**	Meliaceae	X	X	X
Melinis repens	Poaceae	X	X	X
*Nasturtium officinale**	Brassicaceae	X		

Nuxia oppositifolia	Stilbaceae	X		X
Panicum coloratum	Poaceae	X	X	X
Panicum deustum	Poaceae	X	X	
Panicum maximum	Poaceae	X	X	X
*Paspalum urvillei**	Poaceae	X	X	
Pennisetum sphacelatum	Poaceae			X
*Persicaria lapathifolia**	Polygonaceae	X	X	X
Phragmites australis	Poaceae	X	X	X
Phyllanthus reticulatus	Aphyllanthaceae	X	X	X
Polygonum aviculare	Polygonaceae	X	X	X
*Psidium guajava**	Myrtaceae	X	X	X
Rhoicissus tridentata subsp. *cuneifolia*	Vitaceae		X	
Richardia brasiliensis	Rubiaceae	X	X	X
*Ricinus communis**	Euphorbiaceae	X	X	X
Sansevieria hyacinthoides	Asparagaceae	X	X	X
Sclerocarya birrea subsp. *cafra*	Anacardiaceae	X	X	X
Searsia dentata	Anacardiaceae	X	X	
Searsia lancea	Anacardiaceae	X	X	X
*Sesbania bispinosa**	Fabaceae	X	X	X
*Sesbania punicea**	Fabaceae		X	X
Setaria megaphylla	Poaceae	X	X	X
Setaria sphacelata	Poaceae	X	X	X
*Solanum incanum**	Solanaceae	X	X	
*Solanum mauritianum**	Solanaceae	X	X	X
Sorghum bicolor	Poaceae		X	
Sporobolus africanus	Poaceae		X	X
*Spathodea campanulata**	Bignoniaceae			X
Syzygium cordatum	Myrtaceae	X	X	X
*Tagetes minuta **	Asteraceae	X	X	X
*Tecoma stans**	Bignoniaceae	X	X	X
Terminalia prunoides	Combretaceae		X	
Thelypteris confluens	Thelypteridaceae	X		X
Trema orientalis	Celtidaceae	X	X	

Typha capensis	Typhaceae	X	X	X
Trichilia emetica	Meliaceae	X	X	X
*Verbena bonariense**	Verbenaceae	X	X	X
Vernonia colorata	Asteraceae		X	
Zinia peruviana	Asteraceae		X	
Ziziphus mucronata	Rhamnaceae	X	X	X