ZOLA-EMDENI PUBLIC TRANSPORT FACILITY
SOWETO, Gauteng
Update 2022

Aquatic Ecology Specialist Study

ecotone
Freshwater Consultants

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Executive Summary

Introduction

Larchitect requested Ecotone to undertake a surface watercourse assessment of systems associated with the proposed transport facility, Zola, Soweto, Gauteng. The aim of this assessment was to define the risks that may result from the construction and operation of the proposed transport facility to the surface water ecology. The report was updated in January 2022 to consider the new preferred layout.

Study Approach and Methodology

A desktop study was undertaken to determine applicable information with regards to the greater catchment area, associated Ecoregions, nature of the drainage systems and overall catchment utilisation.

Two field assessments were undertaken during October 2017 and October 2019. An instream assessment of *in-situ* water quality, habitat, diatoms and aquatic macroinvertebrates was completed at sites upstream (Z2) and downstream (Z1 and Z3) of the proposed development. Rule based river health assessment tools were adopted for the instream assessment. A follow-up assessment was carried out in January 2022 to pinpoint any changes that may have occurred.

A risk-based impact assessment was applied to highlight the significance of perceived impacts associated with the proposed development in relation to the water resources, both onsite and downstream of the proposed construction activities.

Summary of Findings

- The study area falls within the Highveld ecoregion and is associated with the Tsakane Clay Grassland vegetation type with the geology characterised by an intercalated assemblage of compact sedimentary and extrusive rocks. The area drains into the Klip River which falls within the Upper Vaal Water Management Area. The Klip River is classified as an E ecological category, indicating a *Seriously* modified ecosystem state.

- The study area is characterised as a valley bottom system with shallow water and no distinct riparian zone. The area is not classified as a National Freshwater Ecosystem Priority Area (NFEPA) wetland.
- Site Z1 is situated adjacent to the proposed development, at the source of a drainage line that flows through a wetland area to another drainage line where sites Z2 (upstream) and Z3 (downstream) are located.
- Evidence of litter and dumping is evident at all three sites as well as run-off from the surrounding urban area. Site Z3 also had sewage leaking into the system.
- The Integrated Habitat Integrity (IHI) results showed that sites Z1 and Z2 are both in a *Largely Modified* state, with large losses of natural habitat, biota and basic ecosystem functioning. Site Z3 is in a *Seriously Modified* state, where the loss of natural habitat, biota and basic ecosystem functioning are more extensive.
- In general, the water quality reflected circumneutral pH levels with low salt loads during the October 2017 assessment which were all within threshold criteria for freshwater aquatic ecosystems. The results for the October 2019 assessment, showed that the pH for the Z2 site was within the *Intolerable* range for aquatic ecosystems and the salt loads for both the Z2 and Z3 sites were within the *Tolerable* range. The results from the January 2022 assessment indicated a similar trend with better water quality in the upper reaches (Z1), and increased salt loads in the lower reaches at site Z2 and Z3. This impact is most likely associated with sewage spill observed within the direct catchment.
- The diatom community analyses indicated that the water quality at all the sites, was *Poor* and the %PTV scores were high for sites Z2 and Z3 and low for site Z1. Most of the diatom species at all the sites indicated eutrophic, electrolyte-moderate to rich conditions and are tolerant to polluted conditions. This indicates that there was some form of pollution present at all the sites which was either associated with organic pollution or untreated wastewater.
- The invertebrate habitat assessment for both assessments indicated that all three provided *Poor* habitat availability for invertebrate colonisation. During the October 2017 macroinvertebrate assessment, the same number of taxa were sampled at the Z1 downstream and Z2 upstream sites, with similar ASPT results. Two more taxa were sampled at the Z3 downstream site when compared to the Z2 upstream site, resulting in a higher ASPT for this site. During the October 2019 assessment, the same number of taxa were sampled at the Z1 and Z3 downstream sites, with similar ASPT results. The least number of taxa were sampled at the Z2 upstream site resulting in the lowest ASPT score. Temporally, the results for the Z1

site improved from the October 2017 to October 2019 assessments whereas the results for the Z2 site deteriorated. Although more taxa were sampled during the 2019 assessment at the Z3 site, the ASPT was lower compared to the 2017 results as the sensitivity of the taxa sampled was lower. All the taxa that were sampled at the three sites are taxa that are highly tolerant to pollution.

Impact Assessment

The results of the impact assessment for the construction and operational phase are summarised in **Table 0-1 with the main points summarised below:**

- The impact assessment for the construction phase indicates that the main impacts, prior to mitigation, are those related to erosion and sedimentation and the impact to surface water quality. The impacts to hydrology and increase in alien/pioneer vegetation is considered to be *Low* without mitigation. With mitigation measures, all the potential impacts are of *Low* significance;
- The impact to the surface water quality, hydrology and those related to erosion and sedimentation during the operational phase are considered to be *Medium*. With the implementation of mitigation measures, these impacts can all be of *Low* significance. The increase of alien/pioneer vegetation will be low before and after mitigation during the operational phase;
- With regards to the alternative infrastructure, the new preferred alternative has a lower overall significance score, mainly due to the lower probability as the infrastructure falls outside the wetland buffer zone.

Table 0-1: Summary of residual impacts, after mitigation

Impact	Construction				Operation			
	Original Alternative		New Preferred Alternative		Original Alternative		New Preferred Alternative	
(1) Impacts on hydrology	10	Low	10	Low	15	Low	10	Low
(2) Impacts on surface water quality	18	Low	12	Low	12	Low	8	Low
(3) Impacts related to erosion and sedimentation	30	Low	18	Low	18	Low	18	Low

(4) Impact related to increase alien/pioneer vegetation in disturbed areas	**5**	**Low**	**5**	**Low**	**15**	**Low**	**10**	**Low**

Conclusion

The study aimed to ascertain the baseline condition of the receiving environment associated with the proposed development of the transport facility, Zola, and to define risks that may result from the construction and operation of the proposed transport facility to surface water ecology.

The study area is characterised as a valley bottom system with shallow water and no distinct riparian zone. The riparian and instream habitat integrity of the sites are *Largely* to *Seriously* modified with the diatom assessment indicating poor water quality. No sensitive taxa were sampled during the aquatic macroinvertebrate assessment which indicates a polluted system with a loss of ecological integrity.

It is expected that the impact from of the proposed activity on the aquatic environment will be *Medium* to *Low* during construction and operation, but only with the implementation of appropriate mitigation measures, these impacts will all have *Low* significance for both alternatives. However, the impact scores were slightly lower for the new preferred alternative, mainly due to the infrastructure falling outside the wetland buffer zone.

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List of Abbreviations and Acronyms

ASPT	Average Score Per Taxa
BDI	Biological Diatom Index
CARA	Conservation of Agricultural Resources Act
D	Duration
DWA/F	Department of Water Affairs
E	Extent
EC	Electrical Conductivity
EIS	Ecological Importance and Sensitivity
GSM	Gravel, Sand and Mud
IHAS	Invertebrate Habitat Assessment System
IHI	Integrated Habitat Integrity
M	Magnitude
MAP	Mean Annual Precipitation
MAPE	Mean Annual Potential Evaporation
MAR	Mean Annual Run-off
MASR	Mean Annual Surface Runoff
NFEPA	National Freshwater Ecosystem Priority Areas
NSBA	National Spatial Biodiversity Assessment
NWA	National Water Act
%PTV	Percentage Pollution Tolerance Valves
P	Probability
PES	Present Ecological State
S	Significance Weighting
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System (version 5)
SIC	Stones-in-Current
SOOC	Stones-out-of-Current
SPI	Specific Pollution Sensitivity Index
TDS	Total Dissolved Solids
VEG	Vegetation
WUL	Water Use Licence
WMA	Water Management Area

1. Introduction

1.1. Background

Larchitect requested Ecotone to undertake a surface watercourse assessment of systems associated with the proposed transport facility, Zola, Soweto, Gauteng. The aim of this assessment was to define the risks that may result from the construction and operation of the proposed transport facility to the surface water ecology. The report was updated in January 2022 to consider the new preferred layout.

1.2. Objectives of the report

A specialist aquatic assessment was undertaken in October 2017 and October 2019 on the drainage lines associated with the proposed public transport facility in order to ascertain the baseline condition of the receiving environment via the implementation of the following methodological approach:

- The present state of biological receptors in the receiving environment was ascertained by:
  - Description of the instream response metrics where applicable.
  - Measurement of *in situ* water quality of wetlands.
  - Diatom analyses at sites upstream and downstream of the proposed activities.
- Impact assessment and mitigation measures:
  - Assessment of the perceived impacts on receiving water resources.
  - Provision of mitigation measures for impacts where applicable.
  - An aquatic biomonitoring plan.

The report was updated in January 2022 to consider the new preferred layout. A brief site visit was conducted to pinpoint any notable alterations on the associated watercourses. *In-situ* water quality measurements were taken to highlight any changes in water quality. These changes were taken into account when compiling the impact assessment.

1.3. Legislative Framework

The section below highlights some important legislation pertaining to wetlands and aquatic ecosystems in general on the property.

According to the National Water Act (Act No. 36 of 1998), a water resource is defined as:
"a watercourse, surface water, estuary, or aquifer. A water course in turn refers to:

a) a river or spring;
b) a natural channel in which water flows regularly or intermittently;
c) a wetland, lake or dam into which, or from which, water flows; and
d) any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse. Reference to a watercourse includes, where relevant, its bed and banks."

A wetland is defined as: "land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances support or would support vegetation typically adapted to life in saturated soil."

Section 21 of the National Water Act (NWA; Act No. 36 of 1998) covers the following activities, which might be applicable to the conceptual layout plan for the proposed development. According to Section 21 of the NWA and in relation to aquatic ecosystems, the following activity is considered a use, and therefore requires a water use license:

a) taking water from a water resource;
b) storing water;
c) impeding or diverting the flow of water in a watercourse;
f) discharge water or water containing waste into a water resource through a pipe, sewer, sea outfall or other conduit;
g) disposing of waste in a manner which may detrimentally impact on a water resource;
i) altering the bed, banks, course or characteristics of a watercourse; and
j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people.

According to the Department of Water Affairs (DWA) any activity that falls within the temporary zone of a wetland or the 1:100 year floodline (whichever is greater) qualifies as a Section 21(c) and/or (i) water use activity (depending on the use) and will thus require either a general authorization or Water Use License (WUL). According to the NWA, an application for a WUL should be submitted to the DWA if any of the above activities are to be undertaken.

Where any activities are to take place in or "near" to surface water resources with regards to the above, a water use license application process must be undertaken in order to obtain a permit to impact on any surface water resource. The above applies to both wetlands and watercourses (amongst others) which are both regarded as surface water resources. In terms of wetlands specifically, for water uses c) and i) specifically, a General Authorisation may be registered under Government Notice 509 of August 2016 (Notice No. 40229) as per Section 8 where the outcome of the assessment of the Risk Assessment Protocol shows that the proposed development will have a Low Risk. This notice is only potentially applicable to where activities take place within the regulated area (within 500m radius) of wetlands. Where the outcome of the Risk Assessment Protocol shows that the proposed development will have a Medium to High Risk, a water use license application process is to be undertaken in order to obtain a permit to impact on surface water resources. For watercourses, the regulated area includes impacts taking place within the extent of the watercourse. The extent of a watercourse includes the outer edge of a wetland associated with a watercourse (i.e. channelled valley bottom wetland), outer edge of the riparian habitat or the 1:100 year flood line (whichever is greatest).

In terms of Section 19 of the National Water Act, a person who owns, controls, occupies or uses the land is responsible for the control and prevention of water resource pollution.

The Conservation of Agricultural Resources Act (CARA - Act No. 43 of 1983) was established for the conservation of the natural agricultural resources by the maintenance of the production potential of land, by:

- Combating and preventing erosion.
- Mitigating the weakening or destruction of the water sources.
- Protecting natural vegetation.
- Combating of weeds and invader plants.

According to REGULATION 16: Control of weeds and invader plants:

If invasive weeds (as specified in the Act) occur on any area (also specified) the land user shall, by any of the following means, control those weeds effectively:

a) The weeds shall be uprooted, felled or cut off and shall be destroyed by burning or other suitable methods.
b) The weeds shall be treated with an appropriately registered weed killer.
c) The measures above shall be applied to the seeds, seedlings or re-growth of the weeds to prevent them from setting seed or propagating vegetatively.

2. Study Approach and Methodology

2.1. Literature Review on the General Study Area

A literature survey and desktop study for the general study area was carried out using available information from reference works (Nel *et al*., 2004, 2011; Kleynhans, 2005; Mucina & Rutherford, 2006; DWAF, 2007). Main rivers associated with the proposed development were identified and relevant stretches were characterised (Nel *et al.,* 2004, 2011). Wetland systems located within the study area were identified at a desktop level with the use of shape files obtained from the South African National Biodiversity Institute (SANBI, 2010). General area characteristics were obtained using reference work from Mucina & Rutherford (2006).

2.2. Field Survey and Site Selection

Three field assessments were undertaken during October 2017, October 2019 and January 2022 to determine the state of the biological receptors in the receiving environment associated with the proposed development.

During the field assessments, three instream biomonitoring sites were assessed. These include site Z1 which is located adjacent to the proposed development and sites Z2 and Z3 which is situated upstream and downstream of the proposed development (**Table 2-1** and **Figure 2-1**). During the January 2022, only a visual and *in-situ* assessment was carried out.

Table 2-1: Coordinates of instream assessment points

Point	Location	Latitude	Longitude
Z1	**Downslope**	-26.242116°	27.841608°
Z2	**Upstream**	-26.244063°	27.842813°
Z3	**Downstream**	-26.246222°	27.840289°

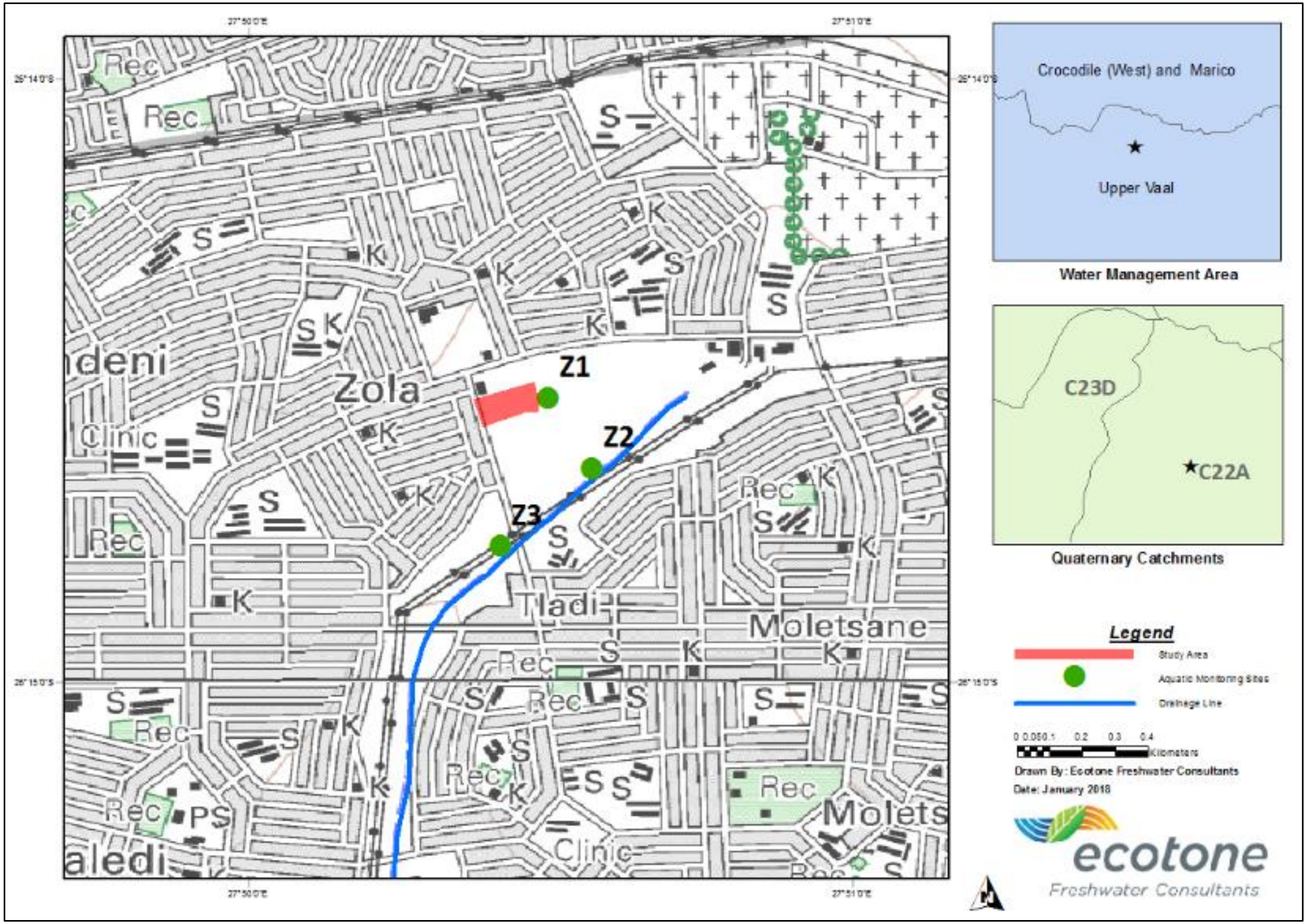

Figure 2-1: Map showing the location of the proposed public transport facility and the instream monitoring sites on 2627BB; 2627BD 1:50 000 maps (surveyor general).

2.3. Index of Habitat Integrity

The IHI (Kleynhans, 1996) was applied to ascertain the change of instream and riparian habitat from natural conditions. The IHI assessment provides a tool for assessing these habitat types by incorporating factors and potential impacts (Kleynhans, 1996). The severity of the impact of modifications is based on six categories. These categories comprise rating scores ranging from 0 to 25: where 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact – **Table 2-2**).

Table 2-2: Descriptive classes for the assessment of modifications to habitat integrity (adapted from Kleynhans, 1996)

Impact Category	Description	Score
None	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 - 5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6 - 10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11 - 15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16 - 20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21 - 25

The habitat integrity assessment is based on two different components of a river: 1) the instream channel, and 2) the riparian zone. Separate assessments are done for both aspects; however, the data for the riparian zone is interpreted primarily in terms of the potential impact on the instream component (Kemper, 1999). The rating system is based on different weights for each criterion (**Table 2-3**).

Table 2-3: Criteria and weights used for the assessment of habitat integrity (adapted from Kleynhans, 1996)

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Bank erosion	14
Water quality	14	Indigenous vegetation removal	13
Bed modification	13	Water abstraction	13
Channel modification	13	Water quality	13
Flow modification	13	Channel modification	12
Inundation	10	Exotic vegetation encroachment	12
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Inundation	11
Solid waste disposal	6		
TOTAL	**100**	**TOTAL**	**100**

The methodology classifies habitat integrity into one of six classes, ranging from *Natural* (Category A) to *Critically* modified (Category F), for both instream and riparian habitat (**Table 2-4**).

Table 2-4: Ecological categories, key colours and category descriptions presented within the habitat assessment (adapted from Kleynhans, 1996)

Category		Description	Score (%)
A	Natural	Unmodified, Natural.	90-100
B	Largely Natural	Few modifications. 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 occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely Modified	Large loss of natural habitat, biota and basic ecosystem functions occurred.	40-59
E	Seriously Modified	The losses of natural habitat, biota and basic ecosystem functions are 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.	<20

2.4. *In situ* Water quality

In situ analysis was undertaken using a pre-calibrated Eutech PCD650 multi-parameter hand-held water quality meter (**Table 2-5**). The results obtained from the assessment of the water quality data were compared to benchmark criteria compiled by Kotze (2002) consisting of source water quality guidelines set by Rand Water (Steynberg *et al.*, 1996; Rand Water, 1998). Water quality information was represented using colour coding to indicate whether water quality variables were within guideline ranges (**Table 2-6**).

Table 2-5: In situ parameters measured

In situ **parameters**	**Abbreviation**	**Units**
pH	pH	[H^1+ ions]
Temperature	Temp	°C
Electrical Conductivity	EC	µS-cm^{-1}
Total Dissolved Solids	TDS	ppm
Turbidity	Turb	FAU

Table 2-6: Water quality ranges as compiled by Kotze (2002) and provided in mg/l. References 1: Steynberg *et al*. (1996); 2: DWAF (1996); 3: Rand Water (1998)

Variable	**Unit**	**Ideal**	**Acceptable**	**Tolerable**	**Unacceptable**	**Ref.**
pH	[H^1+ ions]	6.5-8.5		5-6.5/8.5-9	<5/>9	1,3
Electrical Conductivity	µS-cm^{-1}	<450	450-700	>700-1000	>1000	1
Dissolved Oxygen	mg/l	>9	>5-9	4 to 5	<4	3

2.5. Diatom Assessment

Diatoms were sampled, collected and prepared for identification and enumeration by prescribed and tested laboratory methodology (Taylor *et al*., 2005). Diatom samples were prepared for microscopy by using the hot hydrochloric acid and potassium permanganate method (Taylor *et al*., 2005). Approximately 300 to 400 diatom valves were identified and counted to produce semi-quantitative data for analysis. Prygiel *et al.* (2002) found that diatom counts of 300 valves and above were necessary to make correct environmental inferences. The taxonomic guide by Taylor *et al*. (2007) was consulted for identification purposes. Where necessary, Krammer & Lange-Bertalot (1986, 1988, 1991 a, b) were used for identification and confirmation of species identification. Environmental preferences were inferred from Taylor *et al*. (2007) and various other literature sources as indicated in the discussion section to describe the environmental water quality at each site.

Even though the watercourses under investigation were identified as channelled valley bottom systems and not rivers, two indices, namely the Specific Pollution Sensitivity Index (SPI; CEMAGREF, 1982) and the Biological Diatom Index (BDI; Lenoir & Coste, 1996), which are mainly used to determine the ecological health of rivers, were used in the diatom assessment to possibly indicate the present ecological state of the sites where a sufficient cell count could be obtained. These results should therefore be considered with caution. The SPI has been extensively tested in a broad geographical region and integrates impacts from organic material, electrolytes, pH, and nutrients. In addition, the Percentage of Pollution Tolerant Valves (%PTV; Kelly & Whitton, 1995), which provides an indication of possible impacts of organic pollution, and ecological descriptors (Van Dam *et al*., 1994) were used for data enrichment and interpretation. The overall ecological water quality was determined using all three indices. All calculations were computed using the OMNIDIA ver. 4.2 program (Lecointe *et al*., 1993). For sites, which had an insufficient cell count, the diatom indices could not be calculated, however, the taxa present were recorded to make ecological inferences based on the known ecological preferences of the recorded taxa. These results should therefore be considered with caution.

The limit values and associated ecological water quality classes adapted from Eloranta & Soininen (2002) were used for interpretation of the SPI and BDI scores (**Table 2-7**). The SPI and BDI indices are based on a score between 0 – 20, where a score of 20 indicates no pollution and a score of zero indicates an increasing level of pollution or eutrophication. The %PTV has a maximum score of 100, where a score above 0 indicates no organic pollution and a score of 100 indicates definite and severe organic pollution (**Table 2-8**).

Table 2-7: Class values used for the Specific Pollution Index and Biological Diatom Index was used in the evaluation of water quality (adapted from Eloranta & Soininen, 2002)

Index Score	Class
>17	High quality
13 to 17	Good quality
9 to 13	Moderate quality
5 to 9	Poor quality
<5	Bad quality

Table 2-8: Interpretation of the Percentage of Pollution Tolerant Valves scores (adapted from Kelly, 1998)

%PTV	Interpretation
<20	Site free from organic pollution.
21 to 40	There is some evidence of organic pollution.
41 to 60	Organic pollution likely to contribute significantly to eutrophication.
>61	Site is heavily contaminated with organic pollution.

2.6. Aquatic Macroinvertebrates

Invertebrate Habitat Assessment System: The IHAS (McMillan, 1998) provides a quantitative and comparable description of habitat availability for the aquatic invertebrates sampled. The IHAS was developed to assist with the interpretation of SASS5 scores, particularly in respect of variability in the number and quality of biotopes available for sampling. The goal of IHAS is to adequately reflect the quantity, quality and diversity of biotopes available for colonisation by invertebrates. Only section 1 of the IHAS was employed during this project. Section 1 focuses on sampling biotopes and assesses the quantity and quality of the stones-in-current (SIC), vegetation (VEG) and other biotopes (including stones-out-of-current (SOOC) and gravel, sand and mud (GSM). The quality of each biotope, in terms of potential habitat for invertebrates is expressed as a score. The scores for each biotope are then summed up to give a total Habitat Score (**Table 2-9**).

Table 2-9: IHAS ratings and categories (McMillan, 1998)

IHAS score %	Description	Category
>80	Habitat is more than adequate and able to support a diverse invertebrate fauna.	**Good**
<80>70	Habitat is adequate and able to support invertebrate fauna.	**Adequate**
<70	Habitat is limited and unable to support diverse invertebrate fauna.	**Poor**

South African Scoring System (Version 5): Aquatic macroinvertebrates were collected using the sampling protocol of the SASS 5 method (Dickens & Graham, 2002). The protocol is divided amongst three biotopes, namely VEG, SIC and GSM. Samples were collected in an invertebrate net with a pore size of 1000 microns on a 30cm x 30cm frame by kick sampling of SIC and GSM, and sweeping of VEG for a standardised time or area. The deep-water sampling was limited to the VEG biotope as other biotopes were not available for sampling. Macroinvertebrates were identified to family level using relative reference guides (Dickens & Graham, 2002; Gerber & Gabriel, 2002).

The SASS 5 scoring sheet lists organisms identified to family level (**Table 2-10**). On the scoring sheet each taxon is assigned a ‘quality’ score, based on its susceptibility or resistance to pollution and disturbances (Dickens & Graham, 2002). Resistant taxa are allocated a low score, whereas sensitive taxa susceptible to pollution receive a high score. Identification of taxa is restricted to a maximum of 15 minutes per biotope but, if no new taxon is seen for approximately 5 minutes, the process is stopped, and the next biotope is observed. Identified taxa are marked under the appropriate biotope heading before totalling the three columns into a single total column. An estimation of the abundances of organisms within each taxon is made (i.e. a single individual is recorded as ‘1’, from 2 to 10 is allocated an ‘A’, from 10 to 100 a ‘B’, from 100 to 1000 a ‘C’ and > 1000 a ‘D’). The calculation of results is obtained by summing the scores of each taxon recorded in the Total column (= SASS Score), counting the number of taxa found (= No. Taxa) and dividing the former by the latter (= ASPT – Average Score per Taxon).

When interpreting the SASS data various factors that influence the score need to be considered, including measures of habitat quantity, quality and diversity. It is important to note that where habitat diversity is poor, there will be less biotic diversity and consequently a lower SASS Score. However, the ASPT will be less affected due to the fact that the few organisms present may have the appropriate sensitivity. A low ASPT score may occur where, for example, a sand bed river in pristine condition may be occupied by hardy, adaptable taxa. The ASPT is a more reliable measure of the health of good quality rivers [as opposed to poor quality rivers] than SASS Score is (Chutter, 1998). It is important to have a sound knowledge of aquatic ecology and biology in order to interpret the numerous combinations of biotic and abiotic situations that are found in the environment. Note that taxa marked with an * on the score sheet are air-breathers – which information may be used as an indication of the prevalence of taxa relying on air for oxygen.

Table 2-10: SASS Version 5 Score Sheet (Dickens & Graham, 2002)

SASS Version 5 Score Sheet

Version date: Sept 2005

Date (dd:mm:yr):			(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5) / Time (min)
RHP Site Code:		Grid reference (dd mm ss.s) Lat:	S	Stones In Current (SIC)	
Collector/Sampler:		Long:	E	Stones Out Of Current (SOOC)	
River:		Datum (WGS84/Cape):		Bedrock	
Level 1 Ecoregion:		Altitude (m):		Aquatic Veg	
Quaternary Catchment:		Zonation:		MargVeg In Current	
	Temp (°C):	Routine or Project? (circle one)	Flow:	MargVeg Out Of Current	
Site Description:	pH:	Project Name:	Clarity (cm):	Gravel	
	DO (mg/L):	Thukela survey @ Mandini	Turbidity:	Sand	
	Cond (mS/m):		Colour:	Mud	
	Riparian Disturbance:	Limited - some subsistence farming		Hand picking/Visual observation	
	Instream Disturbance:	None			

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					HEMIPTERA (Bugs)						DIPTERA (Flies)					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3					Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5					Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1					Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2				
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1				
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5				
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					TRICHOPTERA (Caddisflies)						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					GASTROPODA (Snails)					
Baetidae 1sp	4					Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					Cased caddis:						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					PELECYPODA (Bivalvies)					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					SASS Score					
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					No. of Taxa					
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					ASPT					
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					Other biota:					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13										
Lestidae (Emerald Damselflies/Spreadwings)	8					COLEOPTERA (Beetles)											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					Comments/Observations:					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles)	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10									9	
						Psephenidae (Water Pennies)	10										

Procedure:
Kick SIC & bedrock for 2 mins, max. 5 mins. Kick SOOC & bedrock for 1 min. Sweep marginal vegetation (IC & OOC) for 2m total and aquatic veg 1m². Stir & sweep gravel, sand, mud for 1 min total. * = airbreathers
Hand picking & visual observation for 1 min - record in biotope where found (by circling estimated abundance on score sheet). Score for 15 mins/biotope but stop if no new taxa seen after 5 mins.
Estimate abundances: 1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000 S = Stone, rock & solid objects; Veg = All vegetation; GSM = Gravel, sand, mud SWC = South Western Cape, T = Tropical, ST = Sub-tropical
Rate each biotope sampled: 1=very poor (i.e. limited diversity), 5=highly suitable (i.e. wide diversity) Rate turbidity: V low, Low, Medium, High, Very High
Rate flows: Zero, trickle, low, medium, high, flood Rate colour: transparent, tea brown, light brown, dark brown, light green, dark green, yellow, red, grey, milky white, black

2.7. Impact Assessment

The impact assessment, in the context of this assessment, considered the potential for loss of ecological functioning of associated surface water systems and the subsequent impact on the downslope receiving water resources. Four main impacts were assessed:

1. Impacts relating to alteration in hydrology.
2. Impacts relating to alteration in surface water quality.
3. Impacts related to erosion and downslope sedimentation.
4. Impacts related to an increase in alien and pioneer species in disturbed areas.

The significance of each potential impact was calculated as follows: Significance = (E+D+M)*P, where: E = Extent, D = Duration, M = Magnitude, P = Probability. The Significance Rating was calculated by multiplying the Severity Rating with the Probability Rating. The significance rating should influence the development project as described below (**Table 2-11**).

Table 2-11: Significance rating categories showing values for Low, Medium and High significance

Significance	Rating
Low Environmental Significance	**0 - 30**
Medium Environmental Significance	**31 – 60**
High Environmental Significance	**61 -100**

2.8. Limitations of this Study

2.8.1. General

The spatial and temporal extents of Ecotone's services are described in the proposal and are subject to restrictions and limitations. A total assessment of all probable scenarios or circumstances that may exist on the study site was not undertaken. No assumptions should be made unless opinions are specifically indicated and provided. Data presented in this document may not elucidate all possible conditions that may exist given the limited nature of the enquiry.

2.8.2. Biological Response Metrics

Conventional River Health response and driver methodology could not be applied as the water resources where not suitable for the application of South African Scoring System. A diatom assessment was incorporated into the study as this provides a more suitable biological response metric. However, this report includes a section of the sensitivities associated with aquatic macroinvertebrate taxa sampled during the field assessment

2.8.3. Legal Framework

This report does not provide a comprehensive review of legal matters pertaining to the proposed development and associated wetlands. It is recommended that a specialist legal opinion be obtained if and where required.

3. Description of the Affected Environment

3.1. Aquatic Ecoregion Characteristics

The study area falls in the Highveld ecoregion and is associated with the Tsakane Clay Grassland vegetation type and the geology is characterised by intercalated assemblage of compact sedimentary and extrusive rocks (**Table 3-1**, **Figure 3-1**, **Figure 3-2** and **Figure 3-3**). This region consists predominantly of plains with a moderate to low relief as well as various grassland vegetation types (with moist types present towards the east and drier types towards the west and south) (Kleynhans *et al.* 2005). General features of this aquatic ecoregion include:

- Mean annual precipitation: Rainfall varies from low to moderately high, with an increase from west to east.
- Coefficient of variation of annual precipitation: Moderately high in the west, decreasing to low in the east.
- Drainage density: Mostly low, but medium in some areas.
- Stream frequency: Low to medium.
- Slopes <5%: >80%. Few hilly areas 20-50%.
- Median annual simulated runoff: Moderately low to moderate.
- Mean annual temperature: Hot in the west and moderate in the east.

Table 3-1: Environmental variables and geomorphologic description of the study area (Mucina & Rutherford, 2006)

Feature	Description
Bioregion	Mesic Highveld Grassland Bioregion
Vegetation Type	Tsakane Clay Grassland
Landscape features	Flat to slightly undulating plains and low hills. Vegetation is short with dense grassland dominated by mixture of common highveld grasses.
Geology and soils	The most significant rock is basaltic lava of the Klipriviersberg Group, together with the sedimentary rocks of the Madzaringwe Formation of the Karoo Supergroup.

MAP: Mean Annual Precipitation; **MAPE:** Mean Annual Potential Evaporation; **MASR:** Mean Annual Surface Runoff

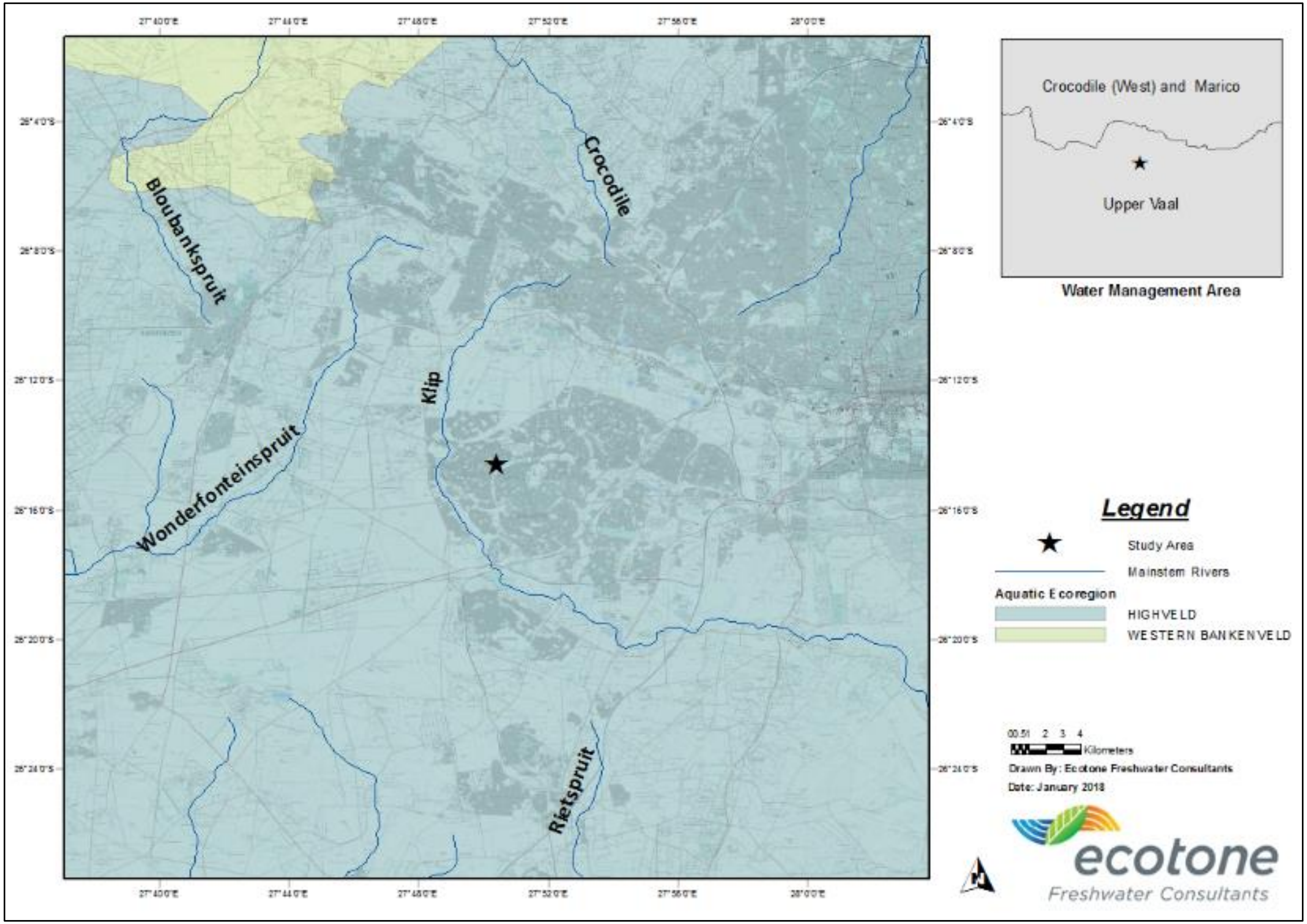

Figure 3-1: Map showing the aquatic ecoregion level 1 classification associated with the study area (Kleynhans *et al.*, 2005).

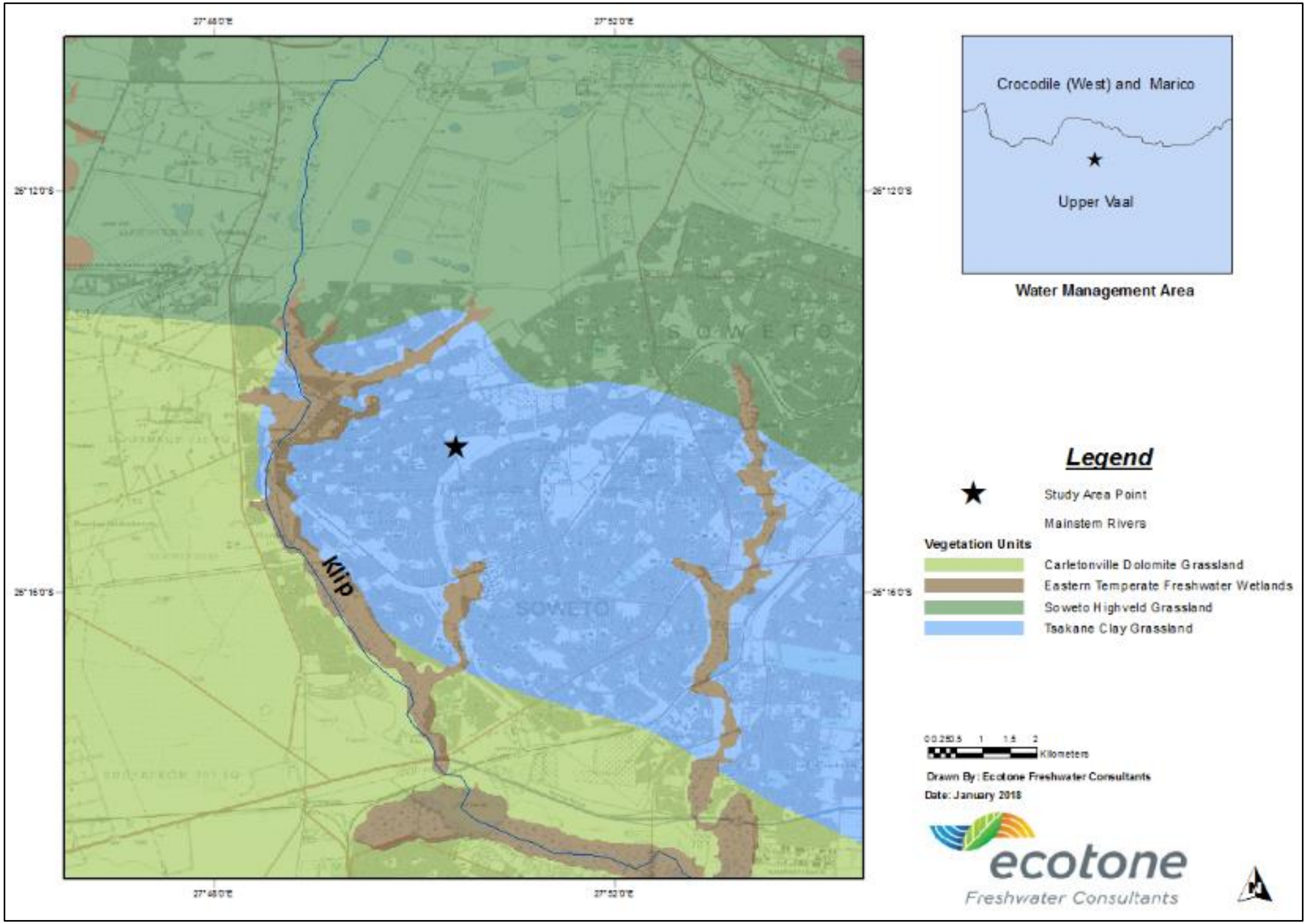

Figure 3-2: Map showing the vegetation type associated with the study area (Nel *et al*., 2004; Mucina & Rutherford, 2006).

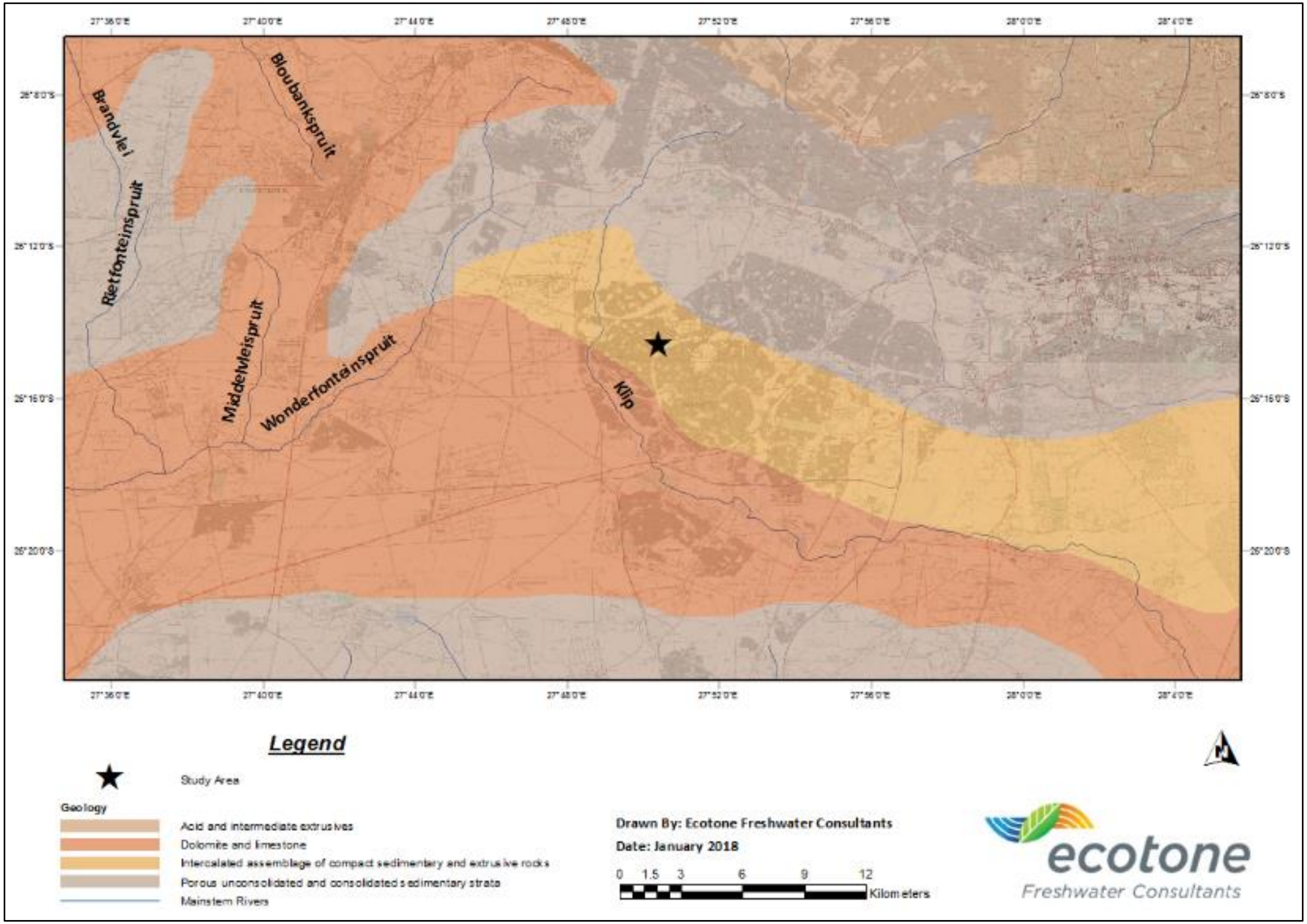

Figure 3-3: Map showing the geology associated with the study area.

3.2. Desktop Ecological Integrity

The study area falls on quaternary catchments C22A in the Upper Vaal Water Management Area (WMA). The study area in relation to the National Freshwater Ecosystem Priority Areas (NFEPA) is provided in **Figure 3-5**. The wetland NFEPA spatial data do not indicate the presence of NFEPA wetlands.

The study area drains into the Klip River (**Table 3-2, Figure 3-4, Figure 3-5** and **Figure 3-6**). According to the DWAF (2007) data the Klip River falls into an E ecological category, indicating a *Seriously* modified ecosystem state. Six attributes were used to obtain the Present Ecological State (PES) on desktop quaternary catchment level by the National Spatial Biodiversity Assessment (NSBA - Nel *et al.*, 2004). These attributes predominantly include habitat integrity of instream and riparian habitat and their respective ratings are provided in **Table 3-3**. The sub-quaternary reach is affected by urban areas at the rivers source in Roodepoort as it flows through Soweto. Other impacts include mining, waste water treatment works, siltation, road crossings and increased flows. The Ecological Importance and Sensitivity (EIS - DWAF, 2007) of the sub-quaternary reach is *Moderate* which indicates that it has a lower conservation value than rivers with a higher EIS and is more suited for development (RHP, 2005) (**Table 3-2**).

Table 3-2: Desktop characterisation of the downstream receiving system

River	Klip
River Order	1
Hydrological Class	Perennial
River Signature	Highveld 3
Conservation status	Critically Endangered
Aquatic Ecoregion	Highveld
Water Management Area	Upper Vaal WMA
NFEPA Areas (Nel *et al*., 2011)	None associated with the study area
Sub-quaternary reach	C22A
PES (DWS, 2014)	**E**
EI (DWS, 2014)	*Moderate*
ES (DWS, 2014)	*Moderate*

PES: Present Ecological State; **EIS:** Ecological Importance and Sensitivity; ***** DWAF, 2000

Table 3-3: The PES ratings assigned to the sub-quaternary reach for the Klip River system (SQR C22A - 01315) with confidence scores 1= low confidence and 4= high confidence

Metric	Rating	confidence
Instream Habitat Continuity Mod	LARGE	3.0
Rip/Wetland Zone Continuity Mod	LARGE	3.0
Potential Instream Habitat Mod Act.	SERIOUS	3.0
Riparian-Wetland Zone Mod	LARGE	3.0
Potential Flow Mod Act.	SERIOUS	3.0
Potential Physico-Chemical Mod Activities	SERIOUS	3.0

Table 3-4: Summary of the criteria used to determine the EI and ES per SQR (DWS, 2014)

Ecological Importance (EI)				Ecological Sensitivity (ES)	
Descriptor	**C22A -01315**	**Descriptor**	**C22A -01315**	**Descriptor**	**C22A -01315**
Number of fish species estimated per SQR	9.0	Number of invertebrate taxa estimated per SQR	27.00	Fish: physicochemical sensitivity	HIGH
Fish: average confidence	4.78	Invertebrate - average confidence	2.63	Fish: no-flow sensitivity	
Fish representation per secondary: class	HIGH	Invertebrate representation per secondary: class		Invertebrate: physicochemical sensitivity	HIGH
Fish rarity per secondary: class	HIGH	Invertebrate rarity per secondary: class	HIGH	Invertebrate: velocity sensitivity	VERY HIGH
Riparian/wetland-instream vertebrates (excl. fish) rating	HIGH	Riparian/wetland-instream vertebrates (excl. fish) rating	HIGH	Riparian/wetland-instream vertebrates (excl. fish) intolerance water level/flow changes	HIGH
Riparian-wetland natural VEG rating based on % natural VEG in 500m	LOW	Habitat diversity class	MODERATE	Stream size sensitivity to modified flow/water level changes	LOW
Riparian-wetland natural VEG importance based on expert rating	HIGH	Habitat Size (Length) Class	HIGH	Riparian/wetland VEG intolerance to water level changes	LOW
		Instream migration link class	MODERATE		
		Riparian/wetland zone migration link	MODERATE		
		Riparian/Wetland Zone Habitat Integrity Class	MODERATE		
		Instream Habitat Integrity Class	LOW		

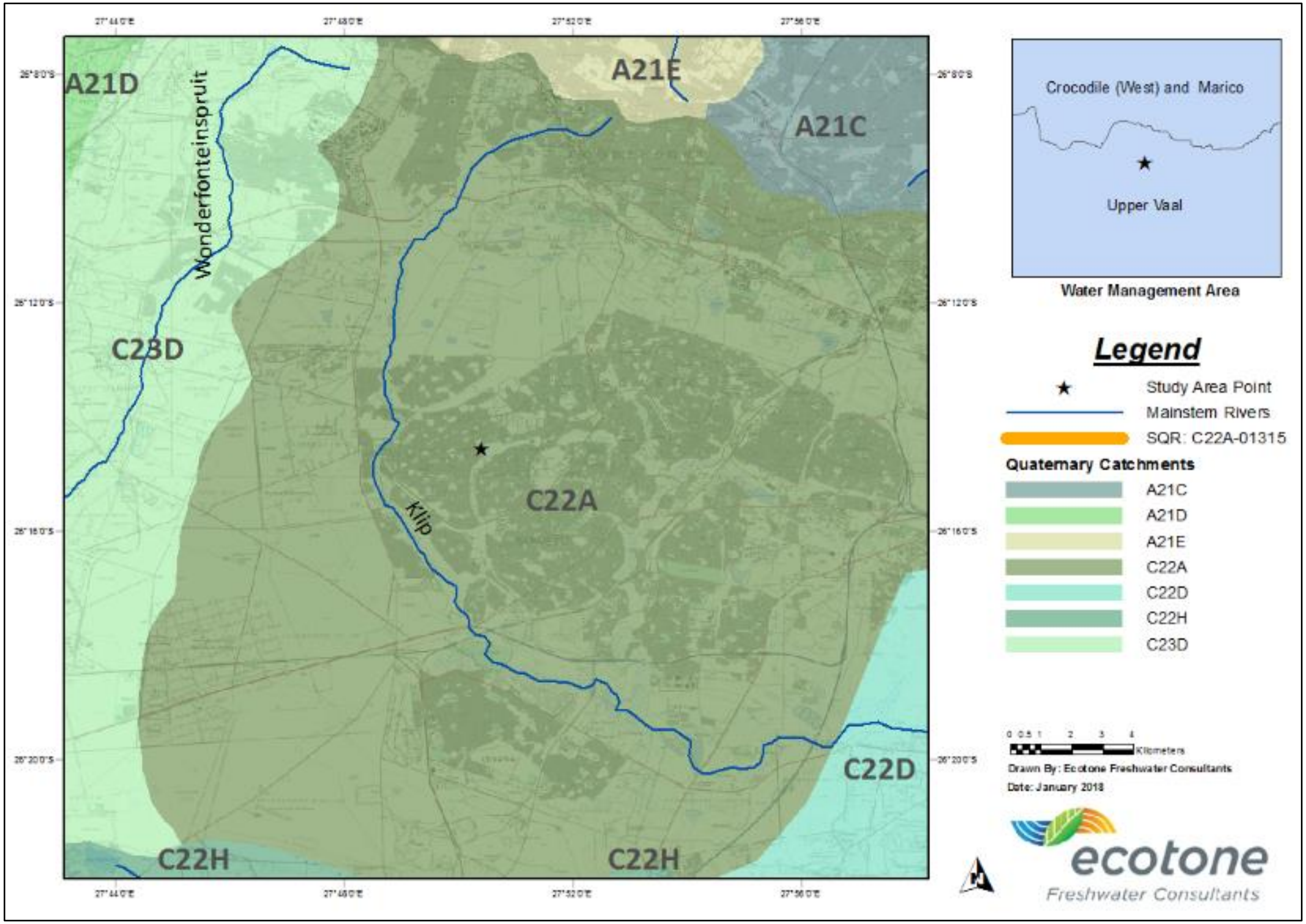

Figure 3-4: Map indicating the SQR and quaternary catchments associated with the study area. Data Source: Chief Directorate – Surveys and Mapping; DWAF, 1995; Nel *et al.*, 2004; DWS, 2014.

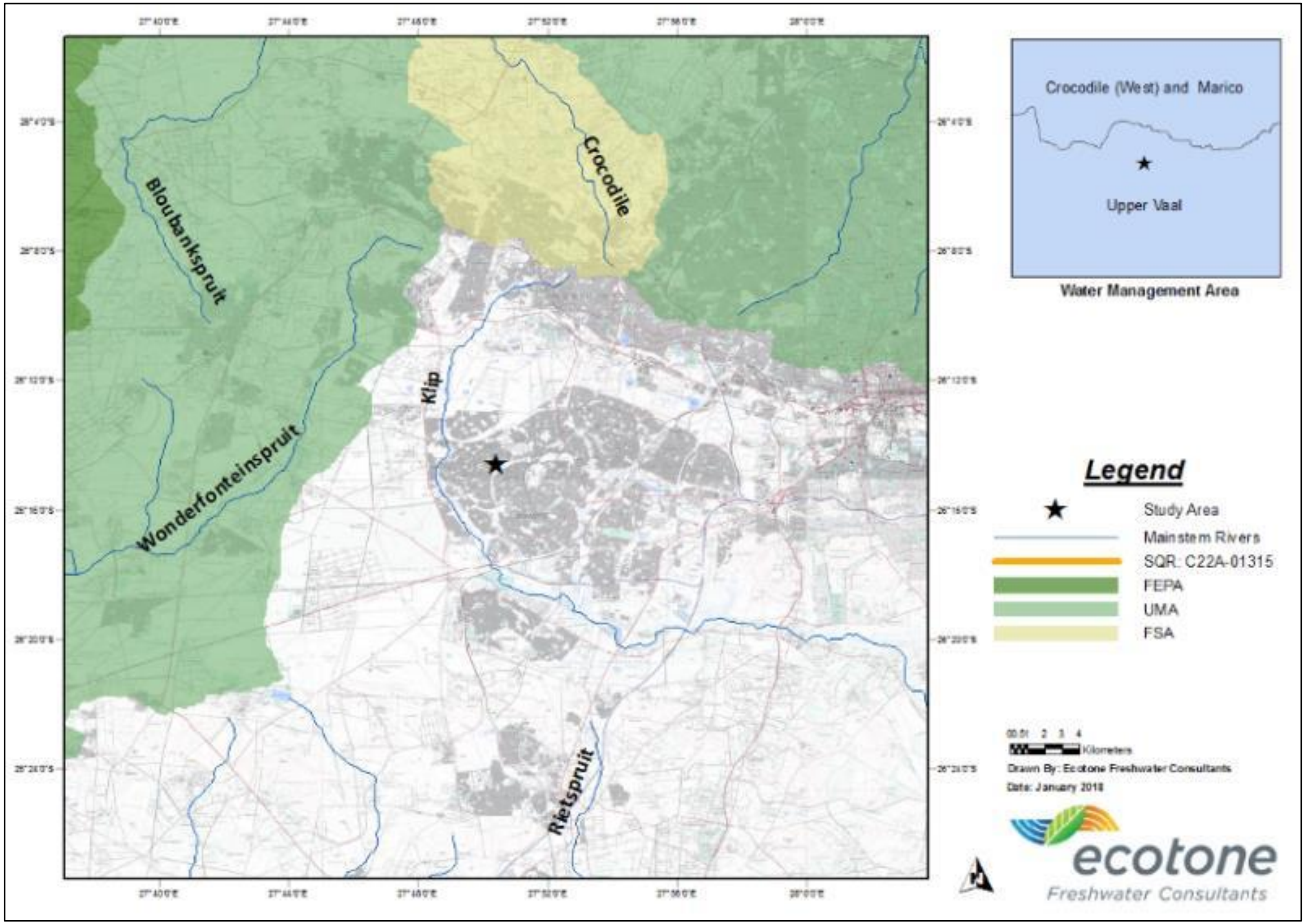

Figure 3-5: Map indicating the study area in relation to the River NFEPAs. Data Source: DWAF, 1995; Nel *et al*., 2004; Nel *et al.,* 2011, 1:50 000 maps - surveyor general.

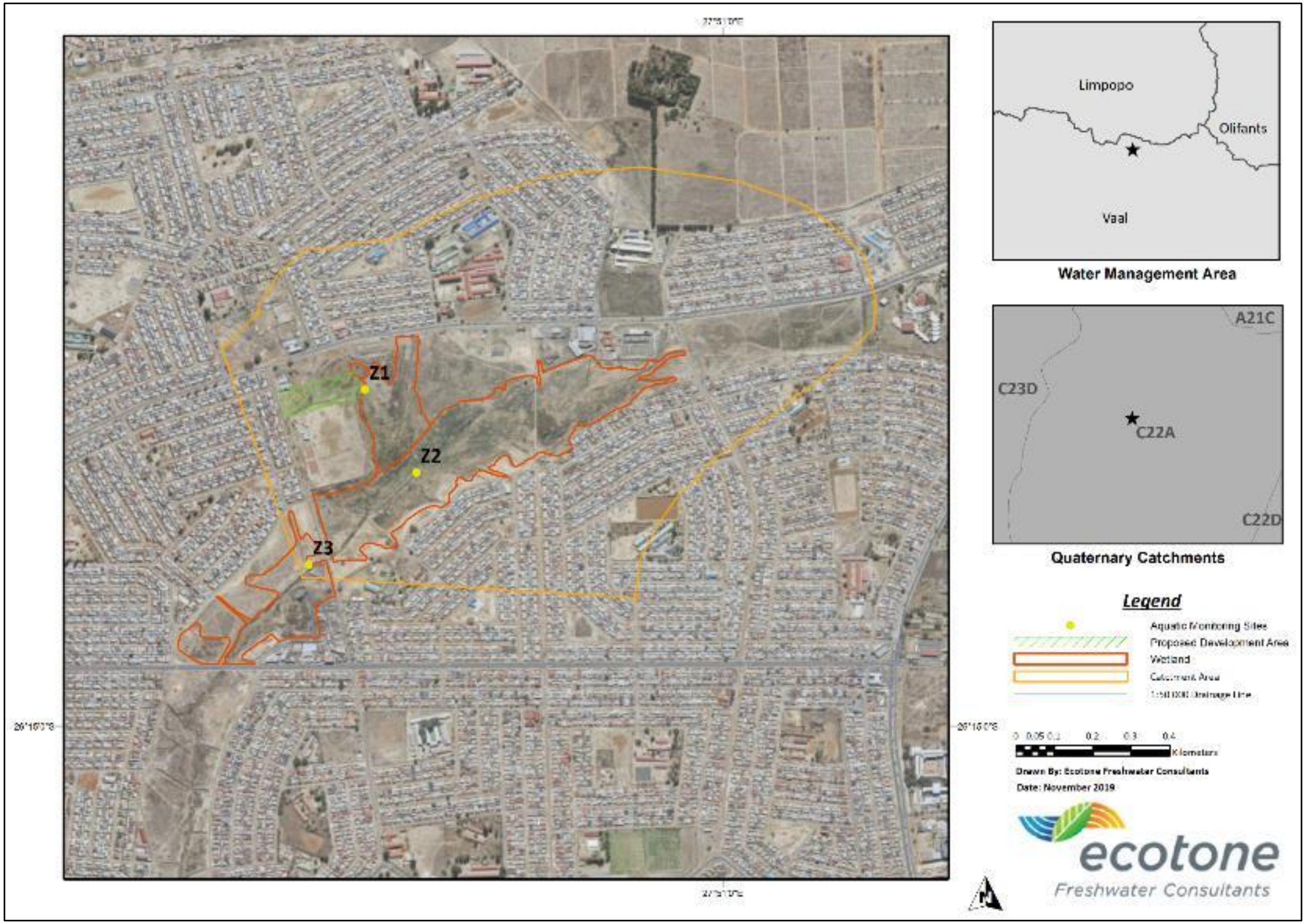

Figure 3-6: Map indicating the catchment area of the associated drainage lines.

3.3. Instream Aquatic Assessment

This section provides the results of the instream aquatic assessment. The instream assessment aims to describe the baseline conditions of drivers (water quality, flow and sediment) and responders (diatoms and aquatic macroinvertebrates). The results of the baseline assessment are useful in three ways:

- It provides a description of instream conditions prior to the onset of the proposed activities.
- It informs the sensitivity metric used to assess the risk associated with the implementation of the proposed activities.
- It provides a platform against which possible impacts resulting from the implementation of the proposed activities can be measured. For this reason, the baseline assessment was completed for three sites; site Z2 upstream and sites Z1 and Z3 downstream of the proposed public transport facility.

3.3.1. Monitoring Sites Description

The study area is characterised as a valley bottom system with shallow water and no distinct riparian zone. Site Z1 is situated adjacent to the proposed development, at the source of a drainage line that flows through a wetland area to another drainage line where sites Z2 and Z3 are located (**Figure 2-1**). Evidence of litter and dumping was evident at all three sites during both assessments, as well as run-off from the surrounding urban area (**Figure 3-7**, **Figure 3-8** and **Figure 3-9**). Site Z3 also had sewage leaking into the system.

Figure 3-7: Sites photographs taken at site Z1, October 2017, October 2019 and January 2022.

Figure 3-8: Sites photographs taken at site Z2, October 2017, October 2019 and January 2022.

Figure 3-9: Sites photographs taken at site Z3, October 2017, October 2019 and January 2022.

3.3.2. Index of Habitat Integrity

The IHI assessment was applied to ascertain the change in both instream and riparian habitat from natural conditions (Kleynhans, 1996). The results indicate that sites Z1 and Z2 are both in a *Largely Modified* state, with large losses to the natural habitat, biota and basic ecosystem functioning (**Table 3-5**). Site Z3 is in a *Seriously Modified* state, where the loss to natural habitat, biota and basic ecosystem functioning is more extensive.

Table 3-5: Results for the IHI for sites assessed

	Z1	**Z2**	**Z3**
Instream habitat integrity %	53	50	40
Instream habitat integrity Class	D	D	D
Riparian habitat integrity %	48	50	38
Riparian habitat integrity Class	D	D	E
Overall IHI%	50.40	49.80	38.70
Overall IHI category	**D**	**D**	**E**

3.3.3. *In situ* Water Quality

The spatial variation in water quality between the three monitoring sites are provided in **Table 3-6.** In general, the water quality reflected circumneutral pH levels with low salt loads during the October 2017 assessment which were all within threshold criteria for freshwater aquatic ecosystems (see **Table 2-6**). The results for the October 2019 assessment, showed that the pH for the Z2 site was within the *Unacceptable* range for aquatic ecosystems and the salt loads for both the Z2 and Z3 sites were within the *Tolerable* range (**Table 2-6).** No notable difference was measured for pH and salt loads between the upstream (Z2) and downstream (Z3) monitoring points during the October 2017 assessment but the results for the October 2019 assessment indicated upstream catchment related activities impacting on the pH and salt loads of the Z2 site and the salt loads of the Z3 site. The results from the January 2022 assessment indicated a similar trend with better water quality in the upper reaches (Z1), and increased salt loads in the lower reaches at site Z2 and Z3. This impact is most likely associated with sewage spill observed within the direct catchment.

Table 3-6: *In situ* water quality variables for sites Z1, Z2 and Z3 measured during the October 2017, October 2019 and January 2022 field assessments

Parameter	Unit	Z1			Z2			Z3		
		Oct '17	Oct '19	Jan '22	Oct '17	Oct '19	Jan '22	Oct '17	Oct '19	Jan '22
pH	[H^1+ ions]	7.31	7.14	6.65	7.04	9.16	6.76	6.71	7.95	8.30
EC	µS-cm^{-1}	237	187	423	228	846	592	236	590	755
TDS	ppm	125	90.2	221	123	420	298	128	295	379
Temperature	°C	22.31	21.7	21.8	20.97	22.9	20.9	21.1	20.6	20.5

(blue)	Ideal
(green)	Acceptable
(orange)	Tolerable
(red)	Unacceptable

3.3.4. Diatom Assessment

The diatom assessment is divided into two sub-sections: (i) Discusses the ecological classification of water quality for each site according to the diatom assemblage during this assessment. (ii) Provides the diatom species and abundance list for each site, and discusses the dominant species and their ecological preference at each site. This allows spatial variation analyses of ecological water quality between sites to be performed.

Ecological Classification

The ecological classification for water quality according to Van Dam *et al*. (1994) and Taylor *et al*. (2007) is recorded in (**Table 3-7**). The diatom assemblages mainly comprised of species with a preference for fresh brackish (<500 µS/cm), circumneutral (pH 7) to alkaline (pH >7) waters and eutrophic conditions. Site, Z1 comprised of diatom species that were N-autotrophic tolerant, indicating a tolerance of elevated concentrations of organically bound nitrogen. Whereas, sites Z2 and Z3 comprised of diatom species that were N-heterotrophic facultative and N-heterotrophic obligatory, indicating a requirement of periodically and continuously elevated concentrations of organically bound nitrogen, respectively. The oxygen saturation requirements ranged from low (>30%) to moderate (>50%) for all the sites. The pollution levels at all sites indicated that there was some form of pollution at all the sites (α-meso-polysaprobic).

Table 3-7: Ecological descriptors for the Zola sites based on the diatom community (Van Dam *et al.*, 1994)

Sites	pH	Salinity	Nitrogen uptake	Oxygen requirements	Saprobity	Trophic state
Z1	Alkaline	Fresh-brackish	N-autotrophic tolerant	Moderate	α-meso-polysaprobic	Eutrophic
Z2	Circumneutral	Fresh-brackish	N-heterotrophic facultative	Low	α-meso-polysaprobic	Eutrophic
Z3	Alkaline	Fresh-brackish	N-heterotrophic obligatory	Low	α-meso-polysaprobic	Eutrophic

Spatial Analysis

A total of 34 diatom species were recorded at the Zola sites (**Table 3-8**). The dominant diatom species recorded at all sites, included *Nitzschia sp., Planothidium frequentissimum* and *Gomphonema parvulum*. The dominant *Nitzschia sp.* is commonly found in α-mesosaprobic to polysaprobic freshwater habitats, and in untreated wastewater. *Planothidium frequentissimum* has a wide ecological amplitude but is absent from acidic habitats. *Gomphonema parvulum* is commonly found in oligosaprobic and mesosaprobic freshwaters.

Additional information is provided for the sub-dominant species in order to make ecological inferences for the three sites assessed (Taylor et al., 2007, Cantonati *et al*., 2017):

- **Z1:** It is important to know that some species, like *Nitzschia sp.,* and *Achnanthidium sp.* have wide ecological amplitudes, and can occur in both clean and polluted water. Thus, these species need to be analysed in conjunction with subdominant species in order to understand how the diatom community is responding to the water quality at this site. *Nitzschia sp.* are usually tolerant of α-mesosaprobic to polysaprobic freshwater habitats. The subdominance of *N. amphibia* pointed to alkaline freshwater with medium to high electrolyte content and this taxon can tolerate conditions up to α-mesosaprobic zone. The diatom assemblage at this site pointed to alkaline freshwater with moderate to high electrolyte content, with species that are tolerant to polluted conditions. The %PTV score was low indicating that there was very little impact associated with organic pollution at this site. This site serves as the source of the river and thus there was relatively low nutrient associated impacts; however, the overall water quality was considered *Poor* (**Table 3-9**).

- **Z2:** The dominance of *G. parvulum* pointed to oligosaprobic and mesosaprobic freshwaters. The subdominance of *N. palea* and *Nitzschia sp*. pointed to α-mesosaprobic to polysaprobic freshwater with high electrolyte content and are tolerant to strongly polluted conditions. *N. palea* in particular is commonly found in untreated wastewater and in habitats that are strongly impacted by industrial sewerage. The presence of *Craticula molestiformis* suggested eutrophic to polytrophic conditions and can tolerate high levels of organic pollution, thriving up to the polysaprobic zone. The diatom species at this site in conjunction with the high %PTV score suggests that this site was impacted by either some form of organic pollution or industrial wastewater entering the system from the surrounding catchment and the overall water quality was *Poor* (**Table 3-9**)**.**
- **Z3:** The dominant species at this site, *P. frequentissimum,* has a wide ecological amplitude but is usually absent from acidic habitats. The subdominance of *C. minusculoides* pointed to eu- to polytrophic, electrolyte-rich to salinized waters. This taxon is usually absent from running waters with good ecological water quality. The presence of *G. parvulum* pointed to mesosaprobic freshwaters. The presence of *N. palea* and *Nitzschia sp*. pointed to eutrophic freshwater, high electrolyte content and both species are tolerant to strongly polluted conditions. The diatom community at this site indicated eutrophic freshwaters and according to the relatively high %PTV score there appears to be impacts associated with organic pollution or untreated wastewater and the overall water quality was considered *Poor* (**Table 3-9**).

Table 3-8: Species and their abundances for the Zola sites, October 2019

Taxa	**Z1**	**Z2**	**Z3**
Achnanthidium exiguum (Grunow) Czarnecki	31	3	10
Achnanthidium sp.	34	0	12
Amphora veneta Kützing	18	0	0
Cavinula lapidosa (Krasske) Lange-Bertalot	0	3	0
Cavinula variostriata (Krasske) Mann & Stickle	0	0	2
Craticula accomodiformis Lange-Bertalot	0	0	3
Craticula buderi (Hustedt) Lange-Bertalot	0	5	16
Craticula minusculoides (Hustedt) Lange-Bertalot	0	0	62
Craticula molestiformis (Hustedt) Lange-Bertalot	11	36	0
Cymbella turgidula Grunow	0	0	4
Diploneis elliptica (Kützing) Cleve	4	0	0

Taxa	**Z1**	**Z2**	**Z3**
Eolimna subminuscula (Manguin) Moser Lange-Bertalot & Metzeltin	0	4	0
Gomphonema minutum(Ag.) Agardh f. minutum	0	0	12
Gomphonema parvulum (Kützing)	0	84	47
Gomphonema species	0	0	4
Hippodonta capitata (Ehr.) Lange-Bert.Metzeltin & Witkowski	0	0	3
Navicula cryptocephala Kützing	0	3	0
Navicula radiosa Kützing	0	6	0
Navicula rostellata Kützing	15	3	3
Nitzschia species	13	23	20
Nitzschia amphibia Grunow f.*amphibia*	38	3	8
Nitzschia palea (Kützing) W.Smith	3	70	28
Nitzschia sp.1	126	33	28
Pinnularia schoenfelderi Krammer	0	3	0
Pinnularia gibba Ehrenberg	0	7	0
Planothidium frequentissimum(Lange-Bertalot) Lange-Bertalot	25	36	70
Planothidium lanceolatum(Brebisson ex Kützing) Lange-Bertalot	2	0	0
Planothidium rostratum (Oestrup) Lange-Bertalot	3	0	0
Platessa hustedtii (Krasske) Lange-Bertalot	3	0	0
Psammothidium acidoclinatum (Lange-Bertalot) Lange-Bertalot	0	4	0
Psammothidium rossii (Hustedt) Bukhtiyarova et Round	5	0	0
PSAMMOTHIDIUM Bukhtiyarova & Round	0	0	2
Sellaphora species	13	14	13
Sellaphora pupula (Kützing) Mereschkowksy	6	10	3
Total	350	350	350
Nutrients			
Salinity			
Dominance			

Table 3-9: Diatom index scores for the study area indicating the ecological water quality

Sites	**%PTV**	**SPI**	**BDI**	**Ecological Water Quality**
Z1	4.6	6.9	9.8	**Poor**
Z2	51.7	5.3	7.4	**Poor**
Z3	27.1	6.9	10.1	**Poor**

3.3.5. Aquatic Macroinvertebrates Assessment

The habitat assessment indicated that all three sites provided *Poor* habitat availability for invertebrate colonisation during both assessments (**Table 3-10**). The Z3 site obtained the highest habitat score during the October 2017 assessment when the stones in current habitat was compared to the other two sites. A general decline in the habitat was noted for all the sites during the October 2019 assessment compared to the results of the October 2017 assessment. These results are important for the interpretation of the invertebrate community assemblage assessment.

Table 3-10: The IHAS scores for sites Z1, Z2 and Z3 during the October 2017 and October 2019 assessments

Habitat Type	Z1		Z2		Z3	
	Oct '17	Oct '19	Oct '17	Oct '19	Oct '17	Oct '19
Stones in current	7	0	0	0	12	0
Vegetation	15	13	16	12	16	9
Other habitat	14	10	12	9	13	13
Total IHAS %	**48%**	**30.67%**	**37.33%**	**28%**	**54.67%**	**29.33%**
Class	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**

The taxa that were sampled during both macroinvertebrate assessments at sites Z1, Z2 and Z3 are reflected in **Table 3-11**. During the October 2017 assessment, the same number of taxa were sampled at the Z1 downslope and Z2 upstream sites, with similar Average Score Per Taxa (ASPT) results. Two more taxa were sampled in the Z3 downstream site when compared to the Z2 upstream site, resulting in a higher ASPT for this site. This could be due to the more abundant stones in current habitat at this site when compared to the other two sites (**Table 3-10**). During the October 2019 assessment, the same number of taxa were sampled at the Z1 and Z3 downstream sites, with similar ASPT results. The least number of taxa were sampled at the Z2 upstream site resulting in the lowest ASPT score. This could be due to the poor habitat (**Table 3-10**) and water quality (**Table 3-6)** at this site. Temporally, the results for the Z1 site improved from the October 2017 to October 2019 assessments whereas the results for the Z2 site deteriorated. Although more taxa were sampled during the 2019 assessment at the Z3 site, the ASPT was lower compared to the 2017 results as the sensitivity of the taxa sampled was lower. During both assessments, all three sites had poor habitat diversity and quality resulting in very low ASPT scores, which is supported by the hardy, adaptable and highly pollution tolerant taxa present at all the sites.

Table 3-11: Invertebrate abundances for sites assessed during the October 2017 and October 2019 assessments (A = 2-10 individuals, B = 10-100 individuals, ASPT = Average Score per Taxa, and * = air breathers)

Taxa	Sensitivity	Z1		Z2		Z3	
		Oct '17	Oct '19	Oct '17	Oct '19	Oct '17	Oct '19
Baetidae 1 sp	**4**					1	
Ceratopogonidae	**5**					1	1
Chironomidae	**2**	B	B	B	B	B	B
Corixidae*	**3**		A				A
Culicidae*	**1**	A	A	B	A	A	A
Dytiscidae*	**5**		A	A		A	A
Hirudinea	**3**	A	A	A	A	B	B
Notonectidae*	**3**		A				
Oligochaeta	**1**	1	A	A	A		A
Physidae*	**3**	A		A	1	1	A
Potamonautidae*	**3**	A	1			A	1
SASS		13	24	15	10	26	26
Number of Taxa		6	9	6	5	8	9
ASPT		**2.17**	**2.67**	**2.5**	**2.0**	**3.25**	**2.89**
(pink)	Highly tolerant to pollution						
(green)	Moderately tolerant to pollution						
(blue)	Very Low Tolerance to pollution						

4. Impact Evaluation

The proposed project involves the construction of a public transport facility, Zola, Soweto (**Figure 4-2**). The extent of the proposed footprint in relation to the study sites and wetlands is illustrated in **Figure 2-1**, with the original alternative illustrated in **Figure 4-1** and the new preferred alternative illustrated in **Figure 4-2**. The original proposed footprint crosses the wetland buffer zone and encroaches on the wetland itself, although most of the footprint within these areas is allocated to be grass area and an attenuation facility (**Figure 4-1**). The Details regarding the impact assessment are provided for construction (**Table 4-1**; **Table 4-2**) and operation (**Table 4-3**; **Table 4-4**) in the following section.

4.1. Construction Phase

The impact assessment for the construction phase (**Table 4-1; Table 4-2**) indicates that the main impacts, prior to mitigation, are those related to surface water quality and erosion and sedimentation. The baseline assessment indicates that the water quality is considered to be in a *Poor* state based on the diatom community assemblage (refer to Section 3.3.4) with an aquatic community assemblage characterised by low diversity, consisting of only a few taxa that are highly tolerant to pollution (refer to **Section 3.3.5**). Erosion due to the removal of vegetation and the resulting increased sedimentation may impact on the already *Largely* to *Seriously* modified state of the habitat integrity of the drainage lines (refer to **Section 3.3.2**). The significance of the potential impacts to water quality and erosion and sedimentation is medium but with mitigation measures the significance is *Low* for both alternatives (**Table 4-1; Table 4-2**). The impacts to hydrology and increases in alien/pioneer vegetation are low without mitigation as the site has already been impacted on by current activities and remains *Low* with mitigation measures for both alternatives (**Table 4-1; Table 4-2**). However, the impact scores were slightly lower for the new preferred alternative (**Table 4-2**), mainly due to the infrastructure falling outside the wetland buffer zone.

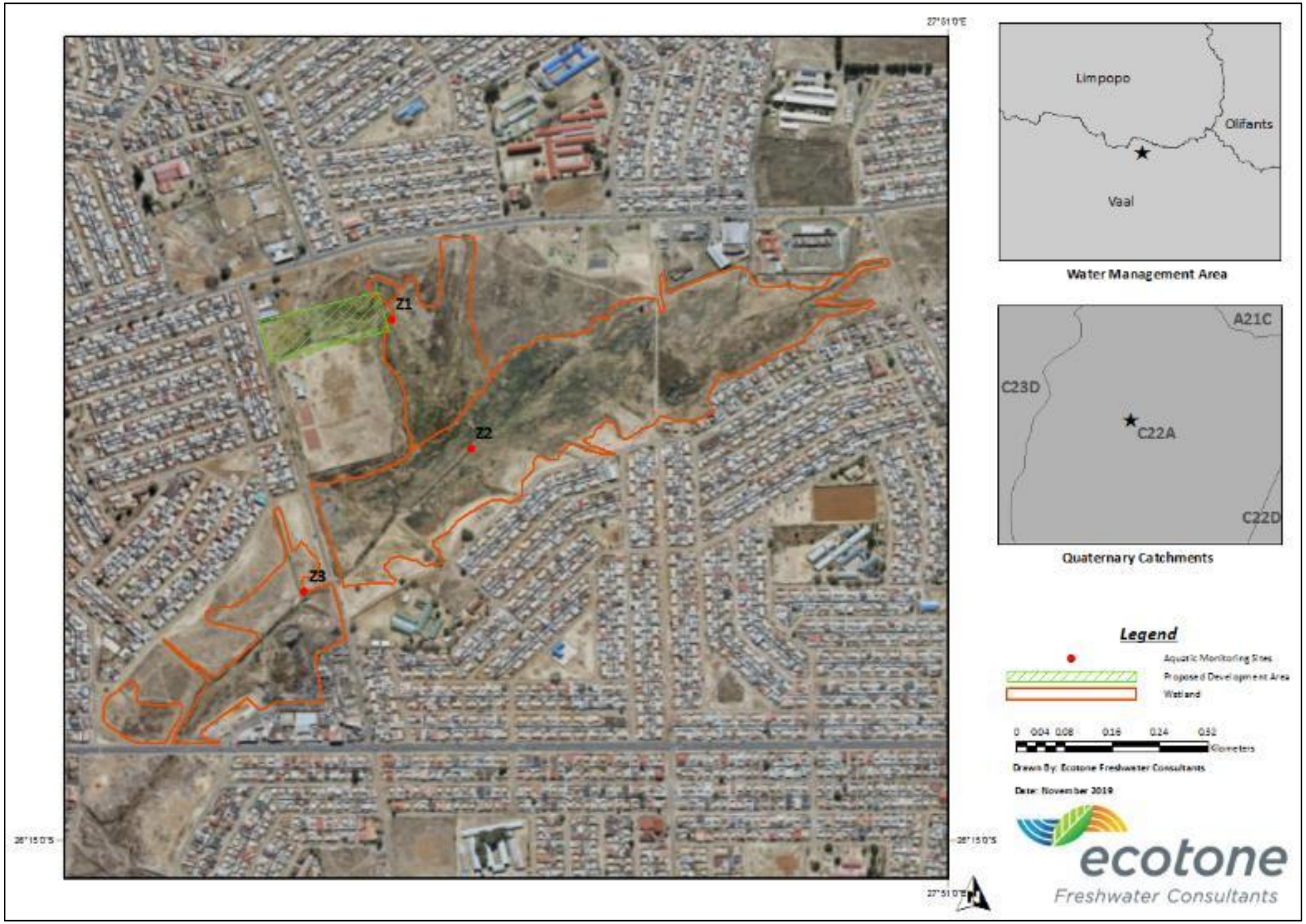

Figure 4-1: Map indicating the location of the proposed public transport facility in relation to the wetlands within the study area.

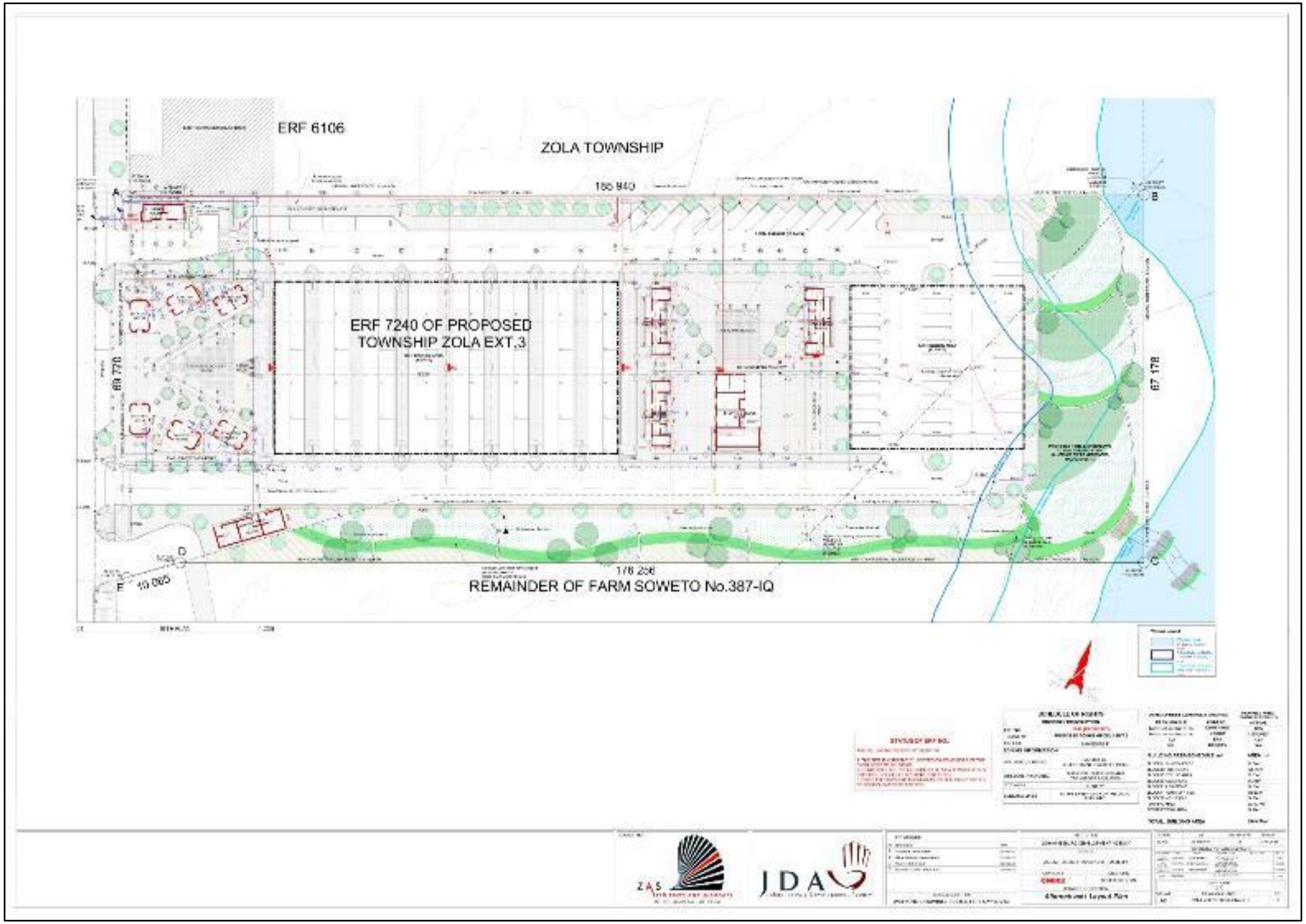

Figure 4-2: Public transport facility, Zola, site development layout plan for alternative#1 layout proposal (not preferred) in relation to the wetlands.

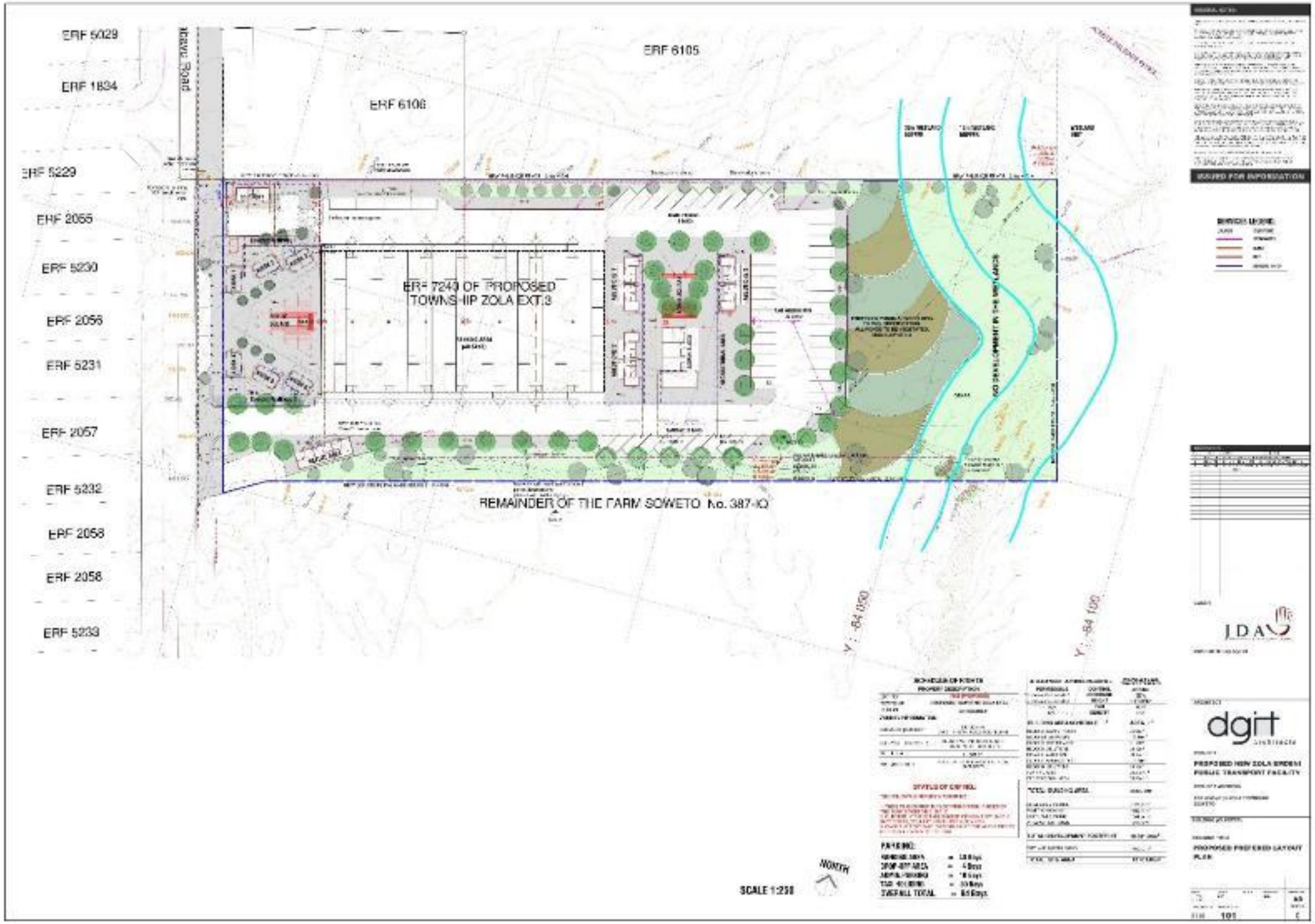

Figure 4-3: Public transport facility, Zola, site development layout plan for the new preferred layout proposal in relation to the wetlands.

Table 4-1: Construction phase impact assessment for the original alternative

Construction Phase – Alternative#1 Layout Proposal (not preferred):								
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Confidence**
(1) Impacts on hydrology	Nature of impact:	Construction activity will involve some vegetation clearing and topsoil removal in the area adjacent to the drainage line (site Z1) which will result in the alteration of the surface runoff characteristics, which in turn will affect the hydrology of the downslope area. The development area already has a compacted soil surface, so the impact on the hydrology during the construction phase will be low.						
	Without Mitigation	3	2	4	3	**27**	**Low**	3
	With Mitigation	2	1	2	2	**10**	**Low**	3
(2) Impacts on surface water quality	Nature of impact:	During the construction phase water quality deterioration will result because of increased sediment loads within the drainage lines and through pollutants derived from spillage, leakage and incorrect disposal of hazardous substances on site. Incorrect waste management and disposal is also likely to contribute further to water quality deterioration.						
	Without Mitigation	4	2	6	4	**48**	**Medium**	3
	With Mitigation	1	1	4	3	**18**	**Low**	3
(3) Impacts related to erosion and sedimentation	Nature of impact:	Disturbance of vegetation and soil during construction will pose the risk of erosion. Eroded soils are likely to increase sedimentation which will lead to changes in vegetation composition and aquatic fauna. Erosion is likely to be highest during the summer months due to increased precipitation.						
	Without Mitigation	3	2	6	5	**55**	**Medium**	3
	With Mitigation	2	2	2	5	**30**	**Low**	3
(4) Impact related to increase alien/pioneer vegetation in disturbed areas	Nature of impact:	Disturbed areas may temporarily provide the opportunity for alien and invasive species to establish. The area is already impacted on by alien vegetation so the further impact due to the construction of the transport facility is considered low.						
	Without Mitigation	2	2	4	2	**16**	**Low**	3
	With Mitigation	2	1	2	1	**5**	**Low**	3

Table 4-2: Construction phase impact assessment for the new preferred alternative

Construction Phase – Preferred Layout Proposal.								
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Confidence**
(1) Impacts on hydrology	Nature of impact:	Construction activity will involve some vegetation clearing and topsoil removal in the area adjacent to the drainage line (site Z1) which will result in the alteration of the surface runoff characteristics, which in turn will affect the hydrology of the downslope area. The development area already has a compacted soil surface, so the impact on the hydrology during the construction phase will be low.						
	Without Mitigation	3	2	4	3	**27**	**Low**	3
	With Mitigation	2	1	2	2	**10**	**Low**	3
(2) Impacts on surface water quality	Nature of impact:	During the construction phase water quality deterioration will result because of increased sediment loads within the drainage lines and through pollutants derived from spillage, leakage and incorrect disposal of hazardous substances on site. Incorrect waste management and disposal is also likely to contribute further to water quality deterioration.						
	Without Mitigation	4	2	6	3	**36**	**Medium**	3
	With Mitigation	1	1	4	2	**12**	**Low**	3
(3) Impacts related to erosion and sedimentation	Nature of impact:	Disturbance of vegetation and soil during construction will pose the risk of erosion. Eroded soils are likely to increase sedimentation which will lead to changes in vegetation composition and aquatic fauna. Erosion is likely to be highest during the summer months due to increased precipitation.						
	Without Mitigation	3	2	6	4	**44**	**Medium**	3
	With Mitigation	2	2	2	3	**18**	**Low**	3
(4) Impact related to increase alien/pioneer vegetation in disturbed areas	Nature of impact:	Disturbed areas may temporarily provide the opportunity for alien and invasive species to establish. The area is already impacted on by alien vegetation so the further impact due to the construction of the transport facility is considered low.						
	Without Mitigation	2	2	4	2	**16**	**Low**	3
	With Mitigation	2	1	2	1	**5**	**Low**	3

4.2. Operational Phase

The impact to the surface water quality, hydrology and those related to erosion and sedimentation during the operational phase are medium, mainly due to stormwater runoff (**Table 4-3**; **Table 4-4**). With the implementation of mitigation measures, these impacts can all be of *Low* significance for both alternatives. The increase of alien/pioneer vegetation will be low before and after mitigation during the operational phase as the site already has a high abundance of alien and invasive species. As with the construction phase impacts, the impact scores were slightly lower for the new preferred alternative (**Table 4-4**).

Table 4-3: Operational phase impact assessment for the alternative#1 layout proposal (not preferred).

Operational Phase								
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Confidence**
(1) Impacts on hydrology	Nature of impact:	The impermeable surface of the transport facility and additional impacts to surface runoff rates may impact on the hydrology of the receiving aquatic system during the operational phase.						
	Without Mitigation	2	5	6	4	**52**	**Medium**	3
	With Mitigation	1	3	2	3	**18**	**Low**	3
(2) Impacts on surface water quality	Nature of impact:	Storm water runoff may be polluted with hydrocarbons and other hazardous substances from parking areas and impermeably surface. This may result in a decrease in water quality within the receiving watercourses.						
	Without Mitigation	2	5	4	4	**44**	**Medium**	3
	With Mitigation	1	1	2	3	**12**	**Low**	3
(3) Impacts related to erosion and sedimentation	Nature of impact:	Inappropriate storm water releases may lead to erosion and downstream sedimentation.						
	Without Mitigation	2	5	6	4	**52**	**Medium**	3
	With Mitigation	2	2	2	3	**18**	**Low**	3
(4) Impact related to increase alien/pioneer vegetation in disturbed areas	Nature of impact:	Under baseline conditions the drainage lines have high cover and abundance of alien and invasive species. It is possible that disturbed areas can provide a longer-term source of encroachment if not managed.						
	Without Mitigation	2	3	2	4	**28**	**Low**	3
	With Mitigation	1	2	2	3	**15**	**Low**	3

Table 4-4: Operational phase impact assessment for the preferred layout proposal.

Operational Phase								
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Confidence**
(1) Impacts on hydrology	Nature of impact:	The impermeable surface of the transport facility and additional impacts to surface runoff rates may impact on the hydrology of the receiving aquatic system during the operational phase.						
	Without Mitigation	2	5	6	4	**52**	**Medium**	3
	With Mitigation	1	2	2	2	**18**	**Low**	3
(2) Impacts on surface water quality	Nature of impact:	Storm water runoff may be polluted with hydrocarbons and other hazardous substances from parking areas and impermeably surface. This may result in a decrease in water quality within the receiving watercourses.						
	Without Mitigation	2	5	4	4	**44**	**Medium**	3
	With Mitigation	1	1	2	2	**8**	**Low**	3
(3) Impacts related to erosion and sedimentation	Nature of impact:	Inappropriate storm water releases may lead to erosion and downstream sedimentation.						
	Without Mitigation	2	5	6	4	**52**	**Medium**	3
	With Mitigation	2	2	2	3	**18**	**Low**	3
(4) Impact related to increase alien/pioneer vegetation within the wetland	Nature of impact:	Under baseline conditions the drainage lines have high cover and abundance of alien and invasive species. It is possible that disturbed areas can provide a longer-term source of encroachment if not managed.						
	Without Mitigation	2	3	2	4	**28**	**Low**	3
	With Mitigation	1	2	2	2	**10**	**Low**	3

4.3. Cumulative Impacts

The receiving aquatic system that will be affected by the construction is small in extent with no ecologically sensitive features present. The system is part of a catchment that is under cumulative stress due to extensive catchment alteration, resulting in habitat destruction and fragmentation. It is unlikely that the proposed expansion will contribute notably to additional loss of ecological integrity of the system.

5. Management Plan

The proposed development of the transport facility, Zola, may result in some construction and operational impacts occurring (see **Section 4**). This section provides a management plan with mitigation measures for the impacts identified in **Section 4**. This mitigation is applicable to both layout plans

5.1. Construction

5.1.1. Changes in Hydrology During Construction

Objectives	Avoid, minimise and/or mitigate, as far as is practicable, the potential impacts on hydrology, during the construction phase.
Performance Criteria	• Visual assessment of changes to the hydrological continuity in the study area.
Mitigation Measures	• Limit the extent of vegetation clearing and site preparations to the authorised footprint. • Limit the extent and movement of heavy machinery to the authorised footprint only. • Avoid in channel construction activity and any flow diversions. • No water abstraction or discharge of any water should occur into the drainage line during the construction phase.
Monitoring and Auditing	• Weekly visual comparison of approximate flow rate at the three sites associated with the construction activity.
Reporting	• Incidence reports on periods where flow requirements are not met.

5.1.2. Changes in Water Quality During Construction

Objectives	Avoid and minimise water quality related impacts on the drainage lines due to construction activity.
Performance Criteria	• Complying with water quality thresholds as set out within **Section 6** of this report as well as any set out in the WUL.
Mitigation Measures	• Accidental spillage should be prevented always. This will require suitable chemical storage and refuelling practices. • Accidental spills or any contaminated water should be isolated and treated as soon as possible. An emergency spill procedure should be drafted, and the construction team should be versed in identifying and responding to accidental spill events. • Changing of oil, refuelling and lubricating of equipment should not be carried out near the drainage lines to minimize the potential for water pollution. • If oil storage and workshop areas are needed on-site, they should be surrounded by a bund wall to contain spillages. In the case where soil becomes contaminated with oil, it must be removed for proper disposal or treatment.

	• No dumping of any building rubble, soil, litter, organic matter or chemical substances should occur within the drainage line. Dumping and temporary storage of the above should only occur at predetermined locations. • In the case of dewatering a construction site, water should be treated, and all suspended particles should be removed. Water removed from a construction site should not be released directly in the water course. Discharge should occur into a sump to aid settling of suspended particles or into a well vegetated area which will help trap sediment and residual contaminants. • Contaminated or potentially contaminated water or runoff should be managed in a controlled way. • Sediment and erosion control measures should be in place and maintained prior to, and during, construction activities. • *In situ* water quality should be monitored at all three sites associated with the construction activity.
Monitoring and Auditing	• *In situ* water quality (pH, electrical conductivity, temperature and turbidity) should be monitored weekly during construction activity. • Diatom and aquatic macroinvertebrate biomonitoring should be carried out at strategically selected sites applying methods used in this assessment after construction.
Reporting	• Weekly monitoring reports on *in situ* water quality variation between upslope and downslope sites should be compiled by the environmental officer. • *Ad hoc* aquatic assessment reports.

5.1.3. Changes in Erosion and Sedimentation During Construction

Objectives	Avoid and minimise erosion and sedimentation related impacts on the drainage lines due to construction activity.
Performance Criteria	• Measurement of active erosion surrogates (i.e. turbidity and or total suspended solids) at all three sites associated with the construction activity. • Effective implementation of erosion and sediment control measures.
Mitigation Measures	• Erosion and silt control mechanisms must be in place prior to the onset of construction activities. This includes the management of surface flow through the construction site. • It is recommended that construction activities should make use of the dry seasonal construction window. This will further reduce the risk associated with erosion/siltation. • Clearing of vegetation needs to be limited in order to limit erosion and should only take place immediately before construction commences. • Sumps or spoil berms need to be constructed to contain excavated spoil/topsoil so that sediment-laden runoff does not enter the drainage lines.
Monitoring and Auditing	• Daily inspections of erosion and sediment control features during construction. The inspection frequency can be adjusted based on the requirement for intervention, but should remain high during periods of higher rainfall (provided that construction during these periods is unavoidable). • Erosion control measures should be inspected regularly during the course of construction and the necessary repairs need to be carried out if any damage has occurred.

	• *In situ* turbidity monitoring, as discussed under water quality monitoring, should take place upstream and downstream of instream activity on a weekly basis. • Diatom and aquatic macroinvertebrate biomonitoring at strategically selected sites applying methods used in this assessment should be completed after construction.
Reporting	• Failure of erosion and sediment controls should be reported on. The reasons for the failure and the corrective action employed should be stated. • Any defects revealed by maintenance and inspection of erosion and sediment control structures should be rectified immediately, and these works are to be cleaned, repaired and augmented as required to ensure effective erosion and sedimentation control thereafter.

5.1.4. Alien and Invasive Species

Objective	Avoid and/or minimise the establishment of invasive alien flora on areas of soil exposed through construction activities.
Performance Criteria	• Assessing the presence and dynamics of invasive alien plant species.
Mitigation Measures	• A team of two or three labourers should be trained in the identification and control of key invasive alien species already in the area or highly likely to occur once construction is underway. • The team should be provided with the correct equipment (e.g. knapsack sprayers) and correct herbicides, which should be stored in a secure facility each day. • Regular monitoring of all areas of exposed soil should take place during Construction Phases.
Monitoring and Auditing	• Regular monitoring of the presence of invasive alien plant species should take place on areas of exposed soil during the Construction phase; areas being decommissioned during the Operational Phase (such as the construction camp) should also be monitored for invasive alien species.
Reporting	• A report on alien plant control measures during construction. • Alien plant should be controlled as soon as possible.

5.2. Operation

5.2.1. Changes in Hydrology During Operations

Objectives	Avoid, minimise and/or mitigate, as far as is practicable, additional hydrological changes due to storm water runoff during the operational phase.
Performance Criteria	• Visual flow observations of inflow and outflow.
Mitigation Measures	• The storm water system should be designed with sufficient attenuation capacity to compensate for the loss in permeable surfaces associated with the footprint of the development. This may be achieved through the incorporation of bio-swales or other ecological engineering structures.

	• The general design should aim to maximise permeability and water retention on site. This will include measures to increase the general surface roughness of paved areas and measures to effectively dissipate runoff energy.
Monitoring and Auditing	• Visual comparison of approximate flow rates upstream and downstream of construction activity for a set period after construction. • Biomonitoring (aquatic invertebrates and diatoms) for a single assessment after construction has been completed.
Reporting	• *Ad hoc* reporting in the comparison of flow upstream and downstream of the construction activity.

5.2.2. Changes in Water Quality During Operations

Objectives	Avoid and minimise water quality related impacts on aquatic ecosystem due to operational activity.
Performance Criteria	• Complying with water quality thresholds as set out in this report (**Section 6**) and any set out in the WUL. • Instream biological response metrics: a potential loss in the representation of aquatic macroinvertebrates and diatoms relatively sensitive to changes in water quality.
Mitigation Measures	• Runoff from the parking area should go through a litter, sediment and oil trap prior to release into the environment. • Use environmentally friendly solvents and paints during routine maintenance. This will aid in preventing water pollution during the operational phase.
Monitoring and Auditing	• During the aquatic assessment, water quality variables, should include: turbidity, pH and electrical conductivity.
Reporting	• The aquatic assessment should be compiled in line with the Monitoring plan (**Section 6**).

5.2.3. Changes in Erosion and Sedimentation During Operations

Objectives	Avoid and minimise erosion and sedimentation related impacts on the aquatic system due to operational activity.
Performance Criteria	• Measurement of active erosion surrogates (i.e. turbidity and or total suspended solids) within the receiving environment. • Visual assessment of erosion and sedimentation features along the drainage lines within the study area.
Mitigation Measures	• Design runoff control features to minimize soil erosion and avoid placement of infrastructure and sites on unstable slopes and consider conditions that can cause slope instability, such as groundwater aquifers, precipitation and slope angles. • Areas where storm water is released should be well armoured against erosion and regularly inspected for stability. • Areas exposed to a higher erosion risk include storm water releases. These areas should be protected against erosion and regularly inspected. • The storm water system should be designed with sediment trapping abilities, these should regularly be inspected and manually emptied.
Monitoring and Auditing	• Inspection needs to be carried out following construction activities to make sure that vegetation is re-established, and that erosion is not a point of concern, particularly with regard to unstable banks. • *In situ* turbidity monitoring, as discussed under water quality monitoring for the operational phase.
Reporting	• Failure of erosion and sediment controls should be reported on. The reasons for the failure and the corrective action employed should be stated. • Any defects revealed by maintenance and inspection of erosion and sediment control structures should be rectified immediately, and these works are to be cleaned, repaired and augmented as required to ensure effective erosion and sedimentation control thereafter. • Aquatic assessment report after construction must be completed.

5.2.1. Alien and Invasive Species

Objectives	Avoid and/or minimise the establishment of invasive alien flora on areas of soil effected by construction activities.
Performance Criteria	• Assessing the presence and dynamics of invasive alien plant species
Mitigation Measures	• The areas that have been decommissioned during the Operational Phase (such as the construction camp) should also be monitored for invasive alien species.
Monitoring and Auditing	• Inspection needs to be carried out following construction activities to make sure that all alien vegetation has been removed.
Reporting	• *Ad hoc* reporting on the removal of alien vegetation.

6. Biomonitoring Plan

Monitoring parameters, frequency, location data, data quality and adaptive actions are summarised in **Table 6-1**.

6.1. Monitoring parameters

The parameters selected for monitoring are *in situ* measurements: pH, electrical conductivity, turbidity and temperature. Visual assessments of the area are to be undertaken to ensure that the sediment and erosion control measures are still in place and working correctly and that there are no signs of erosion.

6.2. Monitoring frequency

The following monitoring frequencies are stipulated for:

- On site water quality measurements: weekly during construction.
- Aquatic assessment: once off assessment post construction. Should the results from the post construction assessment show a great deterioration in the aquatic environment when compared to the baseline results provided in this report, then further monitoring may be required.

6.3. Monitoring locations

The *in situ* water quality measurements should be monitored at the three sites (Z1, Z2 and Z3) but the visual assessment should include the larger study area.

6.4. Data quality

The monitoring program should apply to national approved methods for sampling (See **Section 3**). The *in situ* water quality monitoring can be undertaken by the Environmental Control Officer or under the supervision of a trained individual. The multi-parameter water quality meter should be tested for calibration prior to monitoring. Sampling and Analysis Quality Assurance/Quality Control (QA/QC) plans should be prepared and implemented. A multi-parameter water quality meter calibration certificate should be included in the monitoring reports.

Table 6-1: Monitoring parameters, locations, frequency, thresholds and adaptive actions

MONITORING TYPE AND PARAMETER	LOCATION/S	FREQUENCY AND DURATION	THRESHOLD VALUES	ADAPTIVE ACTION
Water quality (*in situ*)				
pH	• Downslope (Z1) S: -26.242116° E: 27.841608° • Control site (Z2) S: -26.244063° E: 27.842813° • Test site (Z3) S: -26.246222° E: 27.840289°	Weekly during construction.	Between 5-6.5 and 8.5-9	Increase monitoring frequency to once every 4 hours. If values persist for longer than 24 hours, identify cause and stop activity or treat with acid or base addition.
			Values <5 or >9	Stop activity immediately. Identify source and or treat with acid base addition.
Electrical Conductivity			10-15% increase in EC at test site relative to control site	Increase frequency of monitoring to daily. If values do not return to <10 % within 7 days, stop activity, identify source and treat by isolation and evaporation, crystallization or reverse osmosis.
			>16% increase in EC at test site relative to control site	Stop activity immediately, identify source and treat as above. Continue monitoring daily till difference between control and test site is < 10%.
Turbidity			10-15% increase compared to control site for < 24 hours	Increase monitoring frequency to hourly identify source of increased turbidity.
			>15% increase compared to control site for >24 hours	Identify source stop activity, mitigate with sedimentation basin or increase size of sump system.
Temperature			>2 ˚C from background average daily temperature or more than 10%, whichever is more conservative, for any period of time at any monitoring point.	Identify the reason for the temperature variation and treat with surface aeration and or flow equalization.
Aquatic Assessment				
Instream IHI	• Downslope (Z1) S: -26.242116° E: 27.841608°	Once off assessment post construction	Score should be >39.5	Identify driver of change in instream aquatic communities. Do not interoperate response metrics in isolation and make sure that measured variation may not be attributed to sampling effort, habitat variations or season.
Riparian IHI			Score should be >39.5	
Instream IHI	• Control site (Z2) S: -26.244063°		Score should be >39.5	
Riparian IHI			Score should be >39.5	

MONITORING TYPE AND PARAMETER	LOCATION/S	FREQUENCY AND DURATION	THRESHOLD VALUES	ADAPTIVE ACTION
	E: 27.842813°			Address the activity (and driver variable) that resulted in an instream response (i.e. change in water quality, flow or sediment regime). Should the results from the post construction assessment show a great deterioration in the aquatic environment when compared to the baseline results provided in this report, then further monitoring may be required.
Instream IHI	• Test site (Z3) S: -26.246222° E: 27.840289°		Score should be >39.5	
Riparian IHI			Score should be >19.0	
Diatom water quality	• Downslope (Z1) S: -26.242116° E: 27.841608°		Index scores >5	
Diatom water quality	• Control site (Z2) S: -26.244063° E: 27.842813°		Index scores >5	
Diatom water quality	• Test site (Z3) S: -26.246222° E: 27.840289°		Index scores >5	
Aquatic macroinvertebrates (ASPT)	• Downslope (Z1) S: -26.242116° E: 27.841608°		Should not vary >10% relative to baseline	
Aquatic macroinvertebrates (ASPT)	• Control site (Z2) S: -26.244063° E: 27.842813°		Should not vary >10% relative to control site	
Aquatic macroinvertebrates (ASPT)	• Test site (Z3) S: -26.246222° E: 27.840289°		Should not vary >10% relative to control site	

7. Conclusion

The study aimed to ascertain the baseline condition of the receiving environment associated with the proposed development of the transport facility, Zola, and to define risks that may result from the construction and operation of the proposed transport facility to surface water ecology.

The study area is characterised as a valley bottom system with shallow water and no distinct riparian zone. The riparian and instream habitat integrity of the sites are *Largely* to *Seriously* modified with the diatom assessment indicating poor water quality. No sensitive taxa were sampled during the aquatic macroinvertebrate assessment which indicates a polluted system with a loss of ecological integrity.

It is expected that the impact from of the proposed activity on the aquatic environment will be *Medium* to *Low* during construction and operation, but only with the implementation of appropriate mitigation measures, these impacts will all have *Low* significance for both alternatives. However, the impact scores were slightly lower for the new preferred alternative, mainly due to the infrastructure falling outside the wetland buffer zone.

8. References

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