GEORGE
TEL: +27 (0) 44 873 4923 **FAX:**+27 (0) 44 874 5953
EMAIL: info@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: 102 Merriman Street, George, 6530
PO BOX: 9087, George, 6530

CAPE TOWN
TEL: +27 (0) 21 554 5195 **FAX:**+27 (0) 86 575 2869
EMAIL: lauren@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: Unit 71, Eden on the Bay, 5 Beach Estate Boulevard
Blouberg, Big Bay, 7441
PO BOX: 443, Milnerton, 7435

FRESHWATER HABITAT IMPACT ASSESSMENT

FOR THE PROPOSED

Green Valley housing development and service infrastructure, Bitou Local Municipality

PREPARED FOR: Bitou Local Municipality
Private Bag X1002
Plettenberg Bay
6600

PREPARED BY: Sharples Environmental Services cc
Contact Person: Debbie Fordham
Email: debbie@sescc.net

DATE: 6 March 2020

DECLARATION OF INDEPENDENCE

Independent Specialist Consultant

I, Debbie Fordham, declare that I:

- Act as an independent specialist consultant, in this application, in the field of wetland and riparian ecology;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- Have, and will have, no vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014; and
- Will provide the competent authority with access to all the information at my disposal regarding the application, whether such information is favourable to the applicant or not.

The following report has been prepared:

- As per the requirements of Section 32 (3) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Environmental Impact Assessment Regulations 2014 as per Government Notice No. 38282 Government Gazette, 4th December 2014.
- In accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 - Environmental Impact Assessment 2014 Regulations and the National Environmental Management Act, 1998.
- With consideration to Cape Nature's standard requirements for biodiversity assessments.
- In accordance with DEA&DP's Guideline on Involving biodiversity specialists in the EIA process
- Independently of influence or prejudice by any parties.

AUTHOR

The author of this report is in agreeance with the 'Declaration of Independence'.

SPECIALIST	QUALIFICATIONS / AFFILIATIONS	DETAILS
DEBBIE FORDHAM	MSc - Environmental science (wetland science) BAH (Hons) - Environmental Science BA – Environmental Science & Geography	Debbie studied at Rhodes University completing a BA degree, majoring in Environmental Science and Geography. She then completed her Honours degree in Environmental Science in 2009. Debbie has a Master of Science degree on the origin, development and collapse of the Tierkloof Wetland, a peatland dominated by *Prionium serratum* in the Western Cape. She has specialised in aquatic habitat assessment and has conducted numerous aquatic habitat impact assessment reports.

INDEMNITY AND COPYRIGHT

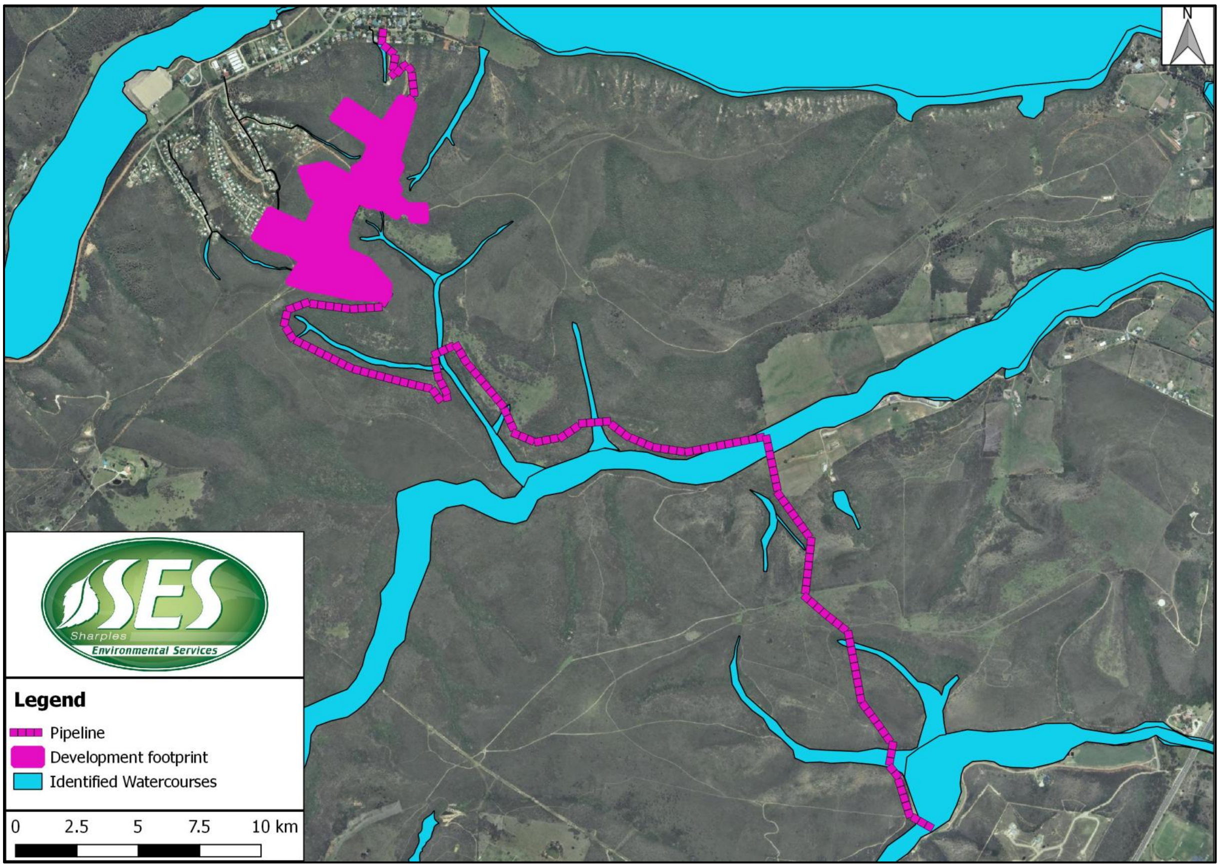
Report citation:
Sharples Environmental Services cc, 2020. Freshwater Habitat Impact Assessment: *The Proposed Green Valley Housing Development and associated service infrastructure, Bitou Local Municipality.*

EXECUTIVE SUMMARY

Sharples Environmental Services cc (SES) was appointed by Bitou Municipality to conduct an independent specialist freshwater habitat impact assessment for the proposed Green Valley Housing Development. Green Valley is an informal settlement on the outskirts of Wittedrift, near Plettenberg Bay, in the Bitou Local Municipality. The local municipality has acquired land on a ridge above Lemon Street in Green Valley known locally as Oppiekoppie. It is proposed to develop this ridge for dense residential housing and install a sewage pipeline to the Plettenberg Bay wastewater treatment works to the south.

The study area of the proposed project is located within the DWS Quaternary Catchment K60F and falls within the Gouritz Water Management Area. The tributaries of the study site feed the Bosfontein and Diep Rivers. It is situated in the Bitou River catchment that enters the Indian Ocean. The aquatic habitats within a 500 metre radius of the proposed project were identified and mapped on a desktop level utilising available data, following which, the infield site assessment (conducted on the 1st of March 2017) confirmed the location and extent of these systems.

It was determined that a number of non perennial streams and a perennial river will be impacted upon by the proposed pipeline crossings along the bulk sewerage pipeline route to the Wastewater Treatment Works. Additionally, a number of non perennial streams may be impacted by the housing development as they are located directly down slope on either side of the watershed where the development will be located. Refer to delineated map below. The tributaries situated on the north western side of the ridgeline, which flow into the Bosfontien River, are highly degraded by past and present land uses. There is little remaining riparian habitat within these dry channels and an almost complete loss of ecological functioning. In contrast, the integrity of the watercourses located to the south and east of the proposed site, and along the proposed pipeline, is largely intact. There are fewer impacts from catchment development and the streams have been subjected to less physical disturbance. The recommended management objective for all the assessed watercourses is to prevent any further degradation and maintain the health of the systems in their present ecological state.



The impact significance of the proposed development was determined for each potential impact of the project. The impacts associated with the project are assessed as being of Medium significance. However, this may potentially be decreased to Low impact significance with the implementation of effective mitigation measures. The impacts are considered to be easily mitigated provided the mitigation measures and monitoring plan within this report are implemented and adhered to during the construction and operational phase of the project.

From an aquatic perspective, there are no fatal flaws associated with the development provided recommendations are adhered to. However, due to increasing population pressures in the area it is recommended that a broad strategic plan is undertaken to reduce conflicts between the rapid urban development and water resource protection. This would allow for the identification and protection of sensitive aquatic habitat on a broader scale and aid future development planning.

The proposed development requires a Water Use License (WUL) in terms of Chapter 4 and Section 21 (c) and (i) of the National Water Act No. 36 of 1998 and is in the application process which must be finalised prior to the commencement of construction.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Sharples Environmental Services cc (SES) were appointed by Bitou Local Municipality to conduct an independent specialist freshwater habitat impact assessment to provide input into the Scoping and Environmental Impact Assessment process and water use authorisation requirements for the proposed Green Valley Housing Development.

1.1 Location and background

Green Valley is an informal settlement on the outskirts of the village of Wittedrift, near Plettenberg Bay, in the Bitou Local Municipality. Plettenberg Bay is a coastal town of the Western Cape; roughly mid-way between Cape Town and Port Elizabeth (Figure 1). The land use in the area is predominately agricultural (Figure 2) with cultivation occurring in the valleys while the hillslopes support low density livestock grazing.

Figure 1: A satellite image indicating the location of the study area relative to Cape Town, George and Port Elizabeth, South Africa

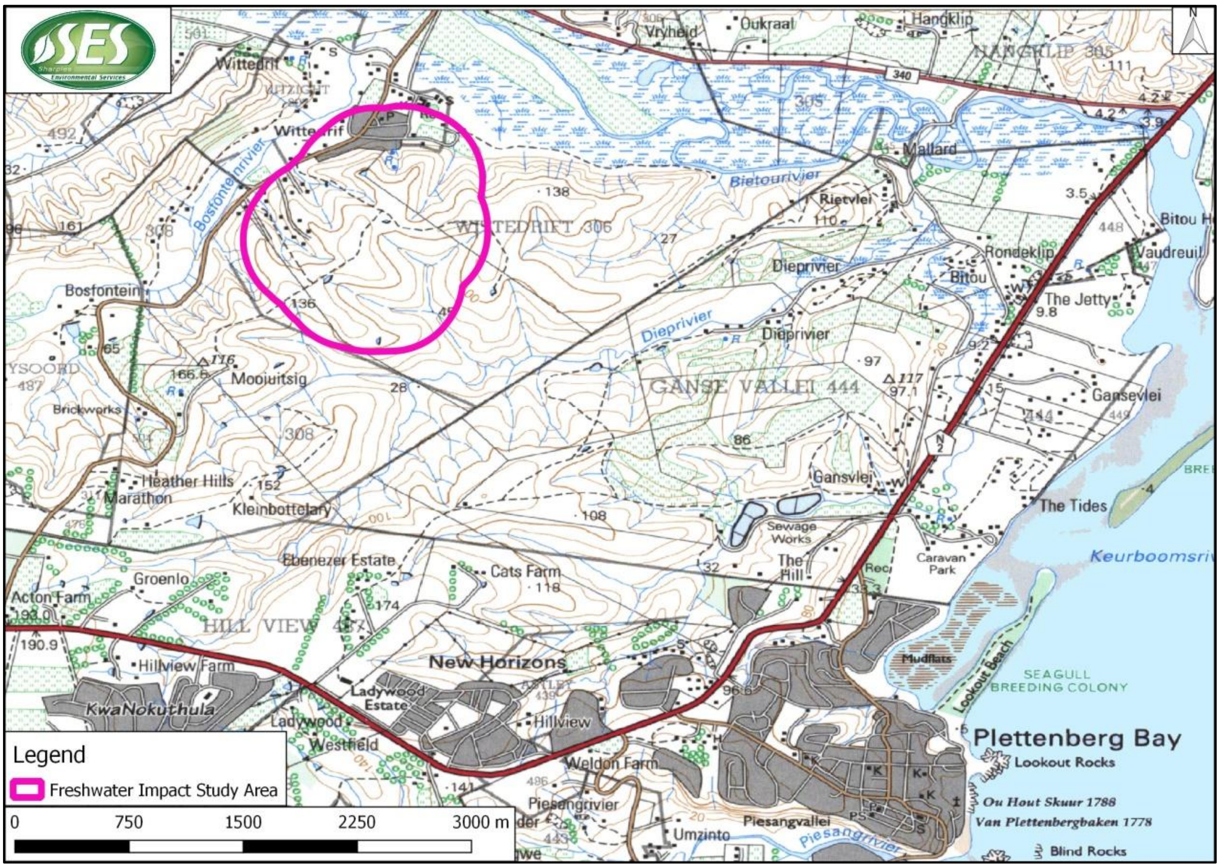


Figure 2: A cadastral map indicating the location of the study area relative to Wittedrift and Plettenberg Bay

1.2 Proposed development and sewage infrastructure

The informal settlement residents of Green Valley have voiced their concerns regarding the lack of formal housing, water and sanitation in the area. The local municipality has acquired land on a ridge above Lemon Street in Green Valley known locally as Oppiekoppie. It is proposed to develop this ridge for formal housing. To service this area, a bulk sewage pipeline is proposed between the housing development and the Plettenberg Bay Waste Water Treatment Works (WWTW) (Figure 3).

An alternative development proposal has not yet been provided for assessment, but the No Go Alternative is assessed within this report. The "no-action" alternative implies a continuation of the current situation or the status quo. It provides a baseline against which to assess the relative impacts of other alternatives. It also assumes that regulations such as Duty of Care and alien invasive plant management under CARA (Conservation of Agricultural Resources Act No. 43 of 1983) will be implemented by the landowner.

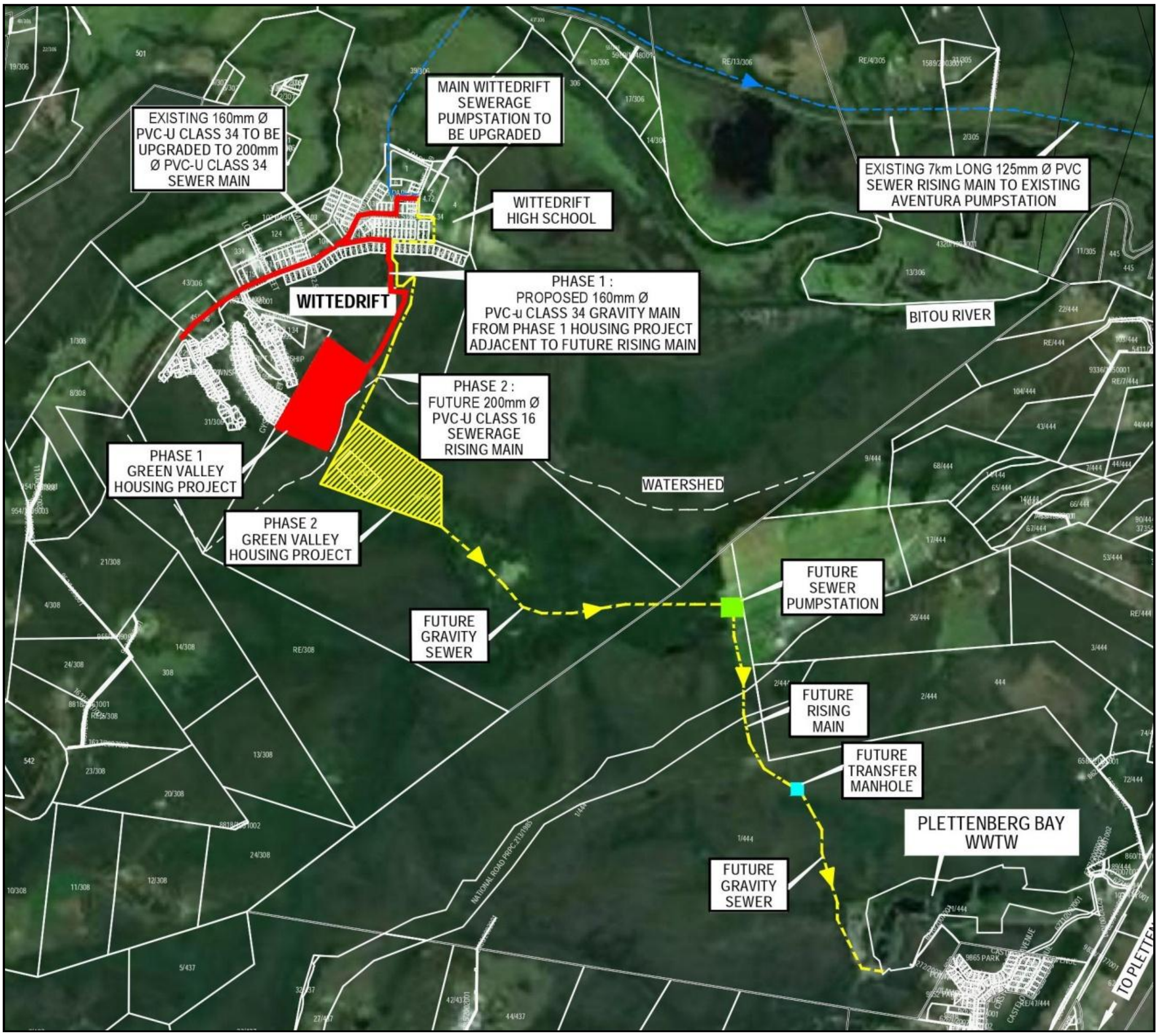


Figure 3: Aurecon preliminary (2017) proposed Green Valley Development sewer link services

1.3 Access routes

According to the Traffic Impact Assessment report compiled by Innovative Transport Solutions (Pty) Ltd (2019), there are two proposed access roads to the development. Refer to Figure 4 below for a representation of the proposed access roads. The two roads proposed are:

- Access Road 1: High Street is extended and connects with a local street in the Green Valley Development.
- Access Road 2: This Street will connect to Pine Street via a proposed street extending from the north western side of the development.

Pedestrian access paths are also proposed. The gradient is very steep and this will need to be accounted for within final designs to prevent erosion. Although reaches of the new access routes are proposed within riparian habitat, they largely follow existing infrastructure that has already impacted the watercourses. Therefore the access routes are unlikely to cause any further degradation within freshwater habitat and are deemed as low impact activities in the context of this site. Any potential impacts from these routes upon freshwater habitat were assessed within the evaluation of the entire development.

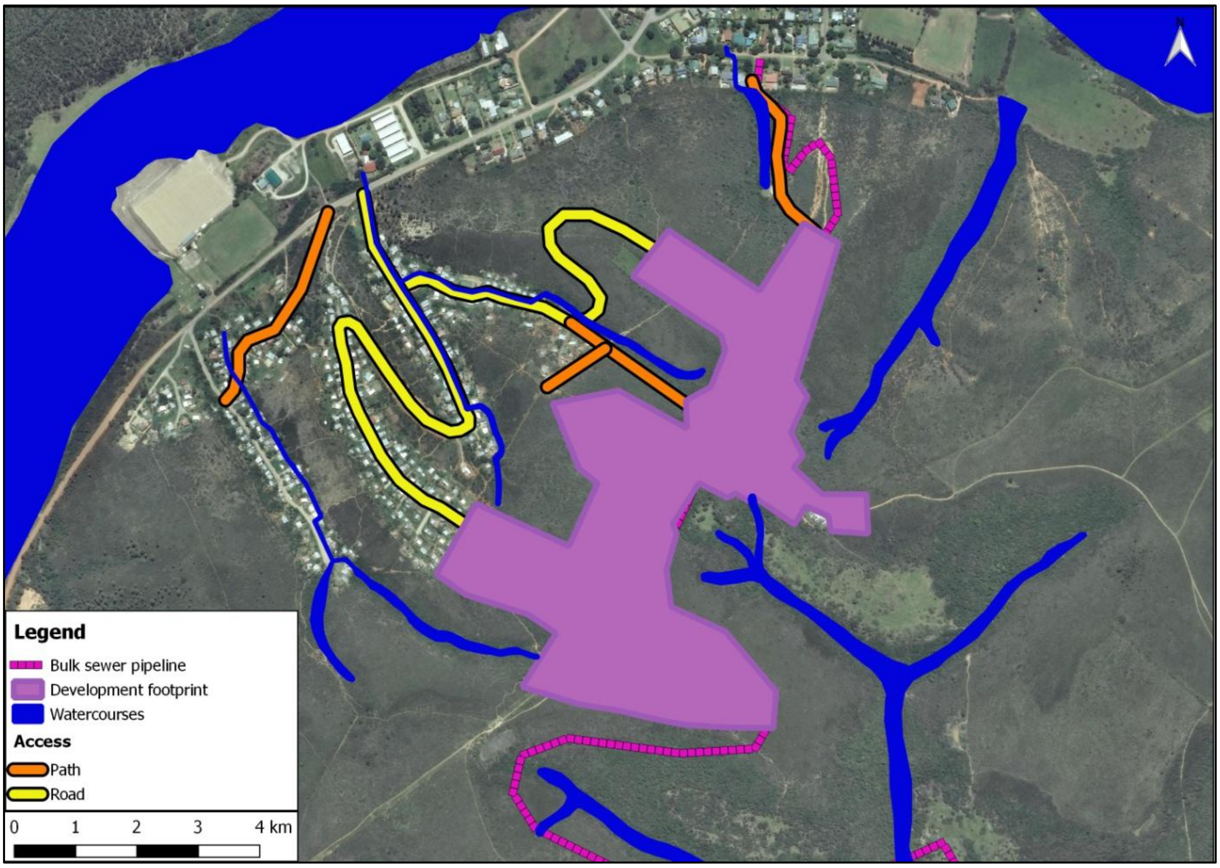


Figure 4: The proposed access route plans in relation to the watercourses of the study area

1.4 Purpose of this report

The protection of water resources is essential for sustainable development and therefore many policies and plans have been developed, and legislation promulgated, to protect these sensitive ecosystems. The proposed project must abide by the relevant legislative requirements. Sharples Environmental Services cc were appointed by Bitou Municipality to conduct an independent specialist freshwater habitat impact assessment for the proposed project, to provide specialist input into the Scoping and Environmental Impact Assessment process and water use authorisation requirements. Table 1 below shows an outline of the environmental legislation relevant to the project.

Table 1: Relevant environmental legislation

Legislation	Relevance
South African Constitution 108 of 1996	The constitution includes the right to have the environment protected
National Environmental Management Act 107 of 1998	Outlines principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state.
Environmental Impact Assessment (EIA) Regulations	Regulations have been promulgated in terms of Chapter 5 of NEMA and were published on 4 December 2014 in Government Notice No. R. 32828. In addition, listing notices (GN 983-985) lists activities which are subject to an environmental assessment.
The National Water Act 36 of 1998	Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water. The water uses under Section 21 (NWA) that are associated with the proposed development are section 21 (c) and (i). The housing development has been authorised under GA, however, the sewage pipeline was not included in that application and requires authorisation. According to the Department of Water and Sanitation (DWS), any structures (e.g. pipelines) within a 500 metre radius from the boundary of a wetland constitutes a Section 21(c) and (i) water use and as such requires a water use licence.
General Authorisations (GAs)	Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a license which should be obtained from the Department of Water and Sanitation (DWS).The project will require a Water Use Authorisation or General Authorisation in terms of Section 21 (c) and (i) of the National Water Act (NWA), Act 36 of 1998, as the development services will cross watercourses. Government Notice R509 of 2016 was issued as a revision of the General Authorisations (No. 1191 of 1999) for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA. However, this does not apply to bulk sewerage pipeline crossings.
National Environmental Management: Biodiversity Act No. 10 of 2004	This is to provide for the management and conservation of South Africa's biodiversity through the protection of species and ecosystems; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; and the establishment of a South African National Biodiversity Institute.
Conservation of Agricultural Resources Act 43 of 1967	To provide for control over the utilization of the natural agricultural resources of the Republic in order to promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants; and for matters connected therewith

1.5 Scope of Work

The Scope of Work in accordance with the specific Terms of Reference supplied by Sharples Environmental Services cc are described below:

1.5.1 Phase 1

- ✓ Contextualization of each study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information.
- ✓ Desktop delineation and illustration of all watercourses within each study area utilising available site-specific data such as aerial photography, contour data and water resource data.
- ✓ A risk/screening assessment of these identified watercourses to determine which ones will be impacted upon by the proposed development areas.

1.5.2 Phase 2

- ✓ Ground truthing, infield identification, delineation and mapping of any affected aquatic ecosystems in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*.
- ✓ Classification of the identified aquatic ecosystems in accordance with the, '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009).
- ✓ Description of the identified watercourses with photographic evidence
- ✓ Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland habitats, utilising:
  - → Level 1 WET-Health tool (Macfarlane *et al*., 2009) – PES
  - → WET-Ecoservices (Kotze *et al*., 2009) - Functional assessment
- ✓ Conduct a Present Ecological State (PES) and present Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats, utilising:
  - → Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
  - → DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- ✓ Indicate the Recommended Ecological Category (REC) of the potentially impacted aquatic ecosystems.
- ✓ Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project.
- ✓ Identify direct, indirect, and cumulative impacts the proposed development will have on aquatic habitats and the significance of these impacts. Rate the significance of the impacts.

- ✓ Recommend actions that should be taken to prevent impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas or ecological processes.
- ✓ Determination of No Go and buffer zones.
- ✓ Identify legislation and permit requirements that are relevant to the development proposal from an aquatic perspective.

2 STUDY AREA

2.1 Local/Regional Setting

The study area is located between the Bosfontein River to the north and the Keurbooms Lagoon at the coast (Figure 5). The Diep River flows in an easterly direction through the study area. Both rivers are tributaries to the Bitou River to the north. The development and associated pipelines will stretch over three quinary catchments. The proposed development is located within the DWS quaternary catchment K60F and falls within the Gouritz Water Management Area (Figure 6). A small length of the proposed pipeline near the WWTW to the south is located within K60G. The tributaries of the study site feed the Bosfontein and Diep Rivers. It is situated in the Bitou River catchment that enters the Indian Ocean near Plettenberg Bay. The summarised biophysical characteristics are indicated below (Table 2).

Table 2: Biophysical characteristics of the area around the proposed project site

BIOPHYSICAL CATEGORIES	BIOPHYSICAL CHARACTERISTICS	SOURCE
Approx. Elevation (a.s.l.)	10 - 130 m	Google Earth^{TM} & Surveyor General
Mean annual precipitation	806.5 mm	Schultz, 1998
Rainfall seasonality	All year	DWAF, 2007
Potential Evaporation	1682.9 mm	Schultz, 1998
Mean Annual Runoff	68.03 mm	
Quaternary catchment	K60F	Schultz, 1998
DWA Ecoregion	South Eastern Coastal Belt	DWA, 2005
National Freshwater Ecosystem Priority Area NFEPA	The systems are tributaries in the Bitou River which is a FEPA	Driver *et* al. 2011

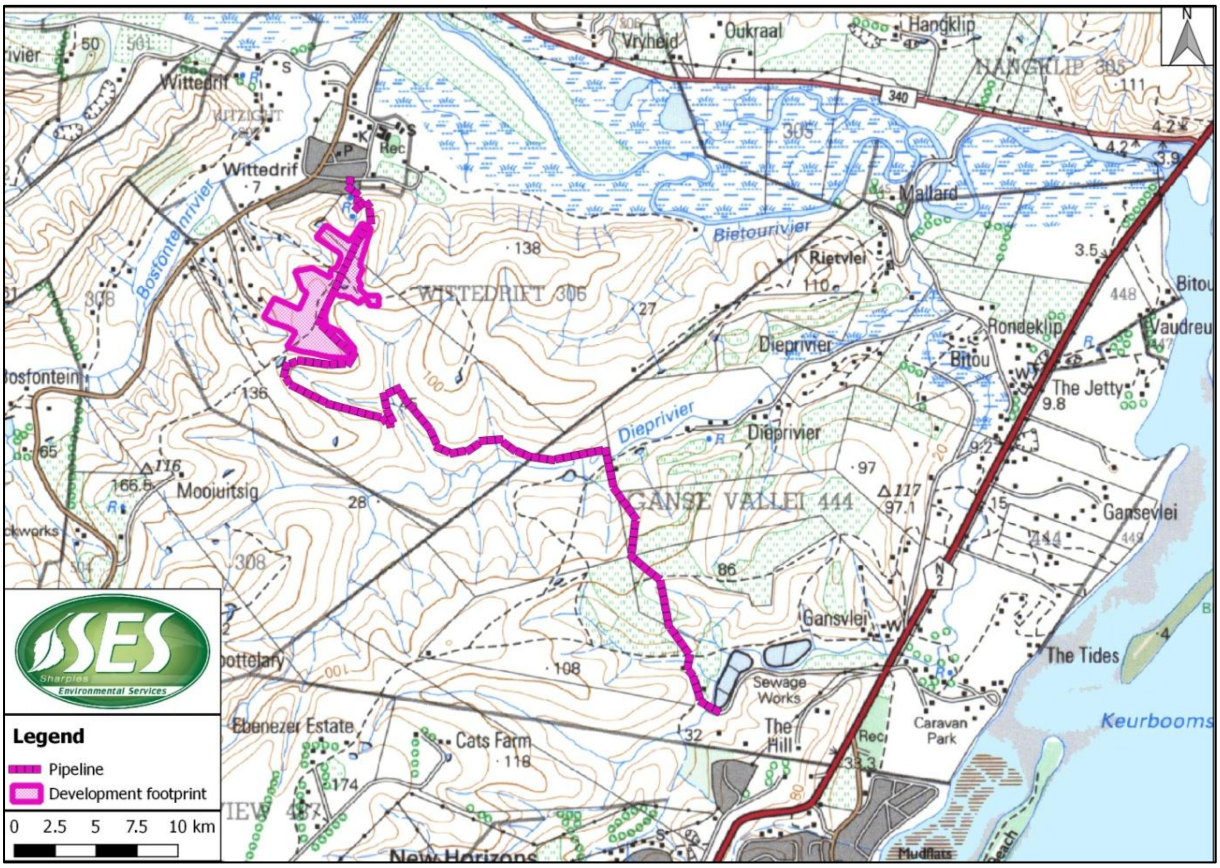


Figure 5: Topocadastral map indicating the Bosfontein River, Diep River, Bitou River and Keurbooms Lagoon

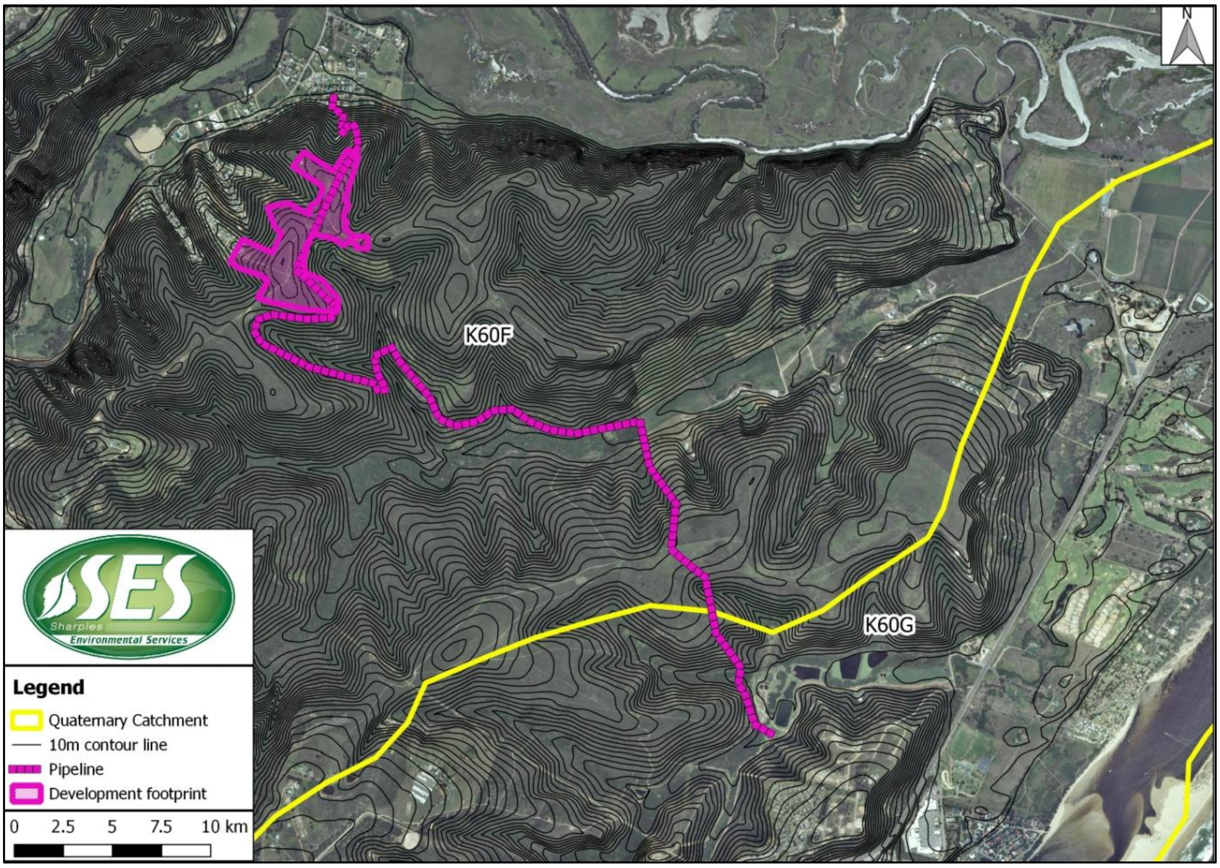


Figure 6: 5m Contour map showing the site in relation to the quaternary catchments

2.2 Climate

The climate of the region is characterized by a temperate coastal climate causes all year rainfall. The temperature is moderated by the sea and varies from between 20°C and 30°C in the summer months (October to April) to between 10°C and 20°C in the wetter winter months (South African National Parks, 2014).

2.3 Vegetation

Mucina and Rutherford (2006) delineated vegetation units throughout Southern Africa. This data has since been refined. As part of the 2018 National Biodiversity Assessment, the National Vegetation Map was produced. According to this data, the entire study site is located in the Garden Route Shale Fynbos vegetation unit (Figure 7). This units' ecosystem threat status was classified as 'endangered' in 2016.

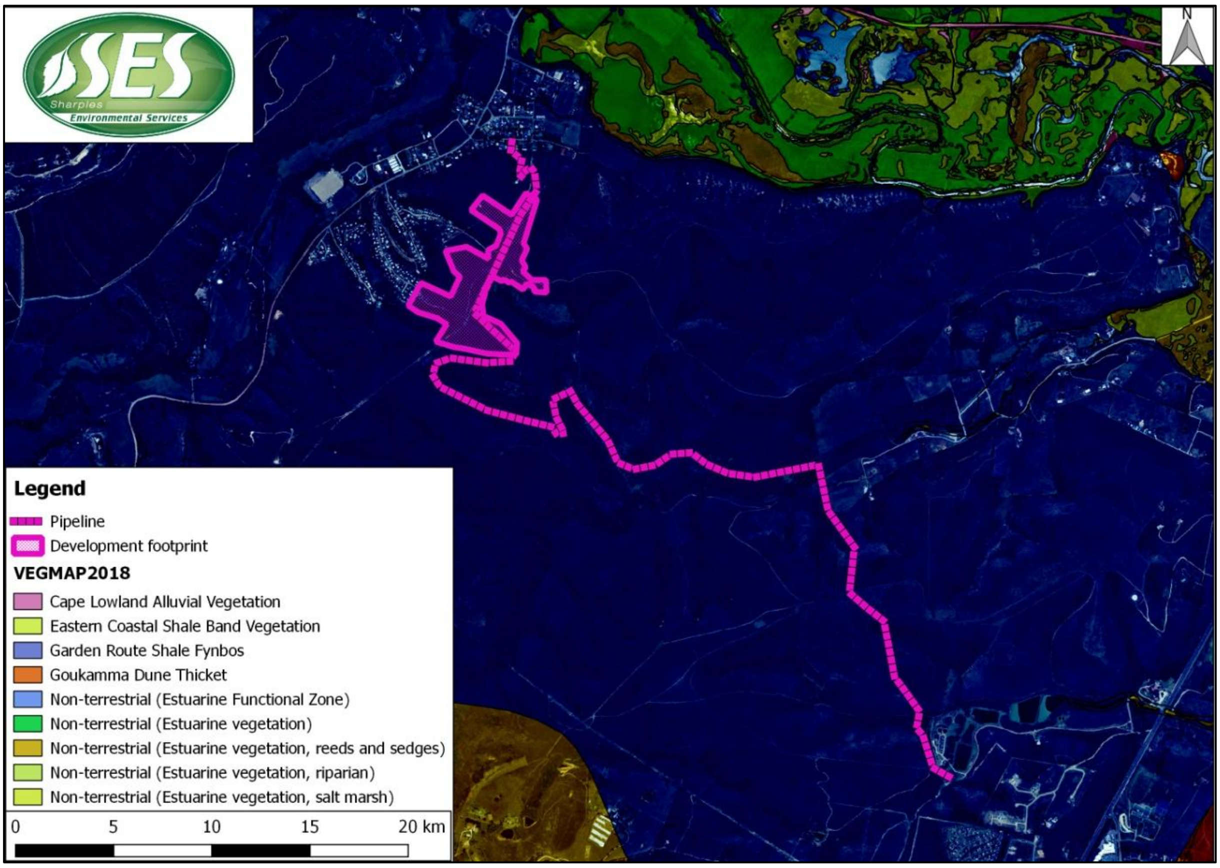


Figure 7: The site in relation to the National Vegetation Map 2018

2.4 Geology

The geology mainly consists of conglomerate, sandstone, siltstone and mudstone of the Kirkwood Formation, Uitenhage Group (Figure 8). The hilltops within the study area consist of partly calcareous sand which is from tertiary to quaternary marine and estuary deposits. Underlying this is the older cretacaceous to tertiary river deposits. The soils have a high erodibility factor of 0.58.

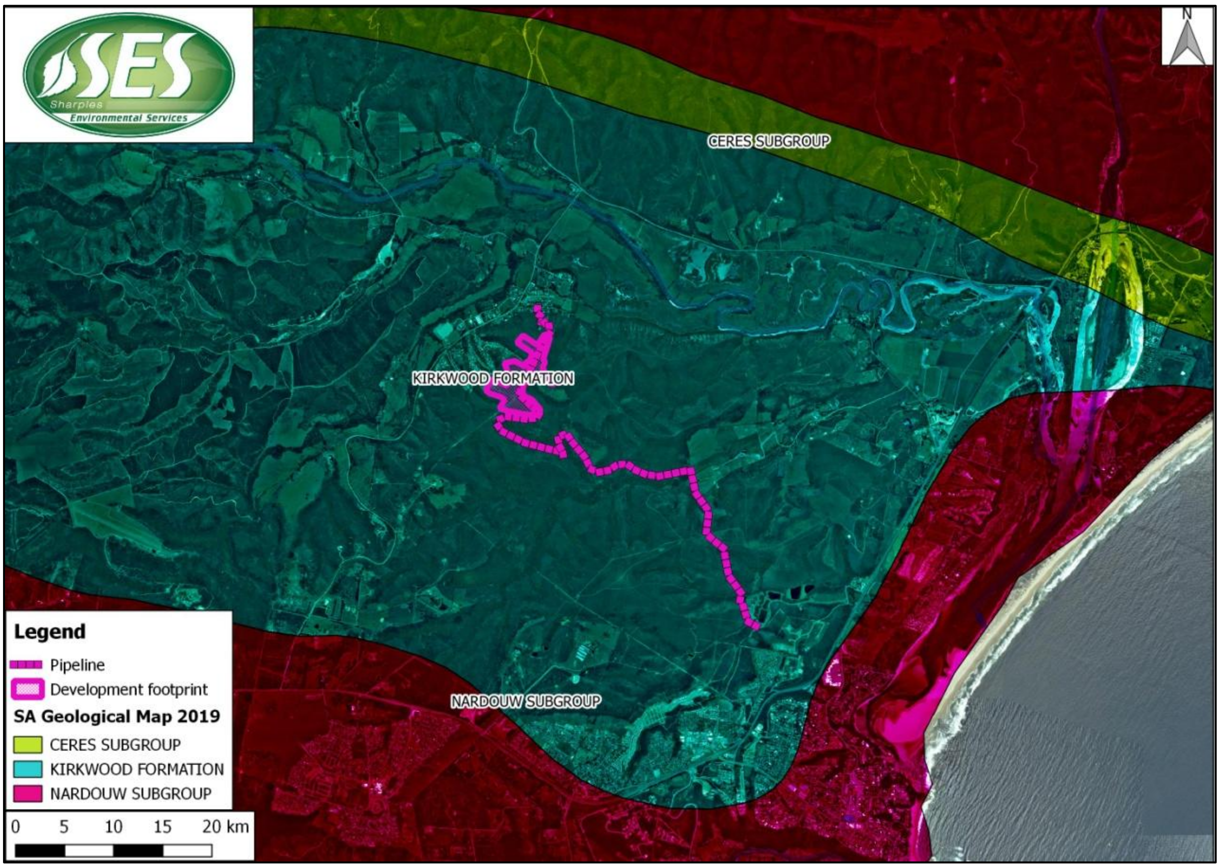


Figure 8: The site in relation to the latest spatial geological database (2019)

2.5 South African National Wetland Map

A South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was established during the National Biodiversity Assessment of 2018 (Van Deventer *et al.* 2018). The SAIIAE offers a collection of data layers pertaining to ecosystem types and pressures for both rivers and inland wetlands. National Wetland Map 5 includes inland wetlands and estuaries, associated with river line data and many other data sets within the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) 2018. Mapping the locality of wetlands is essential so that they may be classified into the different wetland ecosystem types across the country, which in turn can be used along with other data to identify wetlands of conservation significance. The South African National Wetland Map (NWM) utilises the latest spatial data to portray the extent and ecosystem types of the estuarine and inland wetlands, collectively known as wetlands, and informs decision makers in assessing development applications, land use and conservation planning and policy making.

According to this data, there are no wetlands present in the location of the proposed development (Figure 9). However, the Bitou Estuary complex downstream of the study area has been identified by the NWM5 (2018).

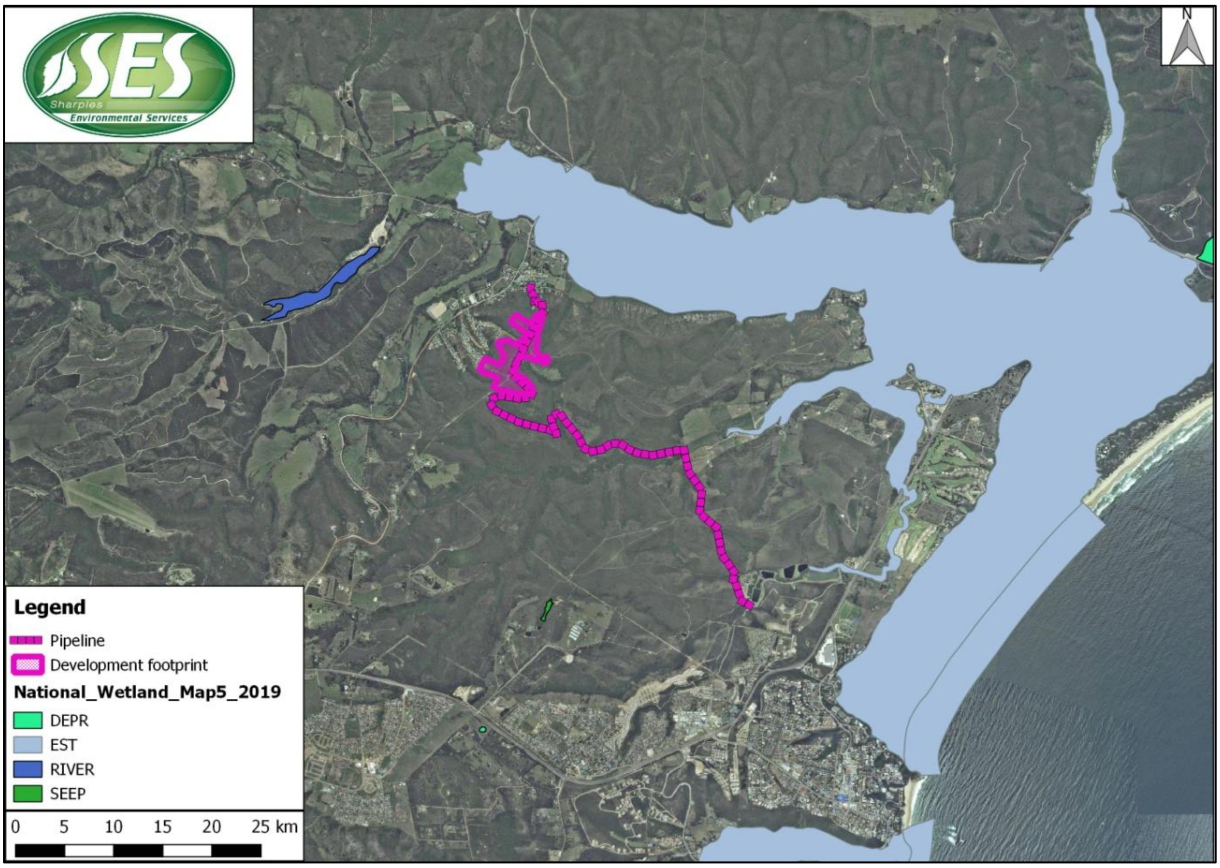


Figure 9: The project site in relation to the National Wetland Map 5 (CSIR, 2019)

2.6 Western Cape Biodiversity Spatial Plan

The primary purpose of a map of Critical Biodiversity Areas and Ecological Support Areas is to guide decision-making about where best to locate development. Critical Biodiversity Areas (CBA's) are required to meet biodiversity targets. These areas have high biodiversity and ecological value and therefore must be kept in a natural state without further loss of habitat or species. Low-impact, biodiversity sensitive land uses are the only land uses allowed in CBA's. The WCBSP made a distinction between areas likely to be in a natural condition (CBA1) and areas that could be degraded (CBA2). Ecological Support Areas (ESA's) are not essential for meeting biodiversity targets but are important as they support the functioning of CBA's and Protected Areas (PA's). ESA's support landscape connectivity surrounds ecological infrastructure that provide ecosystem services and strengthen resilience to climate change. These areas include Endangered vegetation; water source and recharge areas; and riparian habitat around rivers and wetlands. The WCBSP also made a distinction between ESA's in a functional condition (ESA1) and degraded areas in need of restoration (ESA2).

According to the WCBSP data (Pence 2017), there are very few aquatic biodiversity areas within the study area (Figure 10). The location of the proposed development does not affect any Aquatic CBA or ESA habitats. However, the sewer pipeline does traverse a small area classified as ESA2 habitat. Therefore, the design and construction of the pipeline should aim to improve the habitat it crosses.

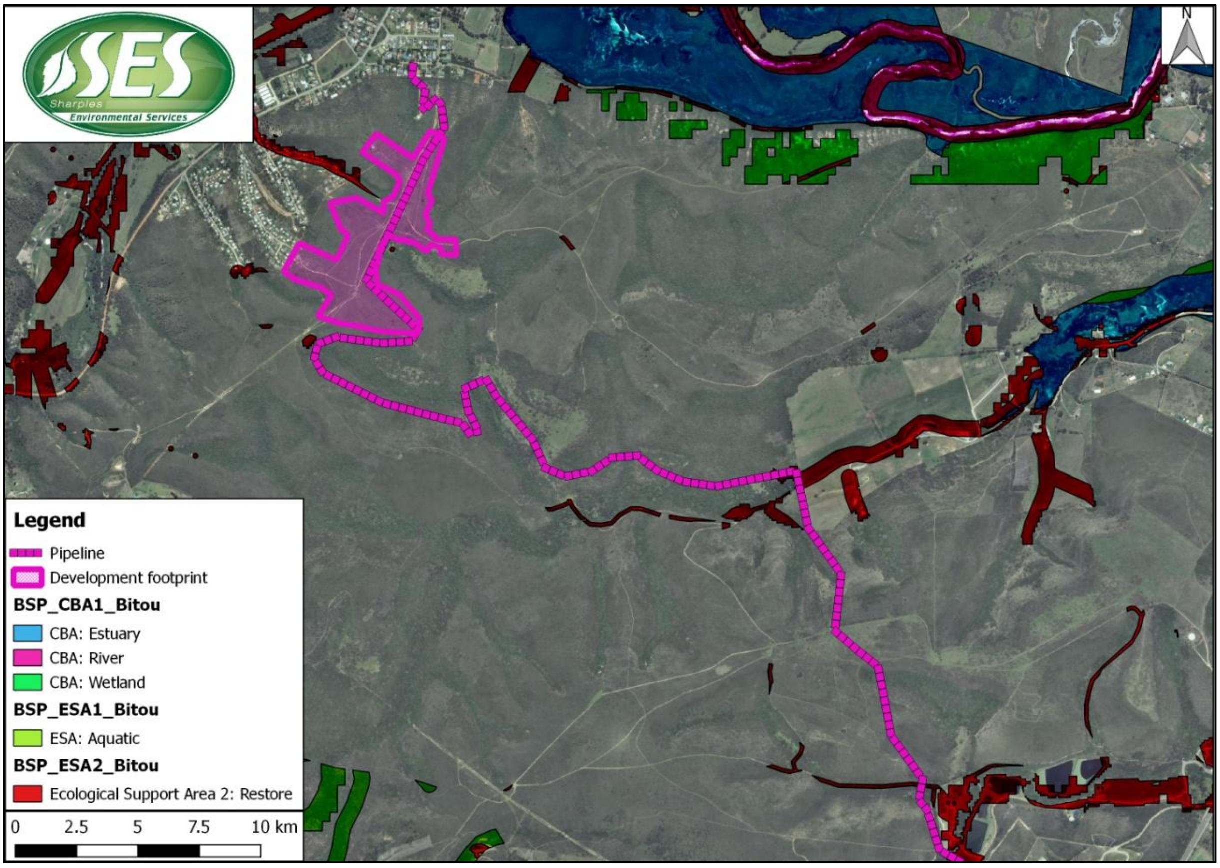


Figure 10: Map showing the proposed project location in relation to the 2017 WCBSP.

2.7 Historic Land Uses

The study of historic aerial photography in freshwater assessment is essential to establishing a 'benchmark' reference state for wetlands/rivers that is required for present ecological state determinations. The earliest available aerial photography is from 1936 (Figure 11) and shows a largely vegetated area with limited human activity. Agricultural activities are evident on the low-lying, gently sloped areas. By 1956 vegetation clearance, probably for livestock grazing, is visible in some areas including the Diep River (Figure 12). The 1974 aerial photograph shows significant land cover changes caused by human activities. The vegetation on most hilltops and in valley bottoms has been modified for agricultural uses (Figure 13). In 1989 the land cover remains largely artificial or grazed, however, the WWTW has been constructed to the south (Figure 14). The area has thus been subjected to land cover and land use changes for decades. These past disturbances within the river catchments will have directly and indirectly altered river processes.

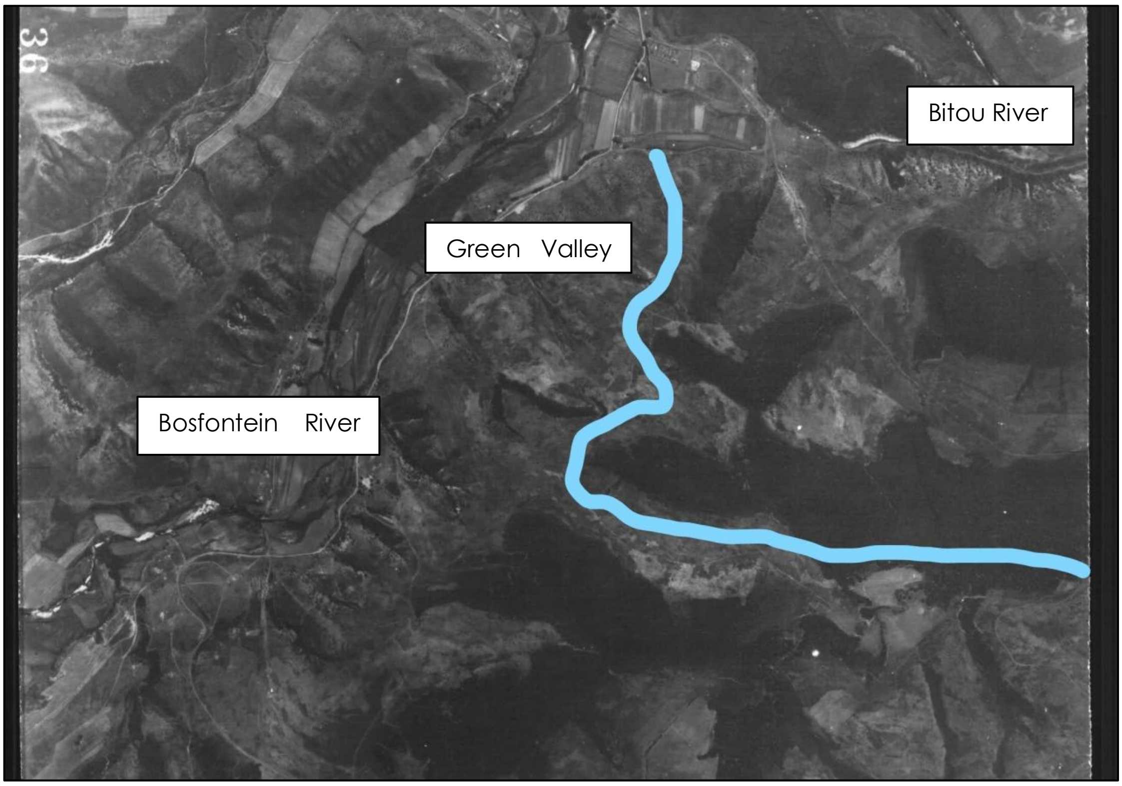


Figure 11: Aerial photography of the study area dated 1936 (the blue line roughly indicates the pipeline route for reference purposes).

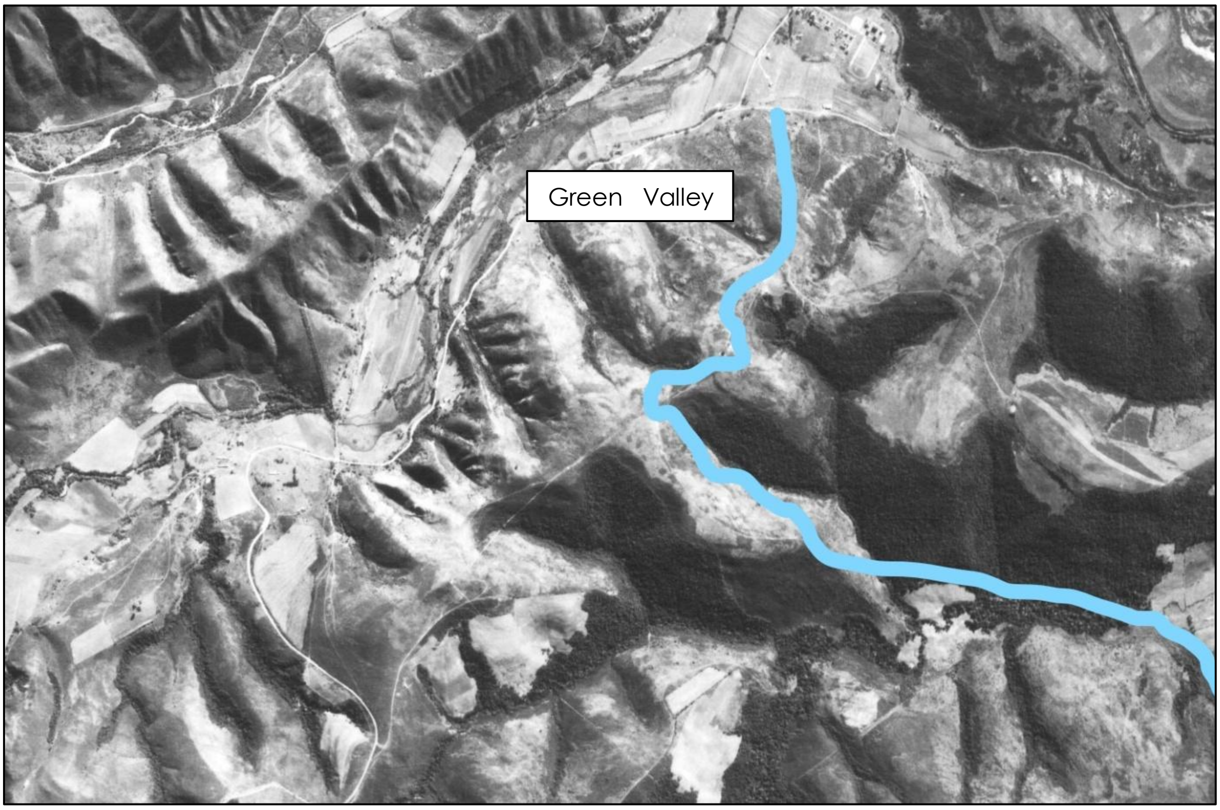


Figure 12: Aerial photography of the study area dated 1956

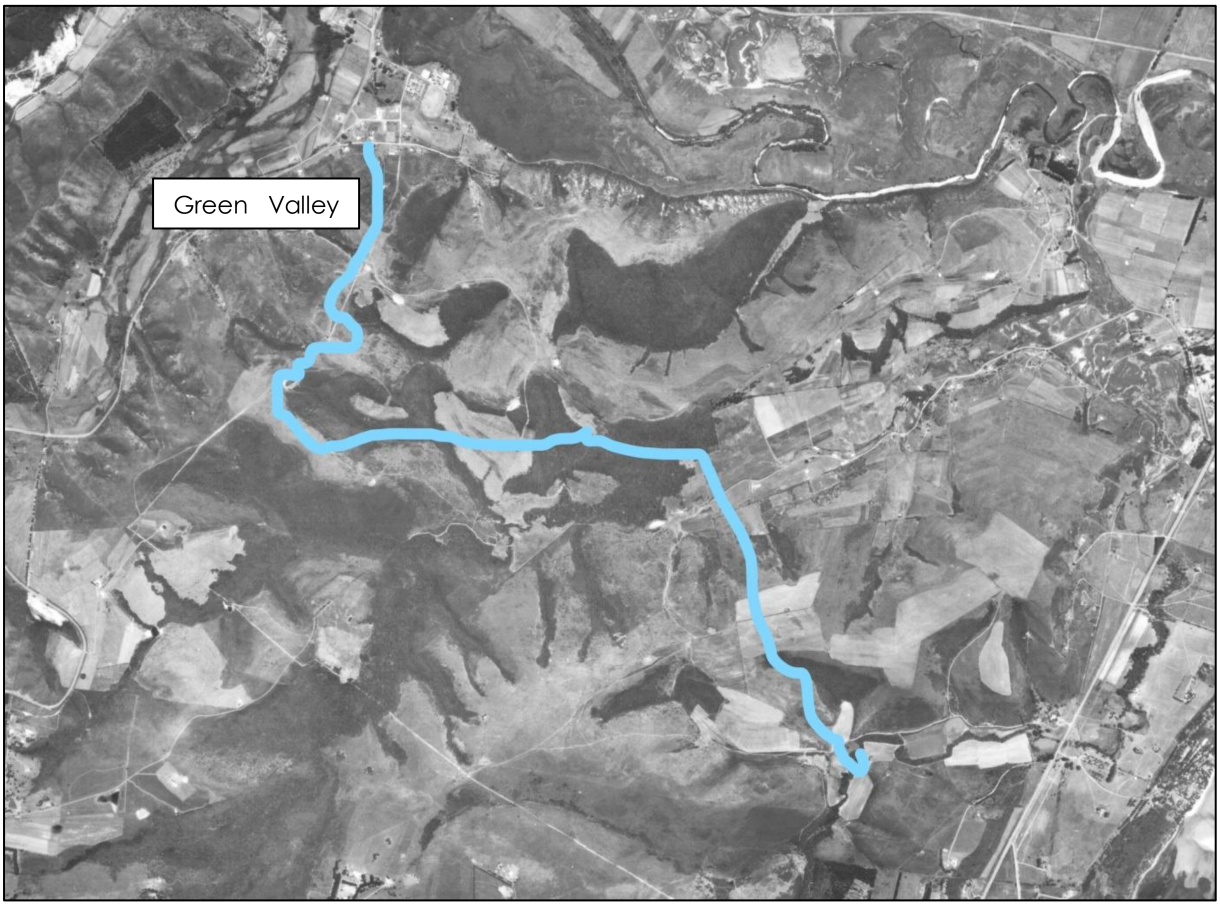


Figure 13: Aerial photography of the study area dated 1974

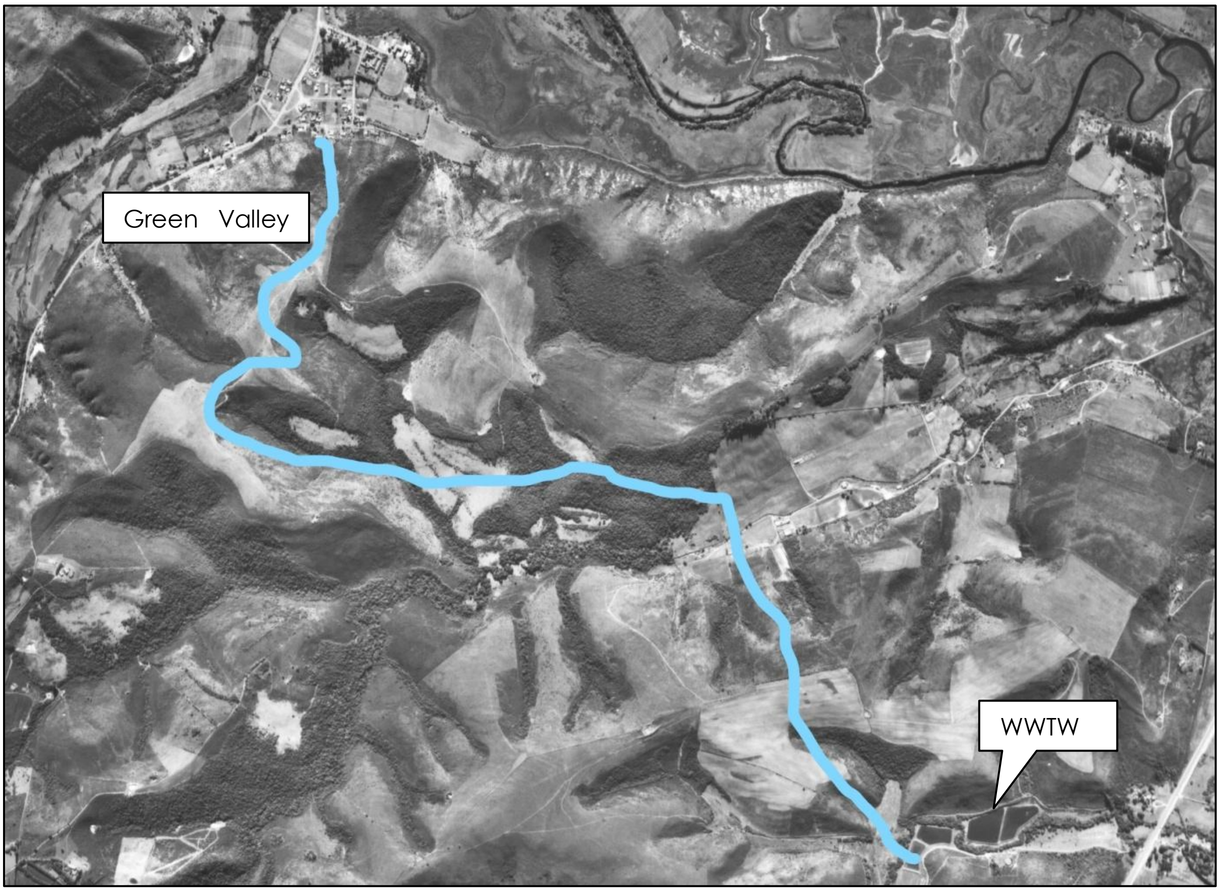


Figure 14: Aerial photography of the study area dated 1989

3 APPROACH AND METHODS

3.1 Status quo assessment

- Desktop delineation was conducted in QGIS (v2.19.0) and Google Earth Pro using available imagery and datasets to identify and screen watercourses within a 500m radius (Department of Water and Sanitation, DWS, regulated area) of the proposed project (Table 3).
- Various data sources were consulted to develop an understanding of the biophysical characteristics of the study area and its conservation context (Table 3). The contextualization of the study area was undertaken in terms of important biophysical characteristics and the latest available aquatic conservation planning information in a Geographical Information System (GIS). It is imperative to develop an understanding of the regional drainage setting and longitudinal dynamics of the watercourse. The conservation planning information aids in the determination of importance and sensitivity, management objectives, and the significance of potential impacts.
- Infield verification and refinement of the location and extent of the watercourses was undertaken to identify the systems that are likely to be impacted by the project and to inform further assessment (Figure 15). The site visits occurred on the 1st of March 2017 and on the 3rd of February 2020 (where the pipeline route was groundtruthed). The infield delineation was conducted in accordance with *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas -Edition 1* (DWAF 2005) (Table 4).
- The delineated aquatic habitats were then each classified separately into HGM units in accordance with the 'National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al.,* 2013) and WET-Ecoservices (Kotze *et al*. 2009) (Table 4).

Table 3: Utilised data and associated source relevant to the proposed project

Data	Source
Google Earth Pro™ Imagery	Google Earth Pro™
DWS Eco-regions (GIS data)	DWS (2005)
South African Vegetation Map (GIS Coverage)	Mucina, Rutherford & Powrie (2018)
South African National Wetland Map 5	CSIR (2018)
Artificial Wetlands	CSIR (2018)
National Biodiversity Assessment Threatened Ecosystems (GIS Coverage)	SANBI (2018)
Geology	Surveyor General (2019)
Contours (elevation) - 5m intervals	Surveyor General
NFEPA river and wetland inventories (GIS Coverage)	CSIR (2011)
NEFPA river, wetland and estuarine FEPAs (GIS Coverage)	CSIR (2011)
Western Cape Biodiversity Framework 2017: Critical Biodiversity Areas of the Western Cape.	Pence (2017)

- Determination of the Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of any affected wetland habitats.
    - The health/condition or Present Ecological State (PES) of the wetland was assessed using the Level 2 WET-Health assessment tool Version 2 (Macfarlane *et al.* 2008), which is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of wetland vegetation.
    - Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The WET-Ecoservices tool (Kotze *et al*., 2009) is utilised to assess the goods and services that the individual wetlands under assessment provide, thereby aiding informed planning and decision-making. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).
    - The Ecological Importance and Sensitivity (EIS) of freshwater habitats is an expression of the importance of the water resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007). The Wetland EIS Tool was utilised to determine EIS (Kleynhans, 1999).
- Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats was undertaken utilising:
    - Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
    - DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- The PES and EIS results then allowed for the determination of management objectives for the potentially impacted aquatic ecosystems.

3.2 Impact assessment

- The watercourses within the 500m buffer study area that were identified as likely to be impacted by the project were assessed further using the appropriate tools (Table 4).
- The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. The anticipated impacts of the proposed development on the associated aquatic habitat were identified and evaluated based on a significance rating scale encompassing factors such as extent, magnitude, duration and significance of impacts.

- Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.
- Actions are thereafter recommended to prevent and mitigate the identified impacts on aquatic habitat, in alignment with the mitigation hierarchy, as well as any measures necessary to restore disturbed areas or ecological processes.
- Any necessary buffer areas or No-Go areas are visually represented. The buffer zone was determined by a tool developed by Macfarlane and Bredin (2016) called *Buffer zone guidelines for rivers, wetlands and estuaries*, site-based information and professional opinion. The final buffer requirement includes the implementation of practical management considerations/ mitigation measures.

Table 4: Tools utilised for the assessment of water resources impacted upon by the proposed project.

METHOD/TOOL*	SOURCE	REFERENCE
Delineation of wetland and/or Riparian areas	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas.*	(DWAF 2005)
Classification of wetlands and/ or other aquatic ecosystems	*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa & WET-Ecoservices*	(Ollis *et al*., 2013), Kotze *et al*., 2009)
Present Ecological State (PES) Assessment (Wetland)	*WET-Health Assessment Version 2*	(McFarlane *et al.* 2009)
Functional Importance Assessment (Wetland)	*WET-Ecoservices Assessment*	(Kotze *et al*., 2009)
Ecological Importance & Sensitivity (EIS) Assessment (wetland)	*DWAF Wetland EIS Tool*	(Duthie 1999)
Present Ecological State (PES) Assessment (River)	*Rapid IHI (Index of Habitat Integrity) tool developed Kleynhans (1996), Modified by DWAF*	(Ecoquat)
Ecological Importance & Sensitivity (EIS River)	*DWAF EIS tool developed by Kleynhans (1999)*	(Kleynhans, 1999)
Aquatic Buffer Zone Determination	*Buffer zone guidelines for rivers, wetlands and estuaries*	Macfarlane and Bredin (2016)

Figure 15: Photograph of fieldwork conducted in February 2020, taken from Green Valley hilltop, looking toward the direction of the WWTW

4 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations are relevant:

- The locations of the proposed infrastructure were extrapolated from data provided by the client.
- Aquatic ecosystems vary both temporally and spatially. Once-off surveys such as this are therefore likely to miss certain ecological information due to seasonality, thus limiting accuracy and confidence.
- Infield soil and vegetation sampling was only undertaken within a specific focal area around the proposed development, while the remaining watercourses were delineated at a desktop level with limited accuracy.
- No detailed assessment of aquatic fauna/biota was undertaken. See botanical assessment.
- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or indicator wetland/riparian species and only provide a very general indication of the composition of the riverine vegetation communities.

- This report deals exclusively with a defined area and the extent and nature of freshwater/aquatic habitat and ecosystems in that area.
- While disturbance and transformation of habitats can lead to shifts in the type and extent of freshwater ecosystems, it is important to note that the current extent and classification is reported on here.
- All soil/vegetation/terrain sampling points were recorded using a Garmin Montana Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- It is assumed that all the mitigation measures detailed in this report will be effectively implemented and monitored.
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar development projects. The degree of confidence is considered good.

5 RESULTS

Following desktop and field analysis of the aquatic habitats, relevant to the proposed development, the subsequent results were obtained.

5.1 Risk Assessment

The aquatic habitats within a 500 metre radius of the proposed project were identified and mapped on a desktop level utilising available data, following which, the infield site assessment (conducted on the 1st of March 2017 and in February 2020) confirmed the location and extent of these systems. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the project and position the system is located in the landscape.

It was determined that a number of non perennial streams may be impacted by the housing development as they are located directly down slope of the watershed proposed for development (Figure 17). It was determined that a number of non perennial streams and a perennial river will be impacted upon by the proposed pipeline crossings along the bulk sewerage pipeline route to the Wastewater Treatment Works (Figure 17). These watercourses were therefore assessed further in detail to determine the level of impact upon the integrity of freshwater habitat as a result of development and associated services.

Once the watercourses were identified for assessment, the study was divided into two areas for ecological assessment purposes (Figure 16). The identified watercourses within the 500 m regulated area of the development were assessed separately from the watercourses potentially impacted by the sewage pipeline. These categories were broken down further in order to group systems that are similar in character and location. Please note that the impact assessment is of all identified watercourses within the entire study area; the development footprint and pipeline route.

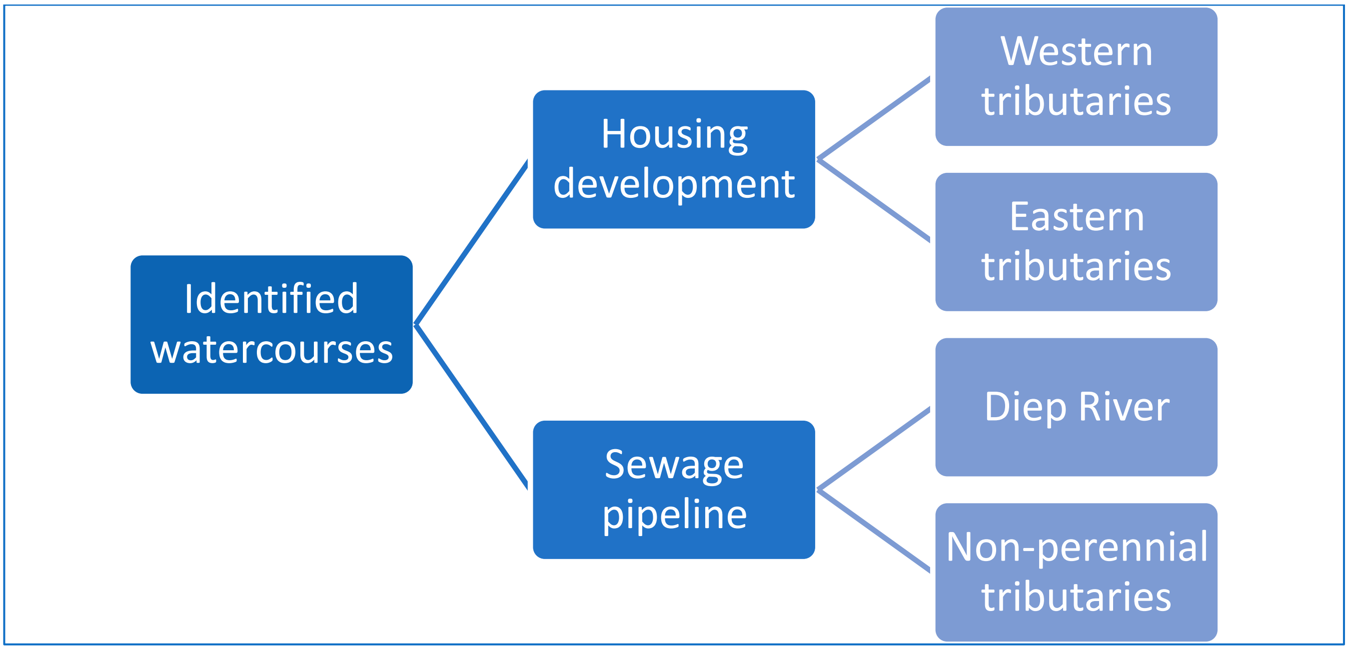


Figure 16: Hierarchy to indicate the method of ecological assessment undertaken for watercourse type

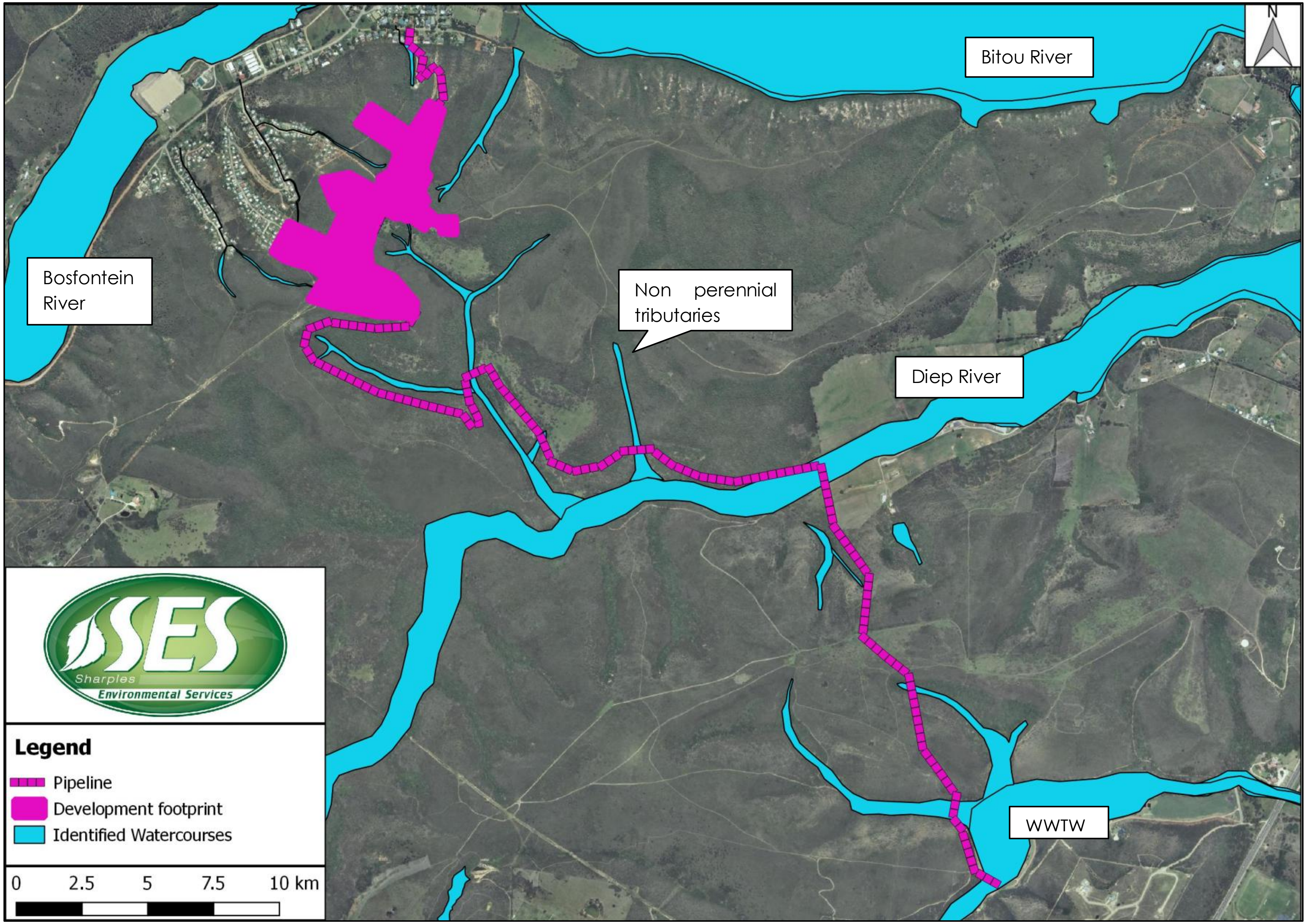


Figure 17: The proposed site of the development in relation to the watercourses identified as likely to be impacted upon.

5.2 Freshwater habitat potentially impacted by the housing development

Two artificial wetland systems (dams) and thirteen riparian systems were identified within the 500m radius and will likely be impacted by the development. Approximately half of the riparian systems drain towards the north west from site, while the other half mostly drain towards the south west of the watershed. The two different catchment areas have been impacted to different degrees by anthropogenic activities. Yet, within these micro catchments, the systems are highly similar. The riparian systems were therefore divided into two groups, the 'eastern tributaries' and the 'western tributaries', for assessment purposes (Figure 18).

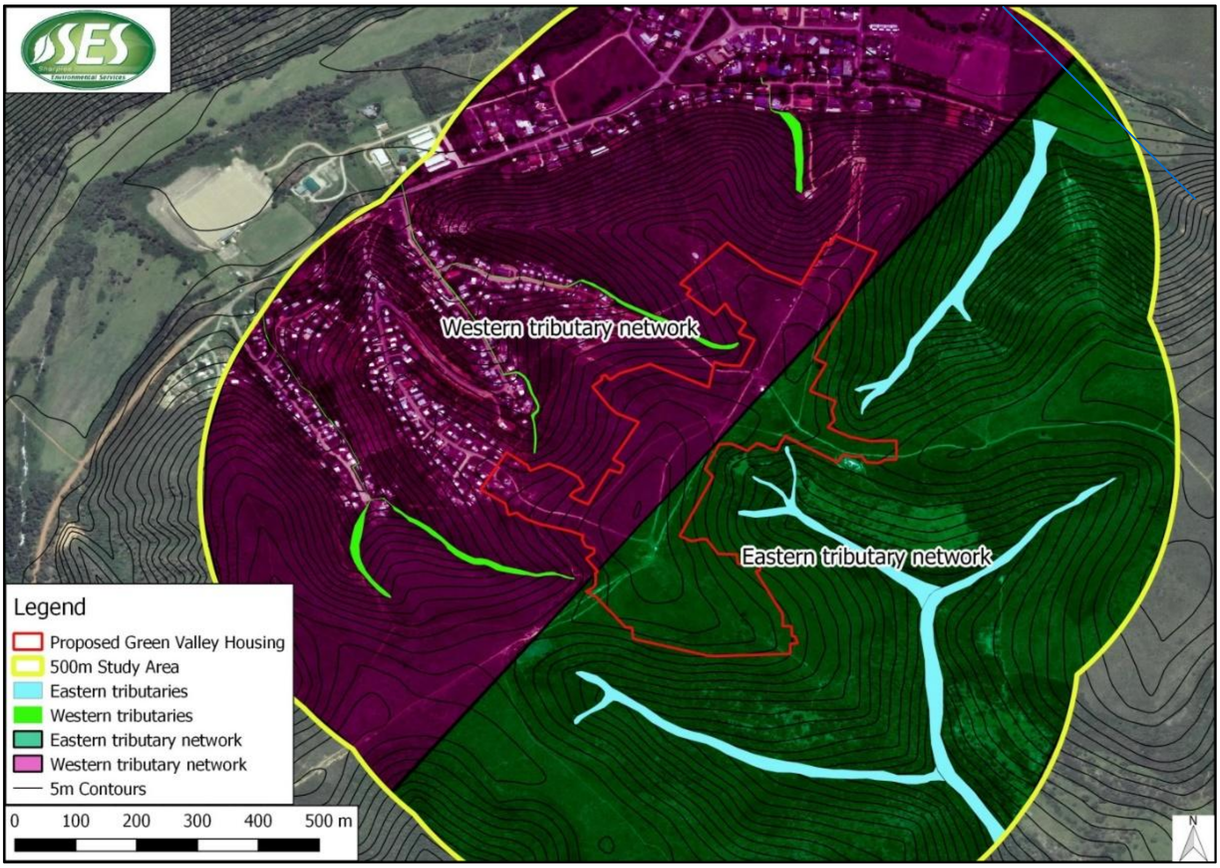


Figure 18: Map illustrating the separate tributary networks assessed

5.2.1 Western tributaries

5.2.1.1 Description:

The tributaries to the north and west of the study area mostly drain into the Bosfontein River, a larger tributary to the Bitou River and estuary. The tributaries are small systems with temporary flow (Figure 19). The systems are of similar ecological integrity as they share biophysical characteristics and have been similarly impacted by land use and cover changes. Towards their source, they are well-vegetated by indigenous plant species such as *searsia lucida, diospyros lycioides, searsia lancea, chrysanthemoides monilifera,* and *carissa bispinosa.* However, there is a moderate level of alien plant infestation in the more disturbed areas (species such as *acacia cyclops* and *pennisetum* *clandestinum*). The rivers have a narrow, confined, and shallow channel consisting of a sandy clay bed.

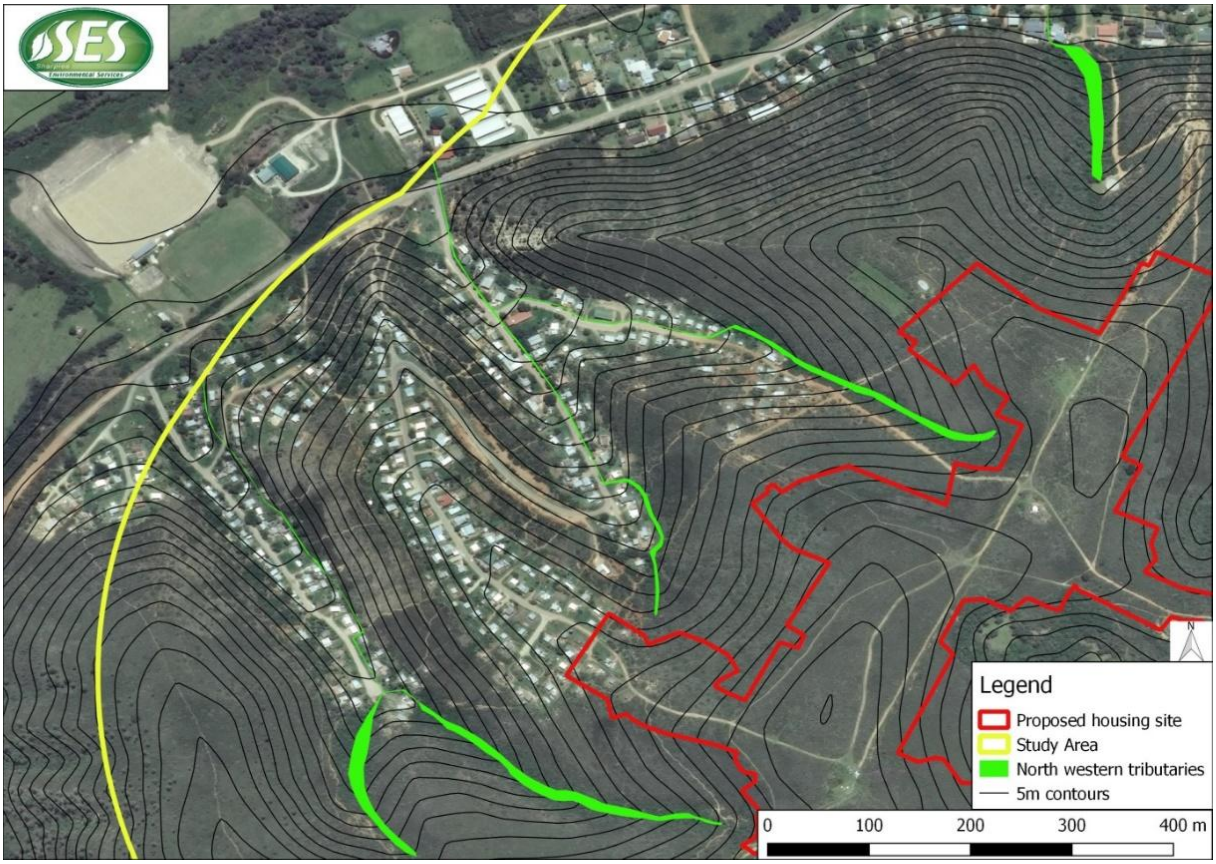


Figure 19: The small, western tributaries within the study area that have been heavily upon

The gravel roads and footpaths within the area have increased sediment inputs and caused erosion on the hillslope. The construction of informal housing and roads is increasing in an upslope direction within these drainage lines. These developments have destroyed riparian habitat to more than mid-way upslope of the valleys. The water is directed into the stormwater network via drains and no riparian vegetation remains. Domestic waste is being dumped into the drainage lines of the area causing obstruction of flow and affecting water quality. Human and animal waste is also entering the systems and affecting the water quality (Figure 20). The proposed development is located within these catchments and will result in further impacts on these systems.

Domestic waste dumped in riparian habitat

Sewage infrastructure on the banks of degraded stream

Figure 20: Photographs illustrating the existing anthropogenic impacts on the western tributary network.

5.2.1.2 Present Ecological State (PES):

The Present Ecological State (PES) refers to the health or integrity of river systems, and includes both instream habitat as well as riparian habitat adjacent to the main channel. The rapid Index of Habitat Integrity (IHI) tool (Kleynhans, 1996) was used to determine river PES by comparing the current state of the in-stream and riparian habitats (with existing impacts) relative to the estimated reference state without anthropogenic impacts. The tributaries of the western network of riparian systems were assessed together due to their similar characteristics. Due to the heavy impacts of housing and infrastructure, as well as the dumping of domestic waste, the systems were classified as largely modified having scored within the 'D' category for PES (Table 5).

Table 5: Present Ecological State of the western tributary systems

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	4.5	20	The majority of each system has been infilled by informal and formal housing and road infrastructure. The riparian bed becomes completely modified towards the foot of each system.
Flow modification	4.5	20	Due to the housing and road infrastructure the flows have been completely diverted into stormwater systems. Additionally, the resultant hardened surfaces of the micro catchments have altered surface runoff substantially.
Inundation	0	95	The systems have been infilled and drained and thus there is no inundation.
Bank condition	4.5	20	As with the bed modifications of the systems, the housing has completely transformed the banks of the systems.
Riparian condition	4	30	The riparian area decreased in integrity in a downslope direction. Upslope of the housing infrastructure there are portions of vegetated riparian area, that although includes some alien vegetation, is dominated by indigenous species. There is slight erosion in these areas already due to vegetation clearing and livestock. Downslope, however, the riparian habitat has been

			completely transformed due to development.
Water quality modification	2	70	Poor stormwater management, dumped domestic waste, and poor ablution facilities in and near the rivers will have decreased the water quality of the systems. However, being intermittent in flow regime, the significance of this is slightly lessened.
Average Score	**3.3**	42.5	The system has been largely impacted by bed, flow, and bank condition modifications. The majority of the riparian zone has been subjected to habitat loss due to housing infrastructure and alien plant infestation. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
Ecological Category	**D**		

5.2.1.3 Ecological Importance and Sensitivity:

The Ecological Importance and Sensitivity (EIS) of riparian areas is a representation of the importance of the aquatic resource for the maintenance of biological diversity and ecological functioning, whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance (Kleynhans *&* Louw*,* 2007). The ecological importance and sensitivity category of the western tributary systems was determined as being 'Low' (D category). The tributaries have been significantly modified and little natural habitat remains. Therefore, there are no rare/endangered, vulnerable or sensitive species. Table 6 below provides a summary of the EIS assessment determinants and results for the systems.

Table 6: The Ecological Importance and Sensitivity of the western tributary systems

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0.5	No rare or endangered species were expected or encountered on site. The tributaries have been significantly modified and little natural habitat remains.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	1.5	As the tributaries are located in the fynbos biome, more than one population (or taxon) judged to be unique on a local scale. However, significant portions of the riparian habitats have been completely transformed.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	0.5	Limited species are expected to be associated with these intermittent, small, degraded systems. The species that may be associated with these riparian systems are likely very tolerant of increases and decreases in flow as the systems are intermittently inundated.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1.5	Limited species are expected to be associated with these intermittent, small, degraded systems.
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1.0	There is a low diversity in aquatic habitat types do to the shallow, straight, and intermittently flowing systems with a uniform substrate material. Additionally, much of the habitat has been lost.
	Refugia (4=Very high - 1=marginal/low)	1.5	The tributaries have a limited ability to provide refuge to biota during times of environmental stress. This is due to the extensive degradation, limited diversity of habitat and intermittent flow regime.

	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1.5	These small intermittent rivers, with limited habitat types, are only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1.0	These are streams with habitat types rarely sensitive to water quality change related to flow decreases or increases.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	0.5	The link between upstream and downstream has been severed in all of these tributaries due to development causing habitat loss. The systems have no remaining link in terms of connectivity for the survival of biota upstream and downstream.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	1	The tributaries are in a developed and disturbed area which is not important for the conservation of ecological diversity on any scale.
MEDIAN OF DETERMINANTS		1.00	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**LOW, EC=D**	Rarely sensitive to changes in water quality/hydrological regime

5.2.1.4 Recommended Ecological Category:

The recommended ecological category (REC) is used to inform future management objective for an aquatic ecosystem. The REC can be determined by using the PES (Present Ecological State) and EIS (Ecological Importance and Sensitivity) scores of the system (see table below; DWAF 2007). However, it is also important to consider the feasibility to realistically either maintain or improve the current condition of the water resource. The west tributary systems assessed have a Fair-Poor 'D' PES and a Low 'D' EIS which places it in the REC 'D' category which advocates the maintenance of the systems (Table 7).

Table 7: Management objectives for the western tributary network based on PES & EIS scores (DWAF 2007).

			Ecological Importance and Sensitivity (EIS)			
			Very High	High	Moderate	Low
PES	A	Pristine	A Maintain	A Maintain	A Maintain	A Maintain
	B	Natural	A Improve	A/B Improve	B Maintain	B Maintain
	C	Good	B Improve	B/C Improve	C Maintain	C Maintain
	D	Fair	C Improve	C/D Improve	D Maintain	**D Maintain**
	E/F	Poor	D Improve	E/F Improve	E/F Maintain	E/F Maintain

5.2.2 Eastern Tributaries

5.2.2.1 Description

The tributaries to the south and east of the study area mostly drain into the Diep River, a larger tributary to the Bitou River and estuary. The tributaries are small systems with temporary flow (Figure 21). The systems are of similar ecological integrity as they share biophysical characteristics and have been similarly impacted by land use and cover changes. As opposed to the north western tributaries across the watershed, the tributaries to the Diep River, and one of the Bitou River mostly on the south and east of the study area are in near pristine condition. These tributaries are well-vegetated with the typical scrub forest of riparian areas of this biome, with only a few alien invasive individuals evident (Figure 22). The instream vegetation was sparse, consisting mainly of *Dietes grandiflora*, amongst dry leaf litter from the forest canopy above. No herbaceous groundcover was observed. *Sideroxylon inerme* (Milkwood trees), a protected species, were observed within these systems. The tributaries all have narrow, shallow channels that are stable despite being steep longitudinally. No erosion was evident within these catchments.

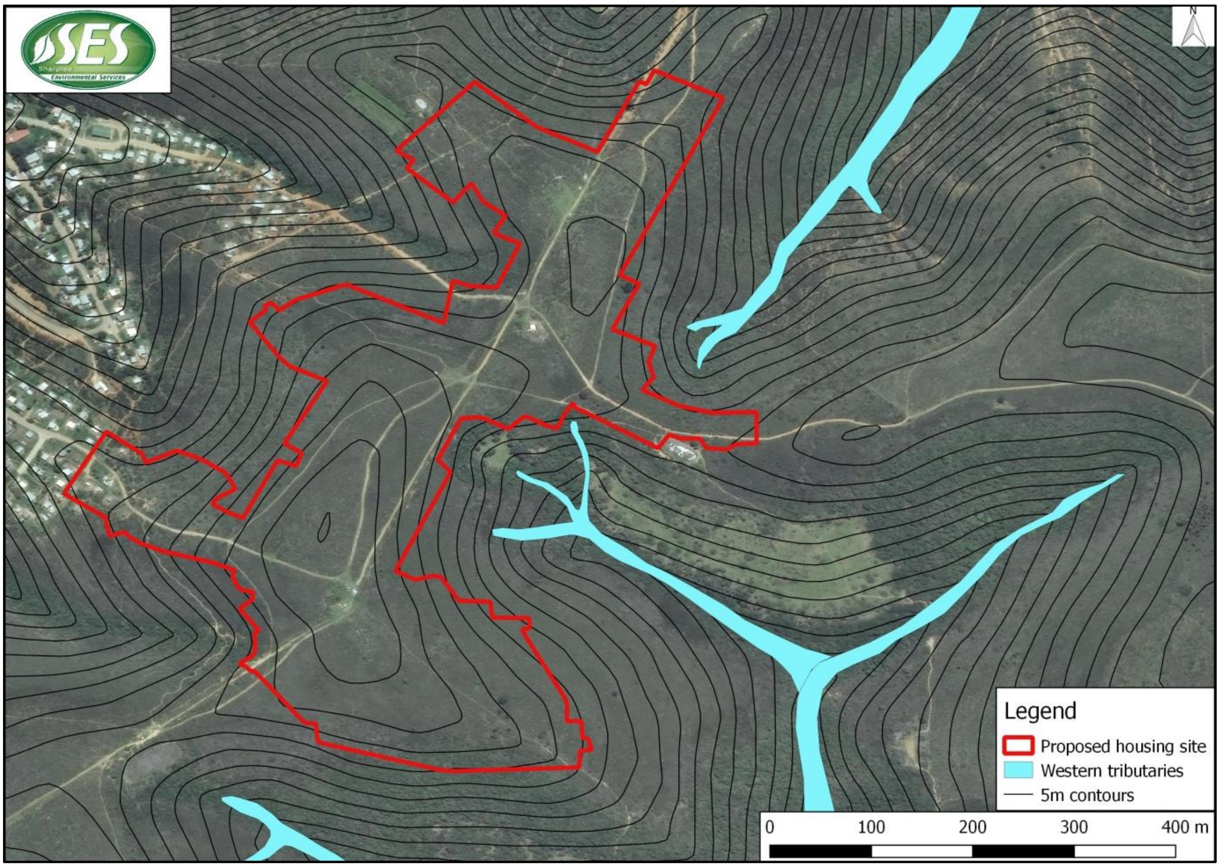


Figure 21: The near natural and pristine western tributaries in relation to the development footprint

The existing impacts upon the systems include livestock grazing, small dams, and footpaths within their catchments. However, these impacts have not significantly changed the riparian areas. The proposed development is located within these catchments and will impact these systems.

Figure 22: Photographs illustrating the characteristics of the streams in the eastern tributary network.

5.2.2.2 Present Ecological State (PES):

The riparian systems of the 'eastern' network were categorised as being in natural to near-natural condition ('AB' system), indicating that the modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small or not evident (Table 8). The bed and banks of the system are stable and well vegetated. The riparian vegetation is almost entirely indigenous, diverse and dense.

Table 8: The Present Ecological State of the eastern riparian systems

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	0.5	90	The systems are unimpacted by roads, erosion or any impacts causing bed modification. However, two of the systems have very slight and localised modification due to small dams at their source.
Flow modification	0.5	90	The systems have not been impacted and are largely pristine. There have been no significant flow modifications.
Inundation	1.5	80	The two small dams at the sources of two of the tributaries have inundated a small portion of river reach. However, this is a negligible amount that does not alter habitat integrity.
Bank condition	0	95	The riparian banks are shallow in depth and not well defined. They are well vegetated with indigenous species and are stable. There has been no decrease in bank condition in these systems.
Riparian condition	0.5	90	The riparian are is stable and well vegetated. There may be one or two invasive species, but it is largely pristine.
Water quality modification	0	95	There are no anthropogenic impacts in the systems micro catchments. There is no potential for pollutants to enter the systems. Additionally, there is no erosion to cause sedimentation.
Average Score	0.5	90.0	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.
Ecological Category	**AB**		

5.2.2.3 Ecological Importance and Sensitivity:

The ecological importance and sensitivity category of the 'eastern' tributary network was determined as being 'Moderate' (C category). The systems do not have a high sensitivity as they are only intermittently inundated with no significant diversity of habitat along the reach. However, they act as an important ecological corridor to the Bitou estuary while providing a moderate amount of refuge to biota. Additionally, due to their pristine and near-pristine state, as well as containing a protected tree species, they are important for conservation purposes. Table 9 below provides a summary of the EIS assessment determinants and results for the south and eastern stream networks.

Table 9: The Ecological Importance and Sensitivity of the eastern tributaries

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1.5	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	2.0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	1.0	The species associated with these riparian systems are likely very tolerant of increases and decreases in flow as the systems are intermittently inundated. A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2.0	The pristine condition of the area and vegetation type results in a moderate species/taxon richness
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	2.0	There is a low diversity in aquatic habitat types do to the shallow, straight, and intermittently flowing systems with a uniform substrate material
	Refugia (4=Very high - 1=marginal/low)	2.0	The systems have a limited ability to provide refuge to biota during times of environmental stress. This is due to the limited diversity of habitat and intermittent flow.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1.5	These small intermittent rivers, with limited habitat types, are only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1.0	These are streams with habitat types rarely sensitive to water quality change related to flow decreases or increases.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	2.0	The tributaries are a moderately important link in terms of connectivity for the survival of biota upstream and downstream and are moderately sensitive to modification. The network provides a corridor to the Bitou Estuary which is of national importance.

	Importance of conservation & natural areas (range, 4=very high - 0=very low)	3	The tributaries are in a natural/undisturbed area which is important for the conservation of ecological diversity on a provincial /regional scale. Additionally, the Milkwood trees within the riparian systems are a protected species.
MEDIAN OF DETERMINANTS		2.00	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**MODERATE, EC=C**	Some elements sensitive to changes in water quality/hydrological regime

5.2.2.4 Recommended Ecological Category:

The watercourses of the assessed south and eastern network obtained a score of Pristine to Near-natural 'AB' for PES and a Moderate 'C' EIS. This places the systems in the REC 'B' category which recommends **maintaining** the river in its present state (Table 10).

Table 10: Management objectives for the eastern tributary network based on PES & EIS scores (DWAF 2007).

			Ecological Importance and Sensitivity (EIS)			
			Very High	High	Moderate	Low
PES	A	Pristine	A Maintain	A Maintain	**A Maintain**	A Maintain
	B	Natural	A Improve	A/B Improve	**B Maintain**	B Maintain
	C	Good	B Improve	B/C Improve	C Maintain	C Maintain
	D	Fair	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	Poor	D Improve	E/F Improve	E/F Maintain	E/F Maintain

5.2.3 Artificial Wetlands

5.2.3.1 Description:

Three artificial wetlands, resulting from dams, were identified within the study area (Figure 23). These dams were produced by human beings and are not naturally occurring. The dams have become artificial wetlands as wetland plants have colonised a historically non-wetland area due to human activities. The dams are very small and were likely created for livestock drinking water. They are located at the head of drainage lines and not within the streams. The systems are shallow, well vegetated (dominated by *Typha capensis*) and geomorphically stable. The two smaller dams, within the development footprint, have been subjected to slightly more human impacts. These two systems will be impacted by the development, as even if they are not completely infilled and destroyed, they will receive stormwater and surface runoff inputs, pollutants and sediments. However, these artificial systems have a low functional importance and their loss is not considered significant. If they are not infilled for housing it is recommended that they are fenced. They could possibly be used as stormwater attenuation systems.

Figure 23: Photographs illustrating the two artificial wetlands that will be impacted by the development

5.3 Freshwater habitat impacted by the sewage pipeline route

5.3.1 Diep River

A perennial Lower Foothills zoned river that originates in Kwanokuthula township of Pletternberg Bay and flows in a norther easterly direction to merge with the Bitou Estuary. There has been significant habitat loss at the head of the system due to drainage and infilling for the construction of houses. Kwanokuthula is densely populated and poorly serviced resulting in the pollution of remaining riparian habitat and downstream reaches. There are also a number of road crossings that have modified flow patterns and initiated erosion. The mid reaches and lower reaches are not directly impacted by urban development, but rather from farming activities (that have straightened the channel and removed riparian vegetation) and the dense infestation of alien invasive tree species (mostly *Acacia mearnsii*).

The reach of the river where the first pipeline crossing will be located is in largely natural ecological state (Figure 24). The river is free flowing through a confined channel that has a cobble and sand substrate. The sandy banks are largely vegetated by indigenous tree species with only a few alien individuals within the riparian area. In contrast, the downstream reach that will be crossed by the pipeline (and where the pump station is proposed) is in poor ecological condition. There is evidence of bank erosion and indigenous riparian vegetation has been replaced with alien plant species such as *Pennisetum clandestimum* and *Acacia Mearnsii (*Figure 25).

Figure 24: Photograph of the Diep River that will be crossed by the proposed sewage line

Figure 25: A reach of the Diep River as it flows into livestock grazing fields to the Bitou River in the north west. Note that there is also a pump station proposed at this location.

5.3.1.1 PES

The ecological state of the Diep River has deviated from the estimated reference condition (Table 11). The PES assessment determined that it is moderately modified but in a fair condition ('C' ecological category). Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

Table 11: Summary of PES assessment of the Diep River

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	2	70	Moderate Impact: In certain reaches of the river the channel has been straightened. Channel incision is evident in most of the reach assessed and sedimentation has buried habitat. However, these modifications have not compromised the ecological functioning of the river and there are large areas that have not been influenced.
Flow modification	3	50	Large Impact: The reach assessed has an in stream weir that affects the river during low flows. However, this has a limited impact and the longitudinal connectivity remains. There are reaches of the river that are entirely vegetated by alien invasive tree species, such as Acacia Mearnsii, that reduce water inputs to the river.
Inundation	0.5	90	Low impact: There are is a weir and impeding structures placed across this watercourse. However, these are small and localised impacts.
Bank condition	2	70	Moderate Impact: The soils are sandy and vulnerable to erosion. There are localities where bank erosion is active due to the roots of alien tree species and informal river crossings. However, the majority of the system is stable and well vegetated.
Riparian condition	2.5	60	Moderate impact: There are areas along the reach assessed where riparian habitat has been modified by vegetation clearance for agriculture and alien invasive tree infestation. However, there are large areas that are not influenced and the riparian zone is intact.
Water quality modification	2	70	Low impact: There are no nearby point pollution sources that could enter the river within the reach assessed. However, there may be significant non point pollutants entering the system from the source of the river in Kwanokathula informal settlement.
Average Score	**2.0**	68.3	**Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged**
Ecological Category	**C**	Good/Fair	

5.3.1.2 EIS

The Ecological Importance and Sensitivity assessment of the Diep River determined that it has Moderate EIS and achieved a 'C' ecological category. The riparian and instream habitat of this reach of the Diep River has a high diversity of habitat types and provides a refuge to biota. Much of this rivers importance is drawn from its connection to the Bitou Estuary downstream (of national conservation importance). The biota of the reach assessed was not considered particularly ecologically important or sensitive. However, due to the perennial nature and moderate size of the river system it is likely to support a significant amount of biota, but of relatively limited diversity.

Table 12: The Ecological Importance and Sensitivity of the Diep River

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		Score (0-4)	Rationale
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1.0	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	1.5	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	3.0	A high proportion of the biota is expected to be dependent on permanently flowing water during all phases of their life cycle.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2.0	The condition of the area and vegetation type results in a moderate species/taxon richness
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	3.0	There is high habitat diversity along the reach assessed. These include free flowing cobble/gravel runs, sandy floodplain features, marginal wetland areas, and riparian vegetation.
	Refugia (4=Very high - 1=marginal/low)	3.0	The river is moderately important as a refuge to biota during times of environmental stress. It has a high diversity of habitat types and is a corridor to the Bitou wetland complex. Additionally, it is relatively less degraded than the other similar systems in the area where urban development has encroached.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	2.0	The river is small in size, has perennial flow with a high diversity of types. Therefore it is moderately sensitive to flow changes.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1.5	The various habitat types are slightly sensitive to water quality change related to flow decreases or increases. However, in some reaches the water quality is likely to be poor already.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	2.0	The Diep River is a moderately important link in terms of connectivity for the survival of biota upstream and downstream and moderately sensitive to modification. The network provides a corridor to the Bitou Estuary which is of national importance.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2.0	There are reaches of the river that are in a natural/undisturbed area which is important for the conservation of ecological diversity on a provincial /regional scale. The Bitou River estuary downstream would be affected by any disturbances to the Diep River.
MEDIAN OF DETERMINANTS		2.00	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**MODERATE, EC=C**	Some elements sensitive to changes in water quality/hydrological regime.

5.3.1.3 REC

The management objective for this river should be to maintain it in its current ecological state without allowing any further degradation (Table 13).

Table 13: Management objectives for the Diep River based on PES & EIS scores (DWAF 2007).

			Ecological Importance and Sensitivity (EIS)			
			Very High	High	Moderate	Low
PES	A	Pristine	A Maintain	A Maintain	A Maintain	A Maintain
	B	Natural	A Improve	A/B Improve	B Maintain	B Maintain
	C	Good	B Improve	B/C Improve	C **Maintain**	C Maintain
	D	Fair	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	Poor	D Improve	E/F Improve	E/F Maintain	E/F Maintain

5.3.2 Non perennial tributaries

5.3.2.1 Description

Figure 26 below indicates the watercourses that are likely to be affected by the proposed sewage pipeline route. The findings of the Diep River assessment have been shown in Section 5.3.1 above. However, the pipeline will also traverse small non perennial drainage lines which have therefore also been assessed in detail. These tributaries merge with the Diep River or the Gansvlei River, which both flow into the Bitou River complex, to the east. The southern portion of the pipeline route has been impacted by veld fires but vegetation has re-established. These small temporary tributaries have been assessed as a group due to their physical similarities.

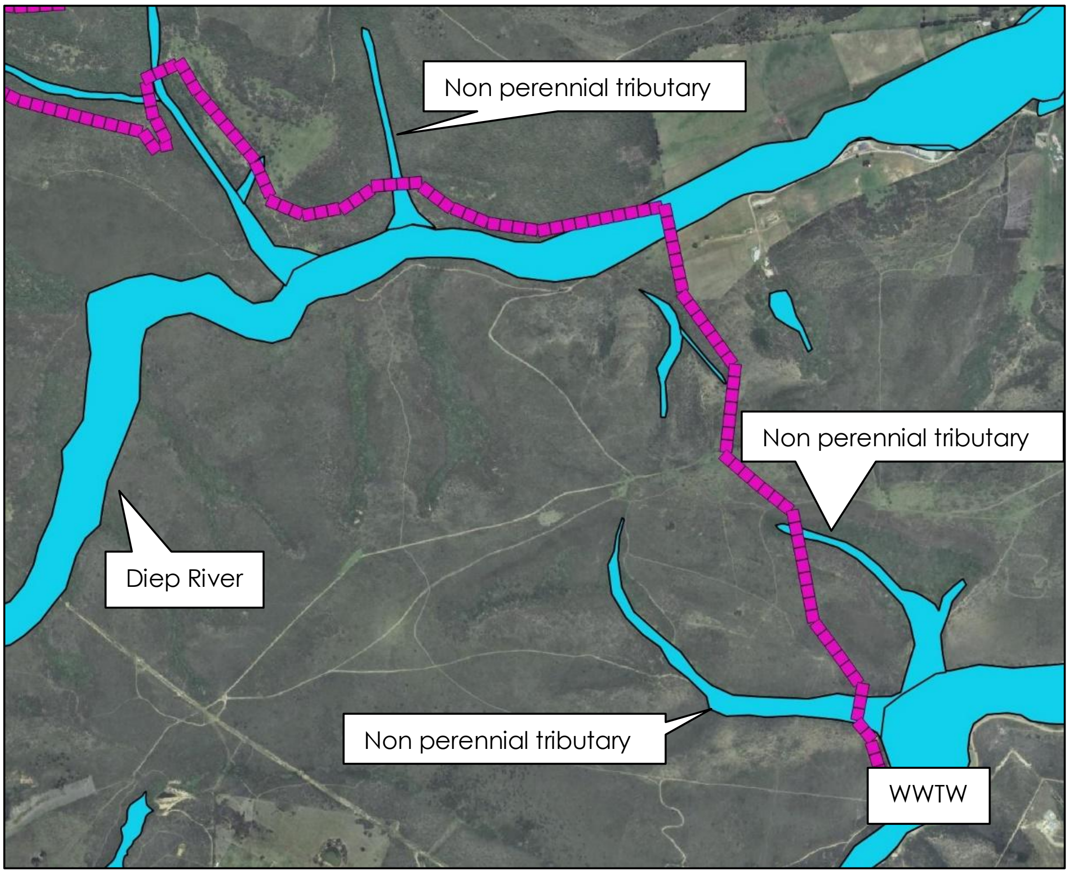


Figure 26: Map indicating the location of the non perennial streams that may be impacted upon by the sewerage pipeline (pink line) from Green Valley to Gansvlei WWTW

The tributaries are small drainage lines where surface runoff concentrates in a shallow channel during rainfall events (Figure 27). The systems are of similar ecological integrity as they share biophysical characteristics and have been similarly impacted by land use and cover changes. These tributaries are well-vegetated with the typical scrub forest of riparian areas of this biome, with only a few alien invasive individuals evident (Figure 27). The burnt areas have a higher infestation level. The streams and their small catchments are relatively undisturbed as there is limited human activity within the area. Dirt tracks and footpaths are present but have not initiated any erosion in the streams.

Figure 27: Photograph showing the channel of one of the non perennial tributaries to be crossed by the proposed pipeline

5.3.2.2 Present Ecological State (PES):

The non perennial tributaries were categorised as being in good condition ('B' system), meaning that these streams are Largely Natural with few modifications (Table 14). This describes watercourses where a small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged (Table 14).

Table 14: The Present Ecological State of the non perennial tributaries affected by the pipeline

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	1.5	80	There are pathways trough these drainage areas but this has not impacted the stream bed. The systems are unimpacted by roads, erosion or any impacts causing bed modification. There is only localised evidence of sedimentation or erosion.
Flow modification	0.5	90	The systems only flow intermittently from surface runoff. These flows have been marginally impacted by altered runoff patterns caused by footpaths or gravel roads upslope. The alien invasive tree species reduce water inputs but there is no abstraction taking place. The regime has not been impacted by decreased or increased inputs. There have been no significant flow modifications.
Inundation	0	95	There are no inundated areas. These are highly seasonal streams and do not have impeding infrastructure or habitat types that would result in inundation.
Bank condition	1.5	80	The riparian banks are stable, shallow in depth and not well defined. They are well vegetated with a mix of indigenous species and alien species. There has been no decrease in bank condition in these systems.
Riparian condition	2.5	60	Past impacts such as commercial forestry have decreased the buffer of the riparian area but the riparian zone is intact. In the southern tributaries near the WWTW a fire has altered the riparian vegetation and resulted in alien tree encroachment. Overall, the riparian area is stable and well vegetated.
Water quality modification	0.5	90	The tributaries are non perennial. There are no source pollutants from anthropogenic impacts in the systems micro catchments. There is no potential for pollutants to enter the systems at present. There is no urban development upslope or within the systems.
Average Score	**1.1**	82.5	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.
Ecological Category	**B**		

5.3.2.3 Ecological Importance and Sensitivity:

The EIS of the non perennial tributaries to be crossed by the pipeline was determined as ‘Moderate’ (C category). The systems do not have a high sensitivity as they are only intermittently inundated with no significant diversity of habitat along the reach. However, they act as an important ecological corridor to downstream rivers while providing a moderate amount of refuge to biota. Additionally, due to their undisturbed ecological state they are important for conservation purposes as intact habitat. Table 15 below provides a summary of the EIS assessment determinants and results for the pipeline intersected tributaries.

Table 15: The Ecological Importance and Sensitivity of the non tributaries crossed by the pipeline

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		Score (0-4)	Rationale
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1.5	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	2.0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	1.0	The species associated with these riparian systems are likely very tolerant of increases and decreases in flow as the systems are intermittently inundated. A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2.0	The pristine condition of the much of the riparian area and thicket vegetation type results in a moderate species/taxon richness
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	2.0	There is a low diversity in aquatic habitat types do to the shallow, straight, and intermittently flowing systems with a uniform substrate material
	Refugia (4=Very high - 1=marginal/low)	2.0	The systems have a limited ability to provide refuge to biota during times of environmental stress. This is due to the limited diversity of habitat and intermittent flow.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1.5	These small intermittent rivers, with limited habitat types, are only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1.0	These are streams with habitat types rarely sensitive to water quality change related to flow decreases or increases.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	2.0	The tributaries are a moderately important link in terms of connectivity for the survival of biota downstream and are moderately sensitive to modification.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	3	The tributaries are in a relatively undisturbed area which is important for the conservation of ecological diversity on a provincial /regional scale.
MEDIAN OF DETERMINANTS		2.00	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**MODERATE, EC=C**	Some elements sensitive to changes in water quality/hydrological regime

5.3.2.4 Recommended Ecological Category:

The non perennial streams proposed to be crossed by the pipeline were grouped for assessment and obtained a score of Largely-natural ‘B’ for PES and a Moderate ‘C’ EIS. This places the systems in the REC ‘B’ category which recommends **maintaining** the rivers in their present state (Table 16).

Table 16: Management objectives for the non perennial streams based on PES & EIS scores (DWAF 2007).

			Ecological Importance and Sensitivity (EIS)			
			Very High	High	Moderate	Low
PES	A	Pristine	A Maintain	A Maintain	A Maintain	A Maintain
	B	Natural	A Improve	A/B Improve	**B Maintain**	B Maintain
	C	Good	B Improve	B/C Improve	C Maintain	C Maintain
	D	Fair	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	Poor	D Improve	E/F Improve	E/F Maintain	E/F Maintain

5.3.3 Artificial wetland

There is an artificial wetland, possibly originating from an old livestock dam, identified within the riparian area of the Diep River, near the proposed pump station (Figure 28). It has been created by human beings and is not naturally occurring. It is seasonally saturated, shallow, well vegetated (dominated by *Cyprus sp.*) and morphologically stable. It was not assessed further due to being artificially formed and having negligible ecological value but is considered as part of the riparian habitat of the Diep River.

Figure 28: Photograph of the artificial wetland within the riparian area of the Diep River

6 IDENTIFIED IMPACTS

Aquatic ecosystems are particularly vulnerable to human activities and these activities can often result in irreversible damage or longer term, cumulative changes. The significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed. The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance is determined. Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society（Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.

The direct and indirect impacts associated with the project are grouped into four encapsulating impact categories where associated or interlinked impacts are grouped. Impacts have been separated into construction and operational phases of the project within these categories. The impacts resulting from the housing development itself are largely indirect in nature while the construction of the sewage pipeline will have direct impacts upon the rivers.

6.1 Disturbance/loss of aquatic vegetation and habitat

The disturbance or loss of aquatic vegetation and habitat refers to the direct physical destruction or disturbance of aquatic habitat caused by vegetation clearing, disturbance of riparian habitat, encroachment and colonisation of habitat by invasive alien plants. The housing development is proposed to be located outside of any riparian habitat and therefore will not have direct impacts but the pipeline will require crossing of riparian habitat which will cause habitat disturbance.

6.1.1 Construction Phase

Indigenous aquatic vegetation within the stream catchments, and possibly within the riparian zone, will be removed and disturbed due to construction activities such as excavations and infilling, as well as machinery and workers on site. This will be a direct and immediate impact resulting in short to medium term vegetation loss. Alien invasive species may be introduced and encroach into disturbed areas. Alien invasive plant encroachment into disturbed areas can outcompete indigenous vegetation and reduce aquatic biodiversity.

6.1.2 Operational Phase

The project will introduce unnatural disturbance to aquatic ecosystems, promoting the establishment of disturbance-tolerant species, including colonization by invasive alien species, weeds and pioneer plants. Although this impact is initiated during the construction phase it is likely to persist into the operational phase. Residents of the proposed development may harvest wood from the riparian habitat for firewood or create footpaths through riparian habitat. The stormwater infrastructure of the housing and associated road network will increase and concentrate flows into the systems. This may lead to erosion in the systems.

6.2 Sedimentation and erosion

Sedimentation and erosion refers to the alteration in the physical characteristics of rivers as a result of increased turbidity and sediment deposition, caused by soil erosion and earthworks that are associated with construction activities, as well as instability and collapse of unstable soils during project operation. These impacts can result in the deterioration of aquatic ecosystem integrity and a reduction/loss of habitat for aquatic dependent flora & fauna. The housing development may result in indirect impacts due to poorly managed stormwater runoff into drainage lines during the operational phase, and ineffective site management during construction can result in sedimentation through material being washed downslope in the riparian areas. The pipeline impacts are far more direct as the trenching through the bed and banks of the rivers can initiate erosion if habitat is not rehabilitated post construction and sedimentation is likely due to soil disturbance and transportation during excavations. These impacts can be magnified should construction coincide with a high rainfall event that is not appropriately planned for.

6.2.1 Construction Phase

Vegetation clearing, excavation, backfilling, stockpiling and exposure of bare soils within and upslope of the stream habitats during construction will decrease the soil binding capacity and cohesion of the upslope soils and thus increase the risk of erosion and sedimentation downslope. This may cause the burying of aquatic habitat and also cause aquatic faunal fatalities. Ineffective site stormwater management, particularly in periods of high runoff, can lead to soil erosion from confined flows. Formation of rills and gullies from increased concentrated runoff. This increase in volume and velocity of runoff increases the particle carrying capacity of the water flowing over the surface. Soil compaction resulting in reduced infiltration and increased surface runoff together with the artificial creation of preferential flow paths due to construction activities, will result in increased quantities of flow entering the systems.

6.2.2 Operational Phase

Where soil erosion problems and bank stability concerns initiated during the construction phase are not timeously and adequately addressed, these can persist into the operational phase of the development project and continue to have a negative impact on adjacent/downstream water resources in the study area. The increase in hardened surface by the development will be considerable and, if not mitigated against, will result in erosion in the systems. Surface runoff and velocities will be increased and flows may be concentrated by stormwater infrastructure.

6.3 Water Pollution

Water and/or soil pollution cause negative changes in the physical, chemical and biological characteristics of water resources (i.e. water quality). This can result in possible deterioration in aquatic ecosystem integrity and a reduction in, or loss of species of conservation concern (i.e. rare, threatened/endangered species).There is a high risk of water pollution from the residential area in the operational phase, especially during rainfall events. Although the rivers surrounding the housing are dry for long periods, they have the capacity to transport pollutants into the larger downstream systems when they do flow. Regarding the sewage pipeline, there will always be potential for the failure of the infrastructure resulting in pollution of the rivers, especially the perennial Diep River.

6.3.1 Construction Phase

During construction there are a number of potential pollution inputs into the aquatic systems (such as hydrocarbons and raw cement). These pollutants alter the water quality parameters such as turbidity, nutrient levels, chemical oxygen demand and pH. These alternations impact the species composition of the systems, especially species sensitive to minor changes in these parameters. Sudden drastic changes in water quality can also have chronic effects on aquatic biota in general and result in localised extinctions. Hydrocarbons including petrol/diesel and oils/grease/lubricants associated with construction activities (machinery, maintenance, storage, handling) may potentially enter the system by means of surface runoff or through dumping by construction workers. Raw cement entering the systems through incorrect batching procedure and/or direct disposal. The incorrect positioning and maintenance of the portable chemical toilets and use of the surrounding environment as ablution facilities may result in sewage and chemicals entering the systems.

6.3.2 Operational Phase

The increase in vehicles on the property due to the development increases the potential for pollutants to enter the systems. During maintenance of the development there could be water pollution impacts similar to those encountered in the construction phase. It is assumed that all waste water will be disposed of via existing infrastructure and will not be treated on the property. However, should any onsite waste water treatment infrastructure fail, and result in raw sewerage entering any watercourses, it may impact the water quality of the systems. In the operational phase there is potential for water pollution to occur during maintenance activities.

6.4 Flow Modification

The changes in the quantity, timing and distribution of water inputs and flows within the watercourse. Possible ecological consequences associated with this impact may include: deterioration in freshwater ecosystem integrity, reduction/loss of habitat for aquatic dependent flora & fauna, and a reduction in the supply of ecosystem goods & services. While the installation of the sewage pipeline is unlikely to modify flow regime, the housing development will impact the surrounding rivers in this way.

6.4.1 Construction Phase

Land clearing and earth works upslope of the rivers will reduce infiltration rates and increase the surface runoff volume and velocity. Such changes in surface roughness and runoff rates may lead to some rill and gully erosion. Altered water inputs from upslope disturbances as well as modified water distribution and retention patterns will ultimately affect the hydrological integrity of water resources.

6.4.2 Operational Phase

Hardened/artificial infrastructure will alter the natural processes of rain water infiltration and surface runoff, promoting increased volumes and velocities of storm water runoff, which can be detrimental to the rivers receiving concentrated flows off of these areas. According to the SANRAL (2006), urbanisation typically increases the runoff rate by 20 -50%, compared with natural conditions. Increased volumes and velocities of storm water draining from the development and discharging into down-slope rivers can alter the natural ecology the systems, increasing the risk of erosion and channel incision/scouring.

7 IMPACT SIGNIFICANCE ASSESSMENT

Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact (or resource being affected), and the likelihood / probability of the impact occurring. A methodology for assigning scores to the respective impacts is described in Annexure 12.

The impact significance of the proposed development was determined for each potential impact of the project (Table 17 and Table 18). The assessment of impacts 'with mitigation' is considered as the best case scenario and assumes that all of the mitigation measures within this report and the EMPr will be successfully implemented. However, assessment under the category 'without mitigation' measures assumes a worst case scenario involving the poor implementation of construction mitigation, bare minimum incorporation of recommended design mitigation, poor operational maintenance, and poor onsite rehabilitation. The No-Go alternative of maintaining the status quo has no impacts associated with it.

The impacts associated with the project are largely of Medium negative significance, however, may be potentially decreased to Low with the implementation of effective mitigation measures. The impacts are considered to be easily mitigated provided the mitigation measures and monitoring plan within this report are implemented and adhered to during the construction and operational phase of the project.

Table 17: Evaluation of potential impacts on the surrounding aquatic habitats during construction of the developemnt and associated infrastructure

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
CONSTRUCTION PHASE	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Medium (3)	Moderate (6)	Highly Likely (4)	**Medium (44)**	Partly	High	Yes
		With Mitigation	Site only (1)	Very short (1)	Minor (2)	Probable (3)	**Low (12)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Medium (3)	Moderate (6)	Highly Likely (4)	**Medium (48)**	Partly	Medium	Yes
		With Mitigation	Site only (1)	Very Short (1)	Minor (2)	Probable (3)	**Low (12)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Short (2)	Low (4)	Probable (3)	**Low (27)**	Partly	High	No
		With Mitigation	Local (2)	Very short (1)	Minor (2)	Improbable (2)	**Low (10)**	Barely	Low	No
	Flow modification	Without Mitigation	Local (2)	Medium (3)	Moderate (6)	Highly Likely (4)	**Medium (44)**	Partly	Medium	No
		With Mitigation	Site only (1)	Short (2)	Low (4)	Probable (3)	**Low (21)**	Barely	Low	No

Table 18: Evaluation of potential impacts of the development on the surrounding aquatic habitats during the operational phase

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
OPERATIONAL PHASE	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Permanent (5)	Minor (2)	Probable (3)	**Low (27)**	Barely	High	No
		With Mitigation	Site only (1)	Permanent (5)	Small (0)	Improbable (2)	**Low (12)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Permanent (5)	Moderate (6)	Highly Likely (4)	**Medium (56)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Permanent (5)	Minor (2)	Improbable (2)	**Low (18)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Permanent (5)	Moderate (6)	Probable (3)	**Medium (42)**	Partly	Medium	Yes
		With Mitigation	Regional (3)	Permanent (5)	Small (0)	Improbable (2)	**Low (16)**	Partly	Low	No
	Flow modification	Without Mitigation	Local (2)	Permanent (5)	Moderate (6)	Highly Likely (4)	**Medium (52)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Permanent (5)	Minor (2)	Probable (3)	**Low (27)**	Barely	Low	No

8 CUMULATIVE IMPACTS

Cumulative impacts on the environment can result from broader, long term changes and not only as a result of a single activity or development. They are rather from the combined effects of many activities overtime. The combined effect of a few projects could lead to significant change that is larger than the sum of the impacts combined. Additionally, this cumulative effect can result in the crossing of certain thresholds.

The impacts of the Green Valley housing development, when assessed on their own, are found to be acceptable (after mitigation). However, due to the increasing development within the broader Plettenberg Bay area, the combination of development impacts (including those associated with Green Valley housing) becomes cumulatively significant. Land-use changes in catchments affect the timing and amount of runoff flow into watercourses, and land-use change within a watercourses affects the pattern of water flow through the them and its residence time. The development layout (especially road designs) indicate future plans for expansion of the Green Valley development area and therefore this proposal cannot be viewed as a final land use plan for the area. High density urban residential development will largely modify the hydrology of a rivers catchment by increasing water inputs and peak flows. The cumulative impacts upon the tributaries of the broader area will ultimately impact systems of highly significant ecological, social and economic value, such as the Bitou and Keurbooms rivers and estuaries. Site selection seems poorly planned from an environmental perspective.

The water resources of the entire country are threatened largely by the cumulative impacts of development rather than individual activities. The most effective and proactive solution is sustainable development planning with a broader spatial and temporal focus. It is imperative that a broader, strategic aquatic assessment be undertaken in relation to current and future development in this area. This would allow for the identification and protection of sensitive aquatic habitat on a catchment scale and aid sustainable development planning.

The cumulative impacts of the proposed project are considered to be of Medium-High significance.

9 MITIGATION MEASURES

The mitigation of negative impacts on biodiversity and ecosystem goods and services is a legal requirement for authorisation purposes and must take on different forms depending on the significance of the impact and the specific area being affected. Mitigation requires the adoption of the precautionary principle and proactive planning that is enabled through a mitigation hierarchy (Figure 29). Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining significant residual negative impacts on biodiversity (DEA 2013).

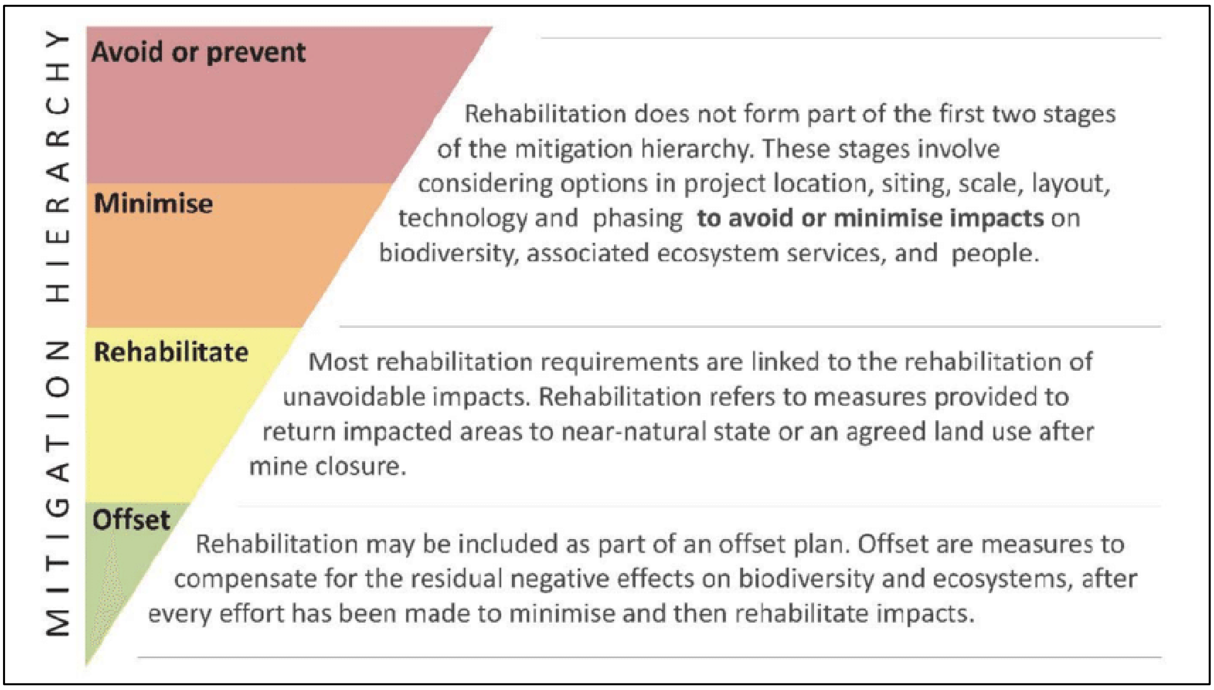


Figure 29: Diagram illustrating the 'mitigation hierarchy' (after DEA et al., 2013).

The mitigation measures detailed within this report must be taken into consideration during financial planning of the construction phase of the development. This to ensure that sufficient funds are available to implement all the measures required to maintain the current PES score of the watercourses impacted upon.

Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Standard management measures should be implemented to ensure that any on-going activities do not result in a decline in water resource quality. Consideration should also be given to the rehabilitation of watercourses where feasible. Mitigation measures related to the impacts associated with the construction activities are intended to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMPr).

In terms of Section 2 and Section 28 of NEMA (National Environmental Management Act, 1998), the landowner is responsible for any environmental damage, pollution or ecological degradation caused by their activities "inside and outside the boundaries of the area to which such right, permit or permission relates". Therefore, the monitoring of the development activities is essential to ensure the mitigation measures are implemented. Compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. In the case where there is extensive damage to any aquatic system, where rehabilitation is required, a suitably qualified aquatic specialist must audit the site. Monitoring for non-compliance must be done on a daily basis by the contractors. Photographic records of all incidents and non-compliances must be retained. This is to ensure that the impacts on the aquatic habitat are adequately managed and mitigated against and the successful rehabilitation of any disturbed areas within any system occurs. The following mitigation measures must be adhered to and monitored:

9.1 Design Phase: Aquatic Buffer Zones

Aquatic buffer zones which are designed to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions, and have therefore been adopted as a standard measure to protect water resources and associated biodiversity. An aquatic impact buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels (Macfarlane and Bredin 2016). Typical threats to buffer zone areas include:

- Access and use by local communities;
- Overgrazing and trampling by livestock;
- Transformation (e.g. new infrastructure);
- Alien plant encroachment; and
- Undesirable burning regimes.

Regarding the proposed Green Valley housing development, a buffer area from the boundary of the riparian habitat must be adopted and demarcated. The specific size of the buffer zone was determined by a tool developed by Macfarlane and Bredin (2016) called *Buffer zone guidelines for rivers, wetlands and estuaries*. The final buffer requirement includes the implementation of practical management considerations/ mitigation measures. The results recommend a minimum 15 m buffer zone between any proposed activities and the western, more degraded, tributaries (see blue buffer line in Figure 30). However, for the eastern, near pristine watercourses, a 30 m aquatic buffer zone is required from the boundary of the riparian zone (see yellow buffer line in Figure 30). A very small portion of the development layout falls within the buffer zone and is recommended to remain a vegetated area. Effective stormwater control measures must prioritise this area and areas near/ intersected by proposed access roads. It is understood that the proposed pipeline will intersect the watercourses and buffer area. Within these areas the pipeline construction must adopt the smallest possible working corridor.

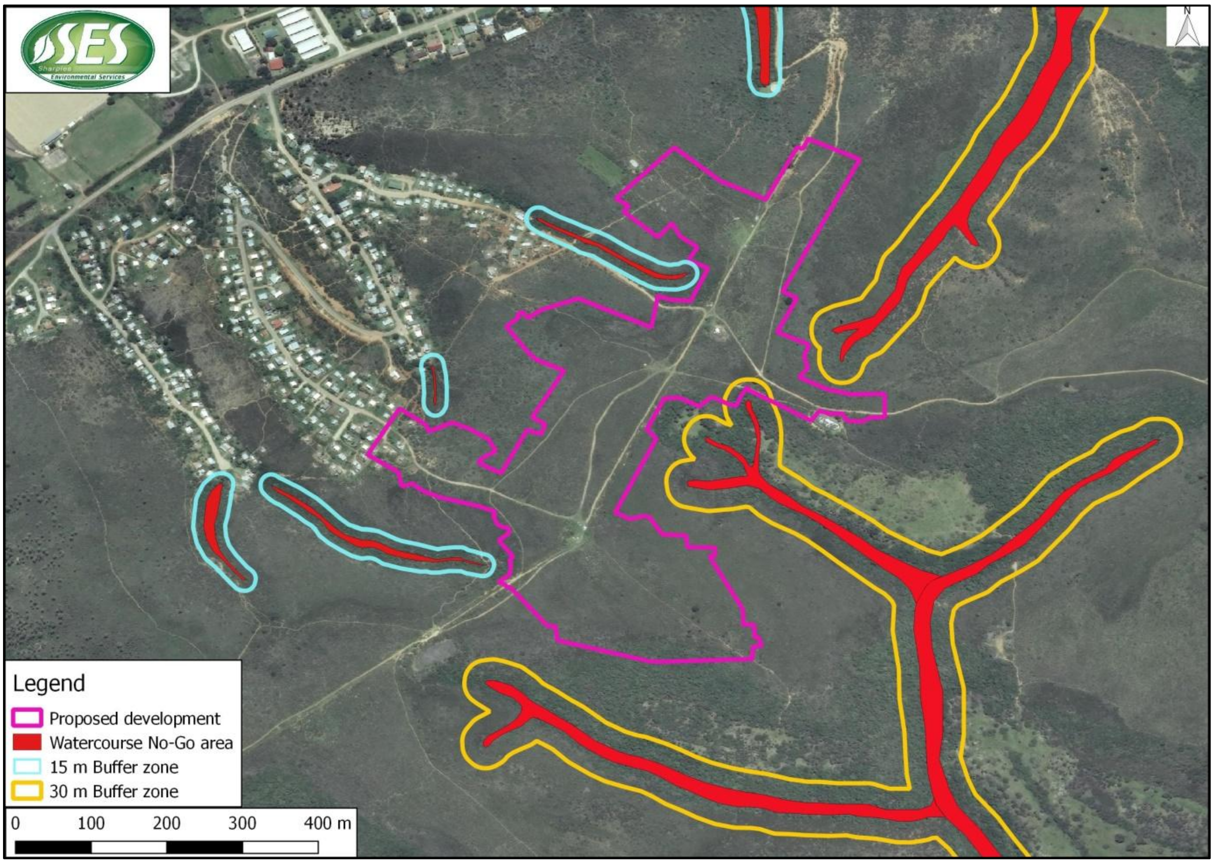


Figure 30: Watercourse No Go areas and buffer zones in relation to the proposed development

The following measures can be used to ensure the protection of the buffer zones:

- Carefully designed and managed buffer zones can contribute to a highly effective storm water management system. This requires approaches as advocated in the South African Guidelines for Sustainable Drainage Systems (Armitage, *et al.* 2013).
- Effective stormwater runoff mitigation measures include:
  - ✓ Rainwater harvesting via capturing runoff from rooftops for supplementary water uses onsite.

- ✓ Permeable pavements or parking areas (especially at schools, churches, etc) can be done via permeable concrete block pavers, brick pavers, stone chip, and gravel. However, this does not suit the steeper areas.
- ✓ Swales are shallow, grass-lined channels with flat and sloped sides. They serve as an alternate option to roadside kerbs and gutters.

- The dissemination of knowledge, through proactive campaigns, field trips and interactive stakeholder agreements. Engage with the community to explain the reasons why the buffer and the water resources are protected and what human activities are allowed. This could be targeted at learners to prevent the dumping of solid waste and other activities that threaten the watercourses and buffer zones.
- Placement of signage near the boundary of the buffer zone should also be considered to help mark the boundary and educate the community about the purpose and value of protecting buffer zones. Information can include a description and visual of alien invasive plant species.
- Monitoring implementation and management of the final buffer areas should be undertaken throughout the duration of construction activities to ensure that the effectiveness of the final buffer zone areas is maintained, and that management measures are appropriately implemented. Regular inspections during the operational phase should also be undertaken to ensure that functions are not undermined by inappropriate activities. The community could be involved in the monitoring.
- When developing a stormwater management plan for the site, it will be critical that due consideration is given to the collection and treatment of stormwater prior to discharge into the natural environment. It is therefore recommended that the stormwater management plan be developed with appropriate ecological input and be developed based on Sustainable Drainage Systems (SUDS). The SUDS systems attempt to maintain or mimic the natural flow systems as well as prevent the wash-off of urban pollutants to receiving waters. To achieve these objectives a detailed Stormwater Management Plan (SWMP) must be prepared at detailed design stage for approval.
- Inlet protection measures to capture solid waste and debris entrained in storm water entering the storm water management system (inlet protection devices) will be incorporated into the design of the system and could include the use of either curb inlet/inlet drain grates and/or debris baskets/bags. It is also important to note that storm water infrastructure will likely require regular on-going maintenance in the form of silt, debris/litter clearing in order to ensure their optimal functioning. They will therefore be designed to cater for regular maintenance.

9.2 Construction Phase

- The mitigation of impacts should focus on managing the runoff generated by the development and introducing it responsibly into the receiving environment. Therefore, the stormwater infrastructure must not be positioned where concentrated flows will enter these systems without efficient energy dissipaters (such as baffle structures like gabion mattresses). Additionally, these stormwater flows must enter the buffer area in a diffuse flow pattern.
- On the steeper sections of the housing and road networks (and the proposed pathways), and on slopes where stormwater will drain into a water resource, it is recommended that the frequency of stormwater outlets is increased to prevent erosion at discharge points.
- Any erosional features within the watercourses must be stabilised to ensure that no further erosion of the systems occurs from surface runoff. Removal of vegetation must only be when essential for the continuation of the project. Do not allow any disturbance to the adjoining natural vegetation cover or soils.
- Stormwater exit points must include a best management practice approach to trap any additional suspended solids and pollutants originating from the proposed development. Education and laws are just two best management practice examples. The most effective and economic way is to prevent the pollutants from reaching the water in the first place, rather than trying to remove them after-the-fact. Individually, people need to understand how their actions have the potential to contribute to pollution. Once they know this, they can make decisions about changing the way they do things to minimize their impacts. Structurally, consider the placement of stormwater grates. To ensure the efficiency of these, they must be regularly maintained.
- The local authority should make an effort to prevent illegal dumping in this area by providing suitable waste disposal facilities where waste can be recycled and disposed of in a controlled manner.
- The footprint of the development must be kept to a minimum, to ensure there is no unnecessary intrusion into any water resource or the buffer zone. It is noted that intrusion will be required to install the sewage pipeline but this disturbance must be kept to a minimum and rehabilitated post construction. Pipeline crossings and access road crossings should be aligned perpendicular to a steam channel.
- The access roads and proposed formal footpaths have a high likelihood of causing localised erosion due to the soils of the area and steep slopes. Erosion protection measures should be designed appropriately and be site specific.
- The recommended use and maintenance of grease traps/oil separators to prevent pollutants from entering the environment from stormwater.

9.3 Post-construction/ Rehabilitation Phase

The proposed project, if completed in accordance with this document and the site-specific EMPr, should not have heavy impacts on the aquatic habitats. There is potential for accidental disturbance therefore guidelines for rehabilitation of aquatic habitats are provided. The aim of the rehabilitation is to ensure the necessary procedures are appropriately implemented in the natural environment that may be negatively affected by the developments. The plan will promote the reestablishment of the ecological functioning of any area disturbed by construction activities. Important guidelines for rehabilitation are:

- The buffer areas must be maintained through alien invasive plant species removal and the establishment of indigenous vegetation cover to filter run-off before it enters the freshwater habitat.
- The solid domestic waste must be removed and disposed of offsite.
- Removal of vegetation must only be when essential for the continuation of the project. Do not allow any disturbance to the adjoining natural vegetation cover or soils.
- All post-construction building material and waste must be cleared in accordance with the EMPr
- Erosion features that have developed due to construction within the aquatic habitat due to the project are required to be stabilised. This may also include the need to deactivate any erosion headcuts/rills/gullies that may have developed by either compacted soil infill, rock plugs, gabions or any other suitable measures can be used for this purpose.
- Pipeline crossing must not alter the cross sectional shape or elevation of the stream channels. If the pipeline crossings are buried below the ground surface within the river channels then rehabilitation must include the return of the longitudinal and cross sectional profile to pre-construction gradients.
- It is the contractor's responsibility to continuously monitor the area for alien species during the contract and establishment period, which if present must be removed.
- Removal of these species shall be undertaken in a way which prevents any damage to the remaining indigenous species and inhibits the re-infestation of the cleaned areas.
- Alien/ invasive species shall not be stockpiled, they should be removed from site and dumped at an approved site.
- Any use of herbicides in removing alien plant species is required to be investigated by the ECO before use, for the necessity, type proposed to be used, effectiveness and impacts of the product on aquatic biota.

- A monitoring programme shall be in place, not only to ensure compliance with the EMPr throughout the construction phase, but also to monitor any post-construction environmental issues and impacts during the vegetation establishment phase.

9.4 Operational Phase

- The stormwater management infrastructure must be designed to ensure the run-off from the development is not highly concentrated before entering the buffer areas. The volume and velocity of water must be reduced through discharging the surface flow at multiple locations surrounding the development, preventing erosion.
- Any evidence of erosion from this stormwater system must be rehabilitated and the volume/velocity of the water reduced through further structures such as gabions, renomattresses and/or energy dissipaters at the exit of the stormwater culverts.
- The recommended use and maintenance of grease traps/oil separators to prevent pollutants from entering the environment from stormwater. Additionally, residents should be educated regarding the effects of pollution on the environment and the responsible methods for the disposal of waste.
- Appropriate waste water infrastructure must be designed to prevent any such water from entering the surrounding environment.
- Maintenance of the buffer area must be implemented for it to remain effective. Apart from erosion control and alien invasive plant eradication, the encroachment of any infrastructure or agricultural activities must be prevented.

10 WATER LICENSING REQUIREMENTS

The proposed development requires a Water Use License (WUL) in terms of Chapter 4 and Section 21 (c) and (i) of the National Water Act No. 36 of 1998 and this must be secured prior to the commencement of construction. The following water uses have been identified for the project:

- Section 21 (c): Impeding or diverting the flow of a watercourse
- Section 21 (i): Altering the bed, banks, course or characteristics of a watercourse

These water uses will be associated with the following activities:

- The construction of infrastructure within the regulated area of the identified watercourses
- Waste water pipelines crossing rivers, adjacent to rivers, as well as within 500 m of the boundary of a wetland.
- The construction of road crossings on a watercourse

- Various potential indirect impacts upon watercourse characteristics from construction and operation phases.

The General Authorisation (GA) for Section 21 c and i water use does not apply for "Any water use associated with the construction, installation or maintenance of any sewerage pipeline, pipelines carrying hazardous materials and to raw water (wastewater) and wastewater treatment works" and therefore a full WULA is required. A water use license is currently being applied for through the online eWULAAs system and with the BGCMA.

11 CONCLUSION

Sharples Environmental Services cc were appointed by Bitou Local Municipality to conduct an independent specialist aquatic habitat impact assessment for the proposed Green Valley housing development, to provide specialist input into the environmental authorisation process and fulfil water use authorisation requirements. All watercourses within the 500m radius study area of the proposed project were identified, delineated, investigated infield, screened and rated in accordance to their risk of being impacted upon. It was found two riparian tributary networks, east and west of the watershed, will be impacted upon by the proposed housing site. It was determined that the associated sewage pipeline to the Plettenberg Bay wastewater treatment works will also impact upon various watercourses. The ecological state and importance of these identified freshwater systems was assessed to produce recommended management objectives.

The direct and indirect impacts associated with the project were identified and grouped into four encapsulating impact categories. The impacts identified are:

- The disturbance or loss of aquatic vegetation and habitat
- Sedimentation and erosion
- Water pollution
- Flow modification

The study has found that the proposed development will likely have a moderate impact upon the riparian systems. However, after stormwater, erosion and sediment control measures are incorporated in the process, the proposed project will have a low impact on aquatic habitat. It is recommended that the final layout plan account for the determined aquatic buffer zones to mitigate developmental impacts. In particular, the impacts must be mitigated to protect the eastern tributaries that are in near pristine condition and flow into the Bitou River, as well as the Diep River to be crossed by the pipeline. The impacts are considered to be possible to mitigate with the measures detailed within this report. From an aquatic perspective, there are no fatal flaws associated with the project provided recommendations are adhered to. However, due to increasing population pressures in the area it is imperative that more strategic aquatic planning be undertaken to reduce land use conflicts in future. This would allow for the identification and protection of sensitive aquatic habitat on a catchment scale and aid for forward development planning.

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13 ANNEXURE (METHODOLOGIES)

13.1 Wetland delineation and HGM type identification

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005a). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

Four specific wetland indicators were used in the detailed field delineation of wetlands, which include:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

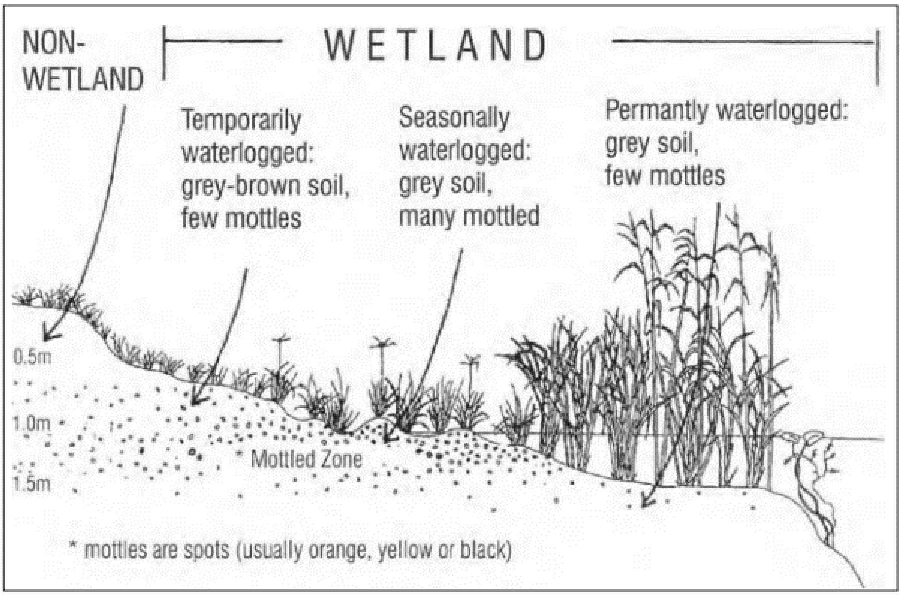

Figure A11.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table A11.1a)

A11.1a: Soil Wetness Indicators in the various wetland zones

TEMPORARY ZONE	SEASONAL ZONE	PERMANENT ZONE
Minimal grey matrix (<10%)	Grey matrix (<10%)	Prominent grey matrix
Few high chroma mottles	Many low chroma mottles present	Few to no high chroma mottles
Short periods of saturation (less than three months per annum)	Significant periods of wetness (at least three months per annum)	Wetness all year round (possible sulphuric odour)

Table A11.1b: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands

VEGETATION	TEMPORARY WETNESS ZONE	SEASONAL WETNESS ZONE	PERMANENT WETNESS ZONE
Herbaceous	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants.
Woody	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).
SYMBOL	**HYDRIC STATUS**	**DESCRIPTION/OCCURRENCE**	
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas	

F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)
D	Dryland species	Almost always grow in drylands

In order to identify the wetland types, using Kotze *et al.* (2009) and Ollie *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. These have been defined based on the geomorphic setting of the wetland in the landscape (e.g. hillslope or valley bottom, whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Figure A11.1b).

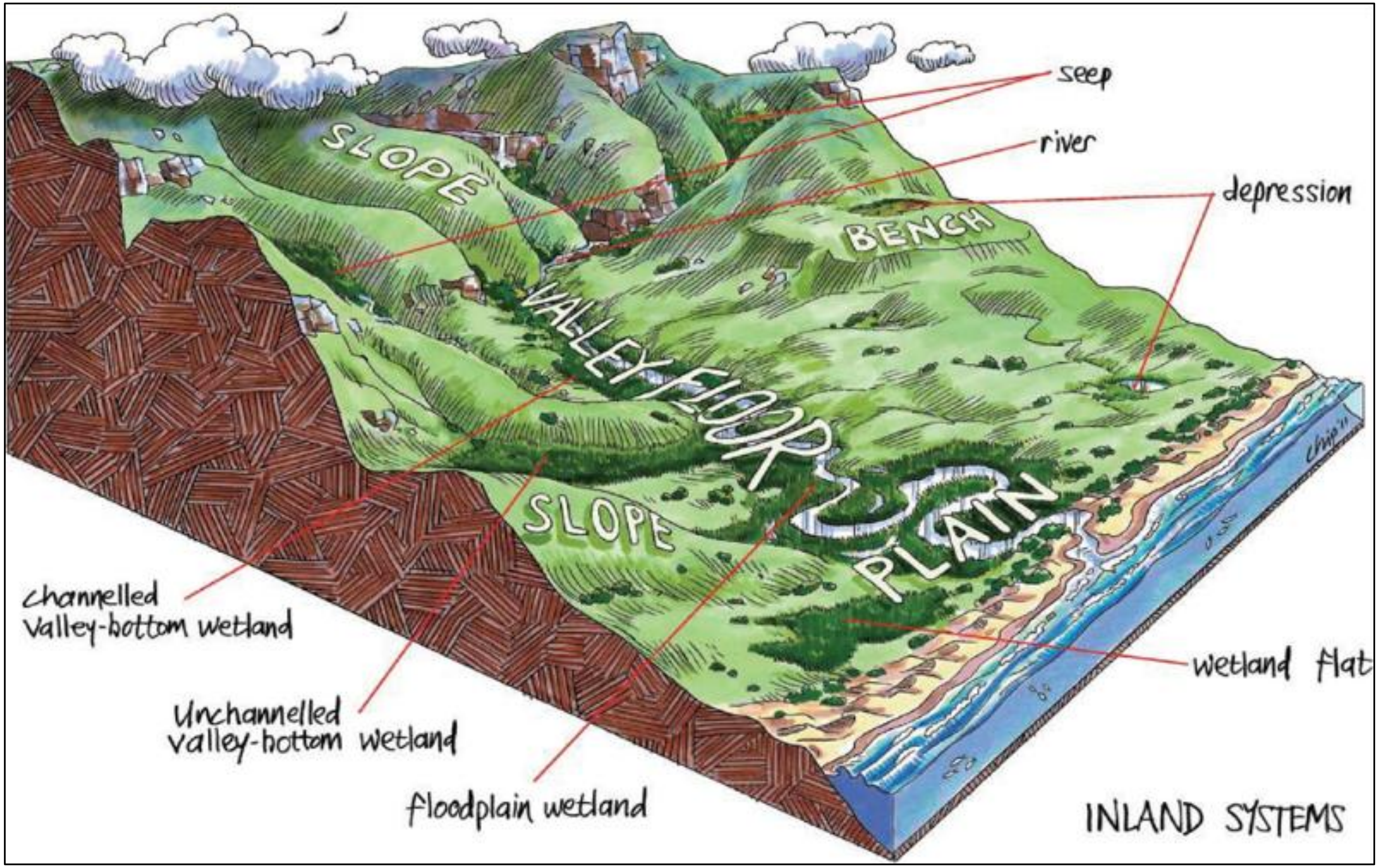

Figure A11.1b: Illustration of wetland types and their typical landscape setting (From Ollie et al. 2013)

13.2 Delineation of Riparian Areas

Riparian zones are described as "the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas" i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (Figure 8). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units (Figure 2), namely the: - Crest (hilltop); - Scarp (cliff); - Midslope (often a convex slope); - Footslope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or stream channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

Topography and recently deposited material associated with riparian areas The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised "macro-channels" which are typical of many of southern Africa's eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

As with the delineation approach for wetlands, the field delineation method for riparian areas focuses on two main indicators of riparian zones: - **Vegetation Indicators**, and - **Topography** of the banks of the river or stream.

Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or stream channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of “restrictive floodplain” within which one or more active channels flow. Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

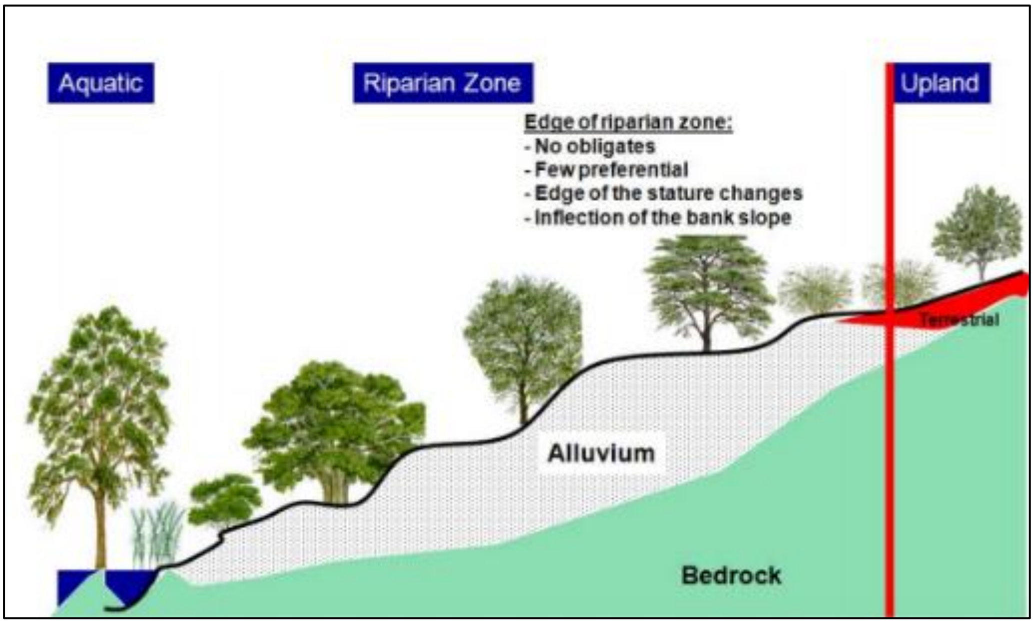

Figure A11.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).

13.3 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively. Level 1 was utilised for the assessment of the wetlands impacted upon by the Dambuza Road upgrade.

WET-Health is a tool designed to assess the health or integrity of a wetland. Wetland health is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health in three separate modules.

Hydrology is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland.

Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (Table A11.2a).

Table A11.2a: Guideline for interpreting the magnitude of impacts on integrity (Macfarlane et al., 2008).

IMPACT CATEGORY	DESCRIPTION	SCORE
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table A11.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table A11.2b. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

IMPACT CATEGORY	DESCRIPTION	RANGE	PES CATEGORY
None	Unmodified, natural.	0 – 0.9	**A**
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9	**B**
Moderat e	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	**C**
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	**D**
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still	6 – 7.9	**E**
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10	**F**

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

13.4 Wetland Functional Importance (Goods and Services)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table A11.4a) - that is, the benefits provided to people by the ecosystem.

Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Flood attenuation	The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
				Streamflow regulation	Sustaining streamflow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
				Carbon storage	The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance[2]**			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits		Provision of water for human use	The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
				Provision of harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
				Provision of cultivated foods	The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits		Cultural heritage	Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants
				Tourism and recreation	Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
				Education and research	Sites of value in the wetland for education or research

Table A11.4a: Ecosystem services assessed by WET-Ecoservices

The steps involved in applying WET-EcoServices can be summarised as follows.

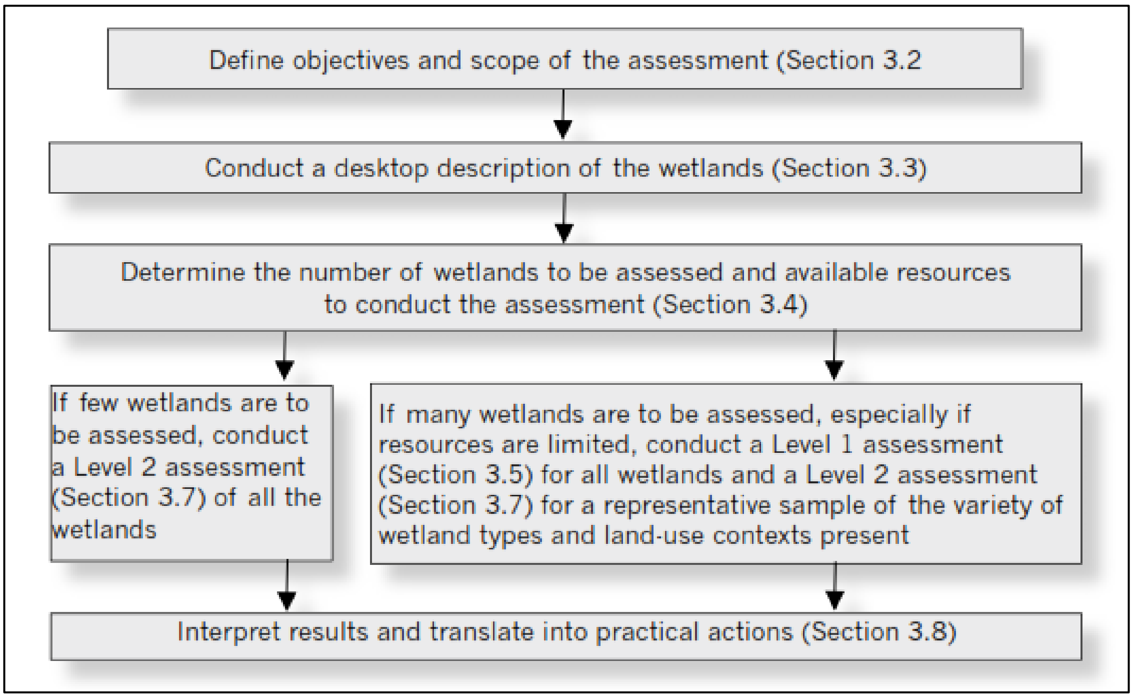

Figure A11.4a: Steps required for Wet-EcoServices. The sections referred to within this figure relate back to the Wetland Management Series: Wet-Ecoservices. WRC Report TT 339/08

13.5 Ecological Importance & Sensitivity (EIS) - Wetlands

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table A11.5a. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 14.5b.

Table A11.5a: Example of scoring sheet for Ecological Importance and sensitivity

ECOLOGICAL IMPORTANCE AND SENSITIVITY:			
Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation for site**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			
HYDROLOGICAL/FUNCTIONAL IMPORTANCE			
IMPORTANCE OF DIRECT HUMAN BENEFITS			
OVERALL IMPORTANCE			

Table A11.5b: Category of score for the Ecological Importance and Sensitivity

RATING	EXPLANATION
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

13.6 Present Ecological State (PES) – Riparian

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table A11.6a) according to the following metrics:

- Bed modification
- Flow modification
- Inundation
- Bank condition
- Riparian zone condition
- Water quality modification

This assessment was informed by (i) a site visit where potential impacts to each metric were assessed and evaluated and (ii) an understanding of the catchment feeding the river and landuses / activities that could have a detrimental impact on river ecosystems.

Table A11.6a: The rating scale for each of the various metrics in the assessment

RATING SCORE	IMPACT CLASS	DESCRIPTION
0	**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.*
0.5 - 1.0	**Low**	*The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.*
1.5 - 2.0	**Moderate**	*The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.*
2.5 - 3.0	**Large**	*The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.*
3.5 - 4.0	**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.*
4.5 - 5.0	**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.*

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table A11.6b).

Table A11.6b: The habitat integrity PES categories

HABITAT INTEGRITY PES CATEGORY	DESCRIPTION
A: Natural	Unmodified, natural.
B: Good	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C: Fair	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D: Poor	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E: Seriously modified	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F: Critically modified	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

13.7 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh et al., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table A11.7a).

Table A11.7a: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided.

Ecological Importance and Sensitivity assessment (Rivers)		
Determinants		**Score (0-4)**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0,5
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0,0
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	0,5
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1,5
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1,0
	Refugia (4=Very high - 1=marginal/low)	1,5
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1,0
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	1,0
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2
MEDIAN OF DETERMINANTS		1,00
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**LOW, EC=D**

The scores assigned to the criteria in Table A11.7a were used to rate the overall EIS of each mapped unit according to Table A11.7b, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane et al., 2008).

Table A11.7b: The ratings associated with the assessment of the EIA for riparian areas

RATING	EXPLANATION
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

13.8 Direct, Indirect and Cumulative Impacts Methodology

Direct, indirect and cumulative impacts should be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.

- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration**, wherein it will be indicated whether:
    - The lifetime of the impact will be of a very short duration (0-1 years) – assigned a score of 1.
    - The lifetime of the impact will be of short duration (2-5 years) – assigned a score of 2;
    - Medium term (5-15 years) – assigned a score of 3;
    - Long-term (> 15 years) – assigned a score of 4; or
    - Permanent – assigned a score of 5.

- The **magnitude**, quantified on a scale of 0-10, where:
    - 0 is small and will have no effect on the environment,
    - 2 is minor and will not result in an impact on processes,
    - 4 is low and will cause a slight impact on processes,
    - 6 is moderate and will result in processes continuing but in a modified way,
    - 8 is high (processes are altered to the extent that they temporarily cease), and
    - 10 is very high and results in complete destruction of patterns and permanent cessation of processes.

- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5, where:
    - 1 is very improbable (probably will not happen),
    - 2 is improbable (some possibility, but low likelihood),
    - 3 is probable (distinct possibility),
    - 4 is highly likely (most likely) and;
    - 5 is definite (impact will occur regardless of any prevention measures).

- The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high;
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources; and
- The degree to which the impact can be mitigated.

- The significance is calculated by combining the criteria in the following formula, **S = (E+D+M) P**, where:
    - S = significance weighting
    - E = extent
    - D = duration
    - M = magnitude
    - P = probability

- The significance weightings for each potential impact are as follows:
    - <30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop the area),
    - 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
    - >60 points: High (i.e. where the impact must have an influence on the decision process to develop the area).

14 DWS RISK MATRIX

No.	Phases	Activity	Aspect	Impact	Flow Regime	Physio & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	PES AND EIS OF WATERCOURSE
1	CONSTRUCTION PHASE	Indigenous aquatic vegetation will be disturbed due to construction activities such as excavations and infilling, as well as machinery and workers on site.	Disturbance /loss of aquatic habitat	Indigenous aquatic vegetation within the stream catchments, and possibly within the riparian zone, will be removed and disturbed due to construction activities such as excavations and infilling, as well as machinery and workers on site. Alien invasive plant encroachment can outcompete indigenous vegetation and reduce aquatic biodiversity.	1	1	2	1	1.25	2	2	5.25	1	1	0	2	4	**21**	**LOW**	90	A minimum 15 m buffer zone between any proposed activities and the western, more degraded, tributaries. However, for the eastern, near pristine watercourses, a 30 m aquatic buffer zone is required. Fencing off the boundary may protect the buffer zone from dumping, livestock and human intrusion.	PES A/B and EIS Moderate
	OPERATIONAL PHASE		Disturbance /loss of aquatic habitat	Colonization by invasive alien species, weeds and pioneer plants. Although this impact is initiated during the construction phase it is likely to persist into the operational phase. Residents of the proposed development may harvest wood from the riparian habitat for firewood or create footpaths through riparian habitat. The stormwater infrastructure of the housing and associated road network will increase and concentrate flows into the systems.	0	0	1	0	0.25	1	5	6.25	1	1	0	2	**4**	**25**	**LOW**	90		PES A/B and EIS Moderate
2	CONSTRUCTIONL PHASE	The alteration in the physical characteristics of rivers as a result of increased turbidity and sediment deposition, caused by soil erosion and earthworks that are associated with construction activities, as well as instability and collapse of unstable soils during project operation.	Sedimentation and erosion	Ineffective site stormwater management, particularly in periods of high runoff, can lead to soil erosion from confined flows. Formation of rills and gullies from increased concentrated runoff. Soil compaction resulting in reduced infiltration and increased surface runoff together with the artificial creation of preferential flow paths will result in increased quantities of flow entering the systems.	2	2	1	1	1.5	2	2	5.5	1	1	0	2	4	**22**	**LOW**	80	The mitigation of impacts should focus on managing the runoff generated by the development and introducing it responsibly into the receiving environment. Therefore, the stormwater infrastructure must not be positioned where concentrated flows will enter these systems without efficient energy dissipaters (such as baffle structures like gabion mattresses). Additionally, these stormwater flows must enter the buffer area in a diffuse flow pattern. On the steeper sections of the housing and road networks, and on slopes where stormwater will drain into a water resource, it is recommended that the frequency of stormwater outlets is increased to prevent erosion at discharge points. The stormwater management plan must attempt to include porous pavements, grassed swales, and infiltration trenches and basins within the property.	PES A/B and EIS Moderate
	OPERATIONAL PHASE		Sedimentation and erosion	The increase in hardened surface by the development will be considerable and, if not mitigated against, will result in erosion in the systems. Surface runoff and velocities will be increased and flows may be concentrated by stormwater infrastructure.	2	2	1	1	1.5	2	5	8.5	1	3	0	2	6	**51**	**LOW**	80		PES A/B and EIS Moderate
3	CONSTRUCTION PHASE	Hydrocarbons including petrol/diesel and oils/grease/lubricants associated with construction activities. Raw cement through incorrect batching procedure and/or direct disposal. The incorrect positioning and maintenance of the portable chemical toilets and use of the surrounding environment as ablution facilities.	Water Pollution	These pollutants alter the water quality parameters such as turbidity, nutrient levels, chemical oxygen demand and pH. These alternations impact the species composition of the systems, especially species sensitive to minor changes in these parameters. Sudden drastic changes in water quality can also have chronic effects on aquatic biota in general and result in localised extinctions. Sewage and chemicals entering the systems.	0	4	2	1	1.75	2	2	5.75	1	1	1	3	6	**34.5**	**LOW**	90	Stormwater exit points must include a best management practice approach to trap any additional suspended solids and pollutants originating from the proposed development. To ensure the efficiency of these, they must be regularly maintained. The recommended use and maintenance of grease traps/oil separators to prevent pollutants from entering the environment from stormwater. The solid domestic waste must be removed and disposed of offsite.	PES A/B and EIS Moderate
	OPERATIONAL PHASE		Water Pollution	The increase in vehicles on the property due to the development increases the potential for pollutants to enter the systems. During maintenance of the development there could be water pollution impacts similar to those encountered in the construction phase.	0	4	2	0	1.5	1	5	7.5	1	3	0	2	6	**45**	**LOW**	80		PES A/B and EIS Moderate