Riparian Habitat and Wetland Delineation Impact Assessment for the proposed Surface Water Developments for Augmentation of the Western Cape Water Supply System

November 2016

REFERENCE

10598

VERSION

FINAL

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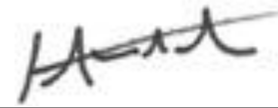
Report name	**Riparian Habitat and Wetland Delineation Impact Assessment for the proposed Surface Water Developments for Augmentation of the Western Cape Water Supply System**	
Reference code	**10598**	
Submitted to	**Nemai Consulting**	
Report writer	**Andrew Husted** **MSc Aquatic Health** **SACNASP 400213/11**	
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Peter Kimberg is a biodiversity consultant with 12 years of experience conducting ecological assessments. He has conducted assessments across southern Africa and in 15 countries in sub-Saharan Africa. He has extensive experience conducting biodiversity studies throughout South Africa, with considerable experience working within Gauteng, and is therefore familiar with the local conditions and local legislature.		

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EXECUTIVE SUMMARY

The Biodiversity Company was appointed to conduct a Riparian Habitat and Wetland Delineation Impact Assessment for the project. This specialist study aimed to assess the local watercourses and wetland (including riparian) systems associated with the proposed project infrastructure alternatives. The study was completed in fulfilment of the Environmental Impact Assessment (EIA) and Environmental Authorisation process for the proposed Surface Water Developments of the Western Cape Water Supply System (Berg River-Voëlvlei Augmentation Scheme) in the Western Cape Province. The scheme involves the transfer of approximately 23 million m^3 per annum from the Berg River to the existing Voëlvlei Dam.

Aquatic Ecology

The focus for the study is one study reach on the Berg River which feeds into the Atlantic Ocean and three points on the Voëlvlei Dam. The area surrounding the proposed project site consists of agricultural and livestock activities. The activities in the area and local land uses have had impacts to the aquatic system and visible disturbances were moderate. Due to these activities, the Berg River system and Voëlvlei Dam are regarded as largely modified at a desktop level.

Desktop Data for Sub-Quaternary Catchment G10F-8604 and G10F-8658, respectively

NFEPA's	**No NFEPAs listed**	**No NFEPAs listed**
Present Ecological Status	**Largely modified (Class D)**	**Largely modified (Class D)**
Ecological Importance	**Low**	**Moderate**
Ecological Sensitivity	**High**	**High**

According to the 2016 low flow season assessment, the state of the Berg River was in a largely modified state, which has led to modified macroinvertebrate and fish community assemblages. Furthermore, impacts to instream and riparian habitat and more notable water quality were evident.

Aquatic Assessment Results for the October 2016 survey

Site	**Berg River**	**Voëlvlei Dam**
In Situ Water Quality Parameters	**Poor**	**N/A**
Integrated Habitat Assessment System	**Good**	**N/A**
Flow	**0.2 - 0.4 m/s**	**Dam (75% full)**
Clarity	**35 cm (Eutrophic)**	**20cm (Turbid)**
Biotic Integrity Based on SASS5 Results	**C (Moderately modified)**	**N/A**
Fish	**Seriously modified**	**Seriously modified**

Current Ecological Status	Seriously modified (E)	Largely modified (D)

Wetland Assessment

The desktop study concluded with reasonable confidence that due to the distance of the Berg River estuary and floodplain from the project area, and also considering the nature of this project, no risks to the Berg River floodplain are expected.

The project area is associated with numerous NFEPA wetland types. These are largely associated with the Berg River and the Voelvlei Dam. None of the local NFEPA wetlands are classified as ecological priority areas.

Numerous wetland types were identified and delineated for the study. These include valley bottom systems, hillslope seeps, depressions and the Berg River floodplain. The ecological status of the riparian area within the floodplain was determined to be largely modified. The integrity of the assessed wetland systems was determined to vary from moderately to largely modified. The local commercial agricultural activities and developments have contributed to the modifications of these systems.

The proposed project will have both direct and indirect impacts on the local watercourses. The most significant risks are associated with the weir and fishway structures, with the level of risk determined to be moderate. These moderate risks are expected for the construction and operation of the project. The risks associated with the supporting activities and linear structures was determined to be low.

Several concerns regarding the fishway design have been highlighted and need to be addressed for the fishway to be successful.

In terms of the road options, Option 1 is the most preferred for the study. The least preferred road option is Option 2. With regards to the pipeline alternatives, Alternative 1 is not recommended, and the preferred alternative is Alternative 3.

It is recommended that an aquatic monitoring programme be implemented after construction activities should the proposed project commence. A buffer zone of 15m and 21m has been prescribed for the construction and operational phase respectively.

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List of Abbreviations

ASPT	Average Score Per Taxon
BA	Basic Assessment
DD	Data Deficient
DO	Dissolved Oxygen
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EC	Electrical conductivity
EI	Ecological Importance
EIS	Ecological Importance and Sensitivity
EPT	Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies)
ES	Ecological Sensitivity
ESA	Ecological Support Area
FEPA	Freshwater Ecosystem Priority Areas
GSM	Gravel, Sand, and Mud
HGM	Hydro-geomorphic
IHAS	Invertebrate Habitat Assessment System
IHIA	Intermediate Habitat Integrity Assessment
IT	Invertebrate Tolerance
LC	Least Concern
NEM:BA	National Environment Management Biodiversity Act's
NEMA	National Environmental Management Act
NFEPA	National Freshwater Ecosystem Priority Areas
NT	Near Threatened
NWA	National Water Act
PES	Present Ecological Status
RHP	River Health Project
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System
SIC	Stones In Current
SOOC	Stones Out OF Current
SQR	Sub-quaternary reach
TWQR	Target Water Quality Range
VU	Vulnerable
WMA	Water Management Area
WULA	Water Use Licence

DECLARATION

I, **Andrew Husted** declare that:

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

Andrew Husted

The Biodiversity Company

8 November 2016

DECLARATION

I, **Dale Kindler** declare that:

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

Dale Kindler

The Biodiversity Company

8 November 2016

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1. INTRODUCTION

Nemai Consulting was appointed to undertake the Environmental Authorisation process for the Proposed Surface Water Developments for Augmentation of the Western Cape Water Supply System.

The Biodiversity Company was subsequently appointed by Nemai Consulting to conduct a Riparian Habitat and Wetland Delineation Impact Assessment for the project. This specialist study aimed to assess the local watercourses and wetland (including riparian) systems associated with the proposed project infrastructure alternatives.

The fieldwork was conducted from 25-27 October, which is considered to be the onset of the dry season period.

1.1 Background

The Western Cape Water Supply System serves the City of Cape Town, surrounding urban centres and irrigators. It consists of infrastructure components owned and operated by both the City of Cape Town and the Department of Water and Sanitation (DWS). In 2007, the Western Cape Reconciliation Strategy Study was commissioned by DWS to determine future water requirements for a 25 year planning horizon. The Study investigated a number of options and found that whilst 556 million m^3 per annum would be available from 2007, the estimated water requirement in 2011 would be 560 million m^3/a, with the implication that the system supply will then be fully utilised and thus additional interventions will thus be required.

Based on the above, DWS identified the need for augmentation of the Western Cape Water Supply System by 2019 and proceeded with pre-feasibility and feasibility studies into potential surface water development options. Initially, six options were assessed at a pre-feasibility level of detail. These options were then prioritized to identify the two most viable options. These were:

- Berg River-Voëlvlei Augmentation Scheme (also known as the First Phase Augmentation of Voëlvlei Dam); and
- Breede-Berg Transfer Scheme (also known as the Michell's Pass Diversion Scheme).

Ultimately, the Feasibility Study found that the Berg River-Voëlvlei Augmentation Scheme option was the most favourable surface water intervention and as such the Department of Water and Sanitation proposes to implement this scheme which involves the transfer of approximately 23 million m^3 per annum from the Berg River to the existing Voëlvlei Dam.

1.2 Project options

The project components include the following:

- A 160 m long low level weir, abstraction works (peak abstraction discharge of 6 m^3/s) and 4 m^3/s raw water pump station on the Berg River;
- A rising main pipeline from the Berg River to Voëlvlei Dam;

- A potential new summer release connection at the existing Swartland Water Treatment Works (WTW) to facilitate summer releases into the Berg River for environmental requirements thus eliminating the need to utilize the existing canal from which water losses occur; and

- The summer release outlet will be located within the same servitude as the main pipeline and will have gabion-type structures at the discharge point.

All the infrastructure and activities that require environmental authorisation need to be assessed as part of the Environmental Impact Assessment (EIA). In this regard, the following associated infrastructure was identified:

- Abstraction works;
- Rising main pipeline and pump station;
- Diversion weir;
- Access roads during construction;
- Access roads during operation; and
- Construction camp (footprint).

Three pipeline routes were investigated during the Technical Feasibility Study and will be assessed as part of the EIA. These routes are related to three potential discharge options into the dam from the diversion weir site. These routes are as follows:

- Pipeline route to Northern Discharge Point = 8 115 m;
- Pipeline route to Central Discharge Point = 5 000 m; and
- Pipeline route to Southern Discharge Point = 6 300 m.

Whilst design flows of 4 and $6m^3/s$ were considered for the rising main during the Technical Feasibility Study, the EIA will only assess the $4m^3/s$ option which was deemed most feasible during the Technical Feasibility Study.

1.3 Aim & objectives

Three pipeline routes, access routes and discharge points' alternatives were provided for the Specialists to assess. The aim of the study is to recommend which alternative layout is preferred and to provide supporting motivation. The following primary objectives were considered for the study:

- Assessing and delineating watercourses (river crossings and wetland crossings as well as wetlands within a 500m radius of project footprint) at varying levels of detail and rigour, based on the risks posed to the affected watercourses;

- Conduct a comprehensive desktop assessment for the local systems;

- Determine the ecological status of the local watercourses and wetland systems where applicable;
- Conduct an assessment of the fishway, comprising a vertical slotted fishway or a rock-ramp type;
- Conduct a risk assessment for the receiving systems in light of the proposed project. Where applicable provide suggestions to avoid impacts, and where impacts are unavoidable prescribe measures to mitigate these impacts; and
- Provide recommendations and a monitoring programme for the project.

2. LIMITATIONS

The following limitations are expected for the project

- According to the DWAF (2005) wetland and riparian area delineation guidelines, key indicators are required for the demarcation of these systems. Due to the fact that the local land uses include commercial agricultural activities and the establishment of infrastructure which includes roads, railways and settlements, the implementation of the required indicators was somewhat inhibited. In an attempt to address this, desktop data and imagery were considered to supplement the study findings.
- Due to the extent of the study area, only areas (or systems) expected to be directly impacted on because of the project alternatives were ground truthed. These areas formed the focus and basis for the baseline study, and impact assessment. The adjacent and extending watercourses were identified, delineated and assessed at a desktop level only.

3. KEY LEGISLATIVE REQUIREMENTS

3.1 National Water Act (NWA, 1998)

The DWS is the custodian of South Africa’s water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (NWA) (Act No. 36 of 1998) allows for the protection of water resources, which includes:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means:

- A river or spring;

- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem, and not just the water itself, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the DWS. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) and (i).

However, according to General Notice 509 as published in the Government Gazette No. 40229 of 2016, it must be noted that as defined by the Replacement General Authorisation in terms of Section 39 of the National Water Act, on account of the extremely sensitive nature of wetlands and estuaries, the section 21(c) and (i) water use General Authorisation does not apply to:

- To the use of water in terms of section 21(c) or (i) of the Act for the rehabilitation of a wetland;
- To the use of water in terms of section 21(c) or (i) of the Act within the regulated area of a watercourse where the Risk Class is Medium or High;
- In instances where an application must be made for a water use license for the authorisation of any other water use as defined in section 21 of the Act that may be associated with a new activity;
- Where storage of water results from the impeding or diverting of flow or altering the bed, banks, course or characteristics of a watercourse; and
- To any water use in terms of section 21(c) or (i) of the Act associated with construction, installation or maintenance of any sewerage pipelines, pipelines carrying hazardous materials and to raw water and wastewater treatment works.

For the purposes of this project, a wetland area is defined according to the NWA (Act No. 36 of 1998): "*Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*".

It must be noted that the NWA definition is not concerned with marine systems and clearly distinguishes wetlands from estuaries, classifying the latter as a water course (SANBI, 2009). Wetlands therefore have one or more of the following attributes to meet the NWA wetland definition (DWAF, 2005):

- A high water table that results in the saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil;
- Wetland or hydromorphic soils that display characteristics resulting from prolonged saturation, i.e. mottling or grey soils; and
- The presence of, at least occasionally, hydrophilic plants, i.e. hydrophytes (water loving plants).

3.2 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Environmental Impact Assessment (EIA) Regulations as amended in December 2014, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed.

4. PROJECT AREA

The project area is situated in the Western Cape, in the vicinity of Riebeck Wes, Riebeck Kasteel and Gouda. The project area that has been defined for the study is approximately a 500m buffer from the project components. The location of an approximate 500m project area in relation to the local road networks and abovementioned towns is presented in Figure 1.

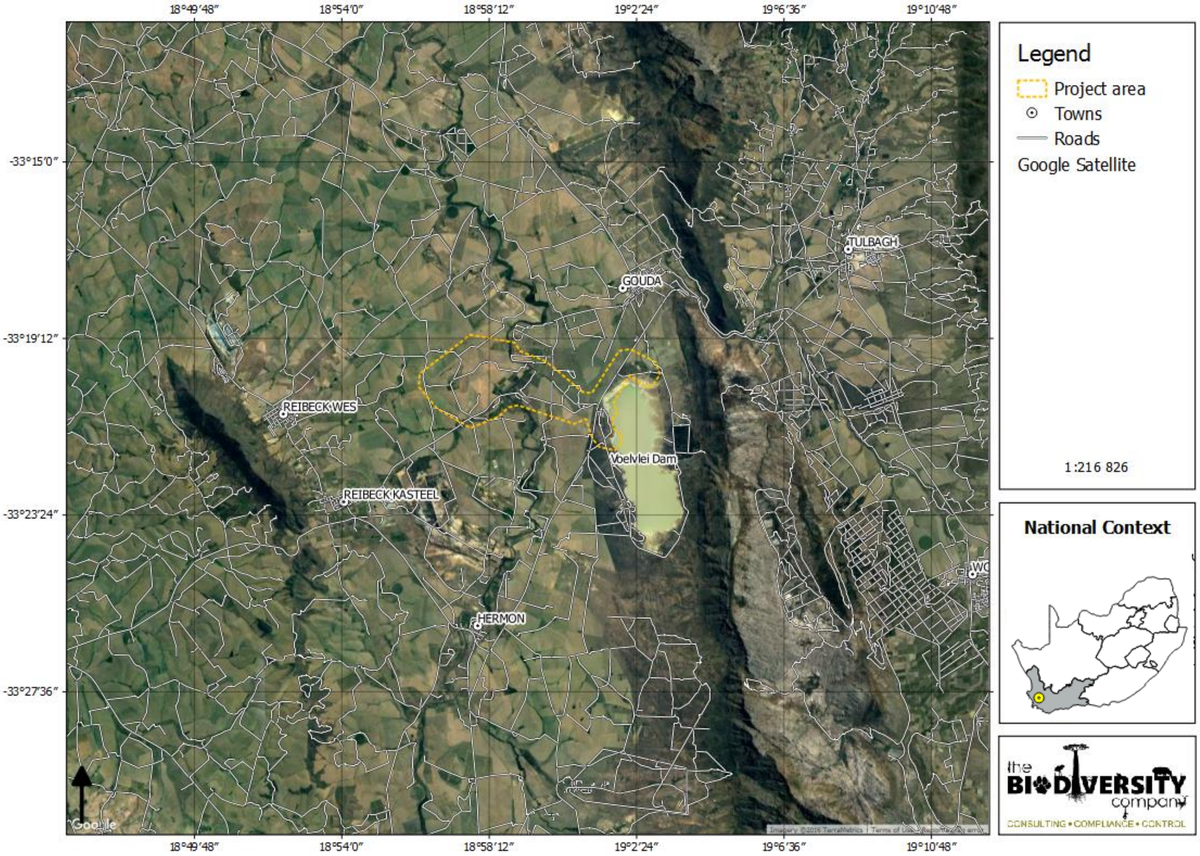

Figure 1: The location of the project area in relation to the local setting

The proposed Berg River-Voëlvlei Augmentation project is situated in the quaternary catchment G10F (Figure 3), within the Berg Water Management Area (WMA 19). The study area is in the Zonquasdrift area in the Western Cape Province, South Africa. The area surrounding the proposed project consists predominantly of large-scale commercial agricultural and livestock activities.

The Swartland WTW facility is located between the Voëlvlei Dam and the Berg River. A canal carries release water from the WTW to the river. A site description, photographs and GPS coordinates for the aquatic reaches sampled (or inspected) are presented in Table 1 and Figure 2.

The Berg WMA is situated in the south-western corner of South Africa. The Berg River forms the only major river in the WMA, with several smaller rivers and streams draining to the ocean. Most of the runoff originates from high mountain ranges in the east and south-east of the Berg WMA, with Table Mountain and the Cape Peninsula mountains in the south-west. Sandy lowlands, with minimal runoff, extend across the central and western part of the Berg WMA. The region receives highly varied winter rainfall, ranging from 3 000mm/annum in the mountains to less than 300mm/annum in the northwest. The Cape Fynbos represents a unique floral kingdom of World Heritage status. The diverse economy is dominated by industrial and other activities in the Cape Town Metropolitan area with tourism and agriculture such as intensive viticulture and fruit farming occurring in the valleys and foothills of the mountains. This changes to extensive rain fed wheat cultivation in the central regions. Several large dams and numerous farm dams regulate the surface runoff from the Berg WMA. Large quantities of water are transferred into the area from the Breede WMA via the Riviersonderend/Berg River Scheme and the Palmiet Pumped Storage Scheme. Further potential for the development of water resources exists mainly with respect to the Berg River, although salinity in the lower reaches of the river is becoming a problem, largely as a result of irrigation return flows (StatsSA, 2010).

Table 1: Photographs, co-ordinates and descriptions for the aquatic sites sampled

	Upstream	**Downstream**
Berg River (River Reach)		
GPS coordinates	Between 33°19'43.30"S; 18°58'50.16"E and 33°20'31.24"S; 18°58'44.66"E	

<table>
<tr><td>Site description</td><td>Located on the Berg River. The river reach was characterised by slow flowing waters over stones, sand, gravel and mud. Adequate marginal vegetation was present. The river reach consisted of mostly deep pools with a small section of riffles and runs. Impacts observed included eutrophic waters, erosion and a weir.</td></tr>
<tr><td>Northern Discharge Point

ATL1</td><td></td></tr>
<tr><td>GPS coordinates</td><td>33°20'6.84"S
19° 2'41.24"E</td></tr>
<tr><td>Site description</td><td>Located on the Voëlvlei Dam in the North-eastern corner of the dam. The site is located at the release point of an existing canal characterised by rock, stones, sand and gravel.</td></tr>
<tr><td>Central Discharge Point

ALT2</td><td></td></tr>
<tr><td>GPS coordinates</td><td>33°20'53.37"S
19° 1'31.10"E</td></tr>
</table>

Site description	Located on the Voëlvlei Dam in the North-western corner of the dam. The site is located approximately 120 meters south of the pump station. The proposed release point consists of scattered rock, stones, sand and gravel.
Southern Discharge Point **ALT3**	
GPS coordinates	33°21'35.84"S 19° 1'39.20"E
Site description	Located on the Voëlvlei Dam on the Eastern bank of the dam. The site is located at an excavated bay characterised by sand and gravel over a gentle slope.

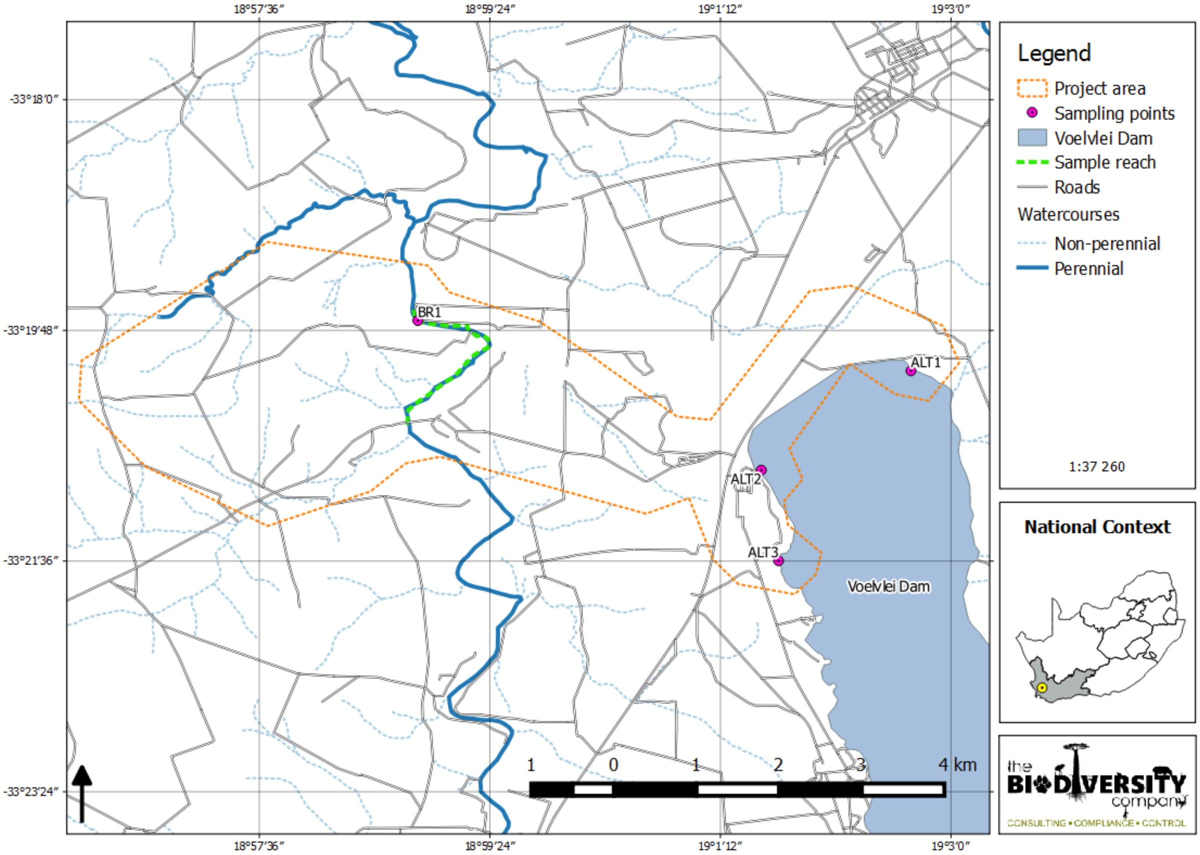

Figure 2: The location of the sample reach and sites for the Berg River and Voelvlei Dam respectively

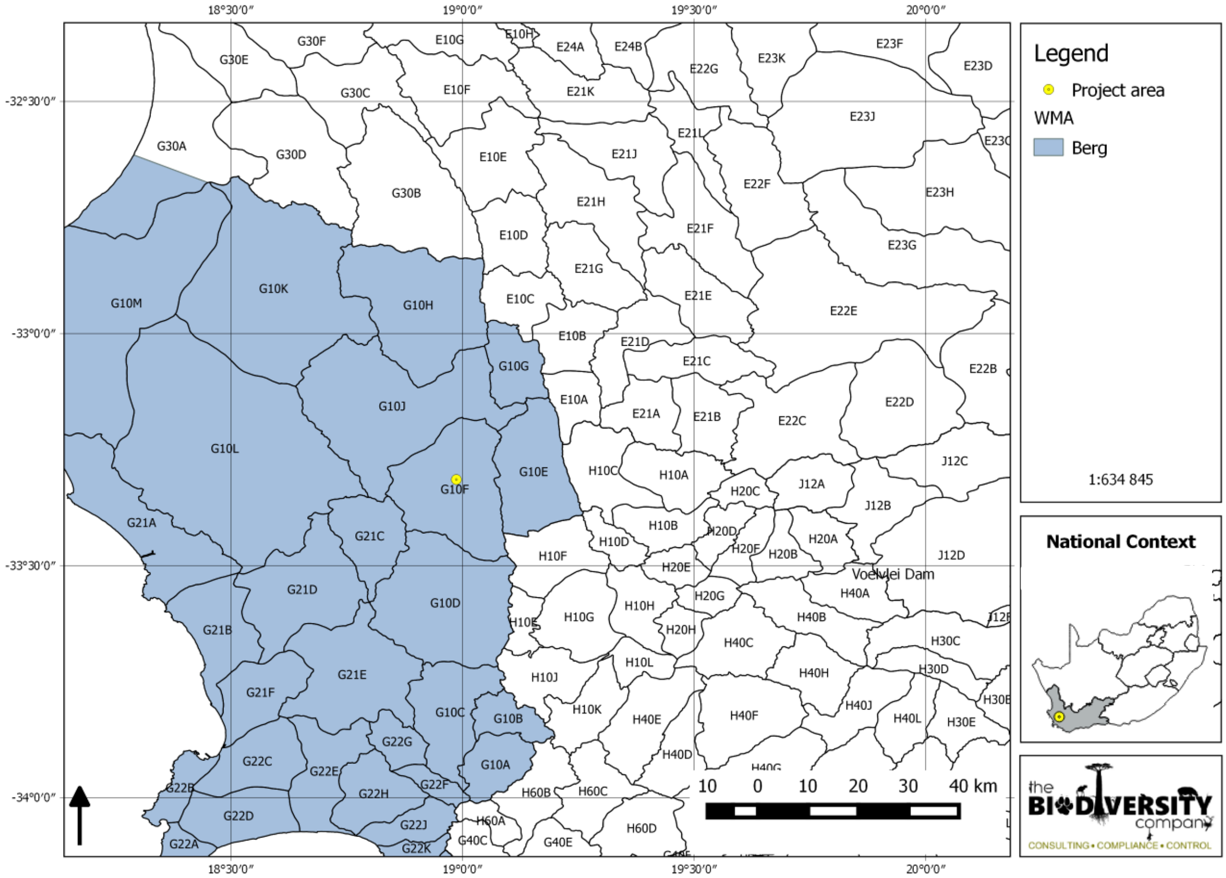

Figure 3: The location of the project area in relation to the WMA and quaternary catchment

5. METHODOLOGY

5.1 Aquatic ecology

5.1.1 *In situ* water quality

During the survey, a portable Exstick 2 multimeter was used to measure the following parameters *in situ*:

- pH;
- Electrical Conductivity (EC);
- Dissolved Oxygen (DO); and
- Water Temperature.

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a “snapshot”, they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

5.1.2 Habitat Assessment

Integrated Habitat Assessment System (IHAS)

The quality of the instream and riparian habitat influences the structure and function of the aquatic community in a stream; therefore, assessment of the habitat is critical to any assessment of ecological integrity. The Integrated Habitat Assessment System (IHAS, version 2) was applied at each of the sampling sites in order to assess the availability of habitat biotopes for macroinvertebrates. The IHAS was developed specifically for use with the SASS5 index and rapid biological assessment protocols in South Africa (McMillan, 1998). The index considers sampling habitat and stream characteristics. The sampling habitat is broken down into three sub-sections namely Stones-In-Current (SIC), Vegetation (VEG), Gravel Sand & Mud (GSM) and other habitat/ general. It is presently thought that a total IHAS score of over 65% represents good habitat conditions, a score over 55% indicates adequate/fair habitat conditions (McMillan, 1998) (Table 2).

Table 2: Invertebrate Habitat Assessment System Scoring Guidelines

IHAS Score	Description
> 65%	Good
55-65%	Adequate/Fair
< 55%	Poor

Intermediate Habitat Integrity Assessment (IHIA)

The aim of the Intermediate Habitat Integrity Assessment (IHIA) is to make an intermediate assessment of the habitat integrity of rivers according to a modified Habitat Integrity approach which can be applied in intermediate determination of the ecological Reserve for rivers in South Africa (DWS, 1999). The methodology is based on the qualitative assessment of a number of pre-weighted criteria which indicate the integrity of the in-stream and riparian habitats available for use by riverine biota.

The criteria considered indicative of the habitat integrity of the river were selected on the basis that anthropogenic modification of their characteristics can generally be regarded as the primary causes of degradation of the integrity of the river (Table 3) (DWS, 1999).

Table 3: Criteria used in the assessment of habitat integrity (from Kleynhans, 1996)

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low

Criterion	Relevance
	availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al*., 1993 in: DWS, 1999). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993 in: DWS, 1999) is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al*., 1992 in DWS, 1999)).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al*., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

The assessment of the severity of impact of modifications is based on six descriptive categories which are described in Table 4.

Table 4: Descriptive classes for the assessment of modifications to habitat integrity (from Kleynhans, 1996)

Impact Category	Description	Score
None	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	**0**

Impact Category	Description	Score
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	**1 - 5**
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	**6 - 10**
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	**11 - 15**
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	**16 - 20**
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	**21 - 25**

The habitat integrity assessment takes into account the riparian zone and the instream channel of the river. Assessments are made separately for both aspects, but data for the riparian zone are primarily interpreted in terms of the potential impact on the instream component (Table 5). The relative weighting of criteria remain the same as for the assessment of habitat integrity (DWS, 1999).

Table 5: Criteria and weights used for the assessment of habitat integrity and habitat integrity (from Kleynhans, 1996)

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

The negative weights are added for the instream and riparian facets respectively and the total additional negative weight subtracted from the provisionally determined intermediate integrity to arrive at a final intermediate habitat integrity estimate. The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific intermediate habitat integrity category (DWS, 1999). These categories are indicated in Table 6.

Table 6: Intermediate habitat integrity categories (From Kleynhans, 1996)

Category	Description	Score (% of Total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

5.1.3 Aquatic macroinvertebrates

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localised disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time. Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell, 1977). Aquatic macroinvertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System, version 5) (Dickens & Graham, 2002). The SASS5 protocol is a biotic index of the condition of a river or stream, based on the resident macroinvertebrate community, whereby each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997). This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net (mesh size of 1000 micron), over the churned up area.

The SASS5 (Figure 4) index was designed specifically for the assessment of perennial streams and rivers and is not suitable for assessment of impoundments, isolated pools, wetlands or pans (Dickens & Graham, 2002). In the Stones-In-Current (SIC) biotope the net is rested on the substrate and the area immediately upstream of the net disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net is also swept under the edge of marginal and aquatic vegetation (VEG). Kick samples are collected from areas with gravel, sand and mud (GSM) substrates. Identification of the organisms is made to family level (Thirion *et al.*, 1995; Davies & Day, 1998; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus *et al*., 2000). The indices used for this study were SASS5 Score and Average Score per Taxon (ASPT). The ASPT score is calculated as follows: SASS5 Score/ No. of Taxa.

Figure 4: Kick and sweep sampling method, SASS5 (South African Scoring System Version 5)

5.1.4 Biotic Integrity Based on SASS5 Results

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the South Western Coastal Belt - Lower ecoregion were obtained from Dallas (2007) (Table 7 and Figure 5). Due to limited data available to generate biological bands for this ecoregion, classification results should be interpreted with caution.

Table 7: Biological Bands / Ecological categories for interpreting SASS data (adapted from Dallas, 2007)

Class	Ecological Category	Description
A	Natural	Unimpaired. High diversity of taxa with numerous sensitive taxa.
B	Largely natural	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
C	Moderately modified	Moderately impaired. Moderate diversity of taxa.
D	Largely modified	Considerably impaired. Mostly tolerant taxa present.
E/F	Seriously Modified	Severely impaired. Only tolerant taxa present.

** Average Score per Taxa*

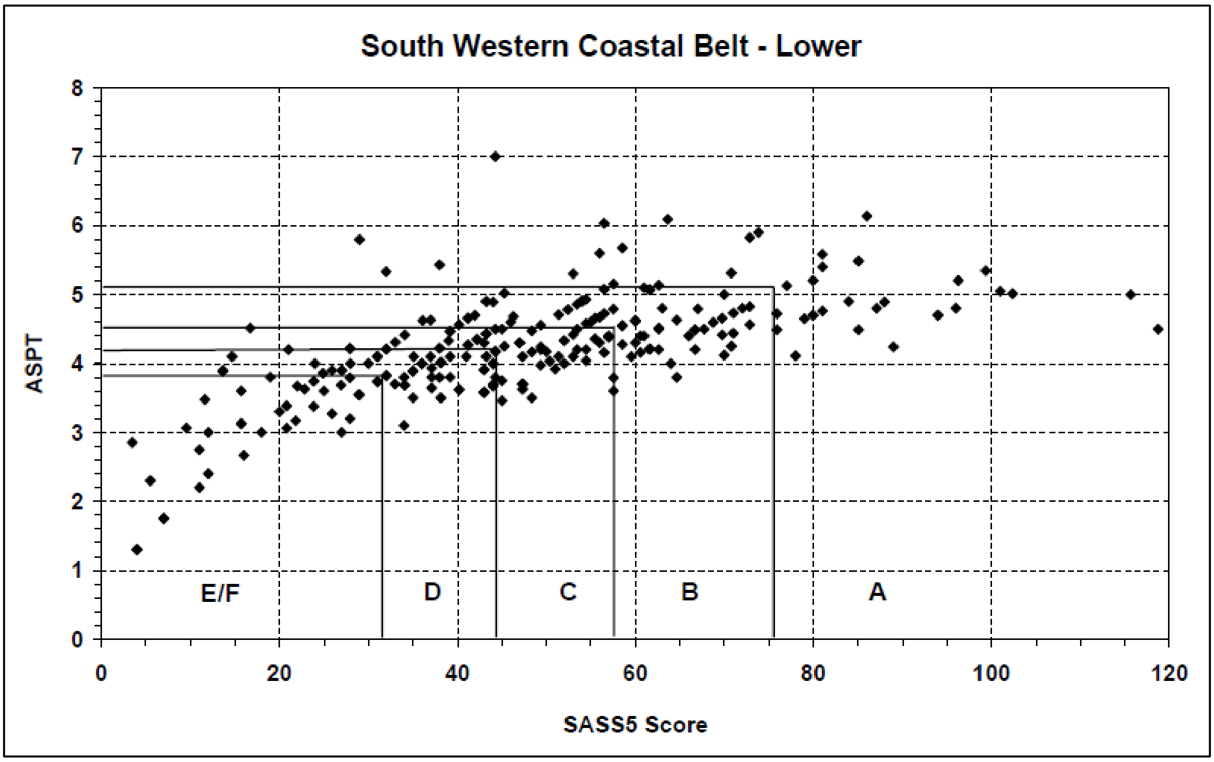

Figure 5: Biological Bands for the South Western Coastal Belt – Lower zone, calculated using percentiles

5.1.5 Fish

Fish samples were collected by means of electrofishing. Electrofishing is the use of electricity to catch fish. The electricity is generated by a system whereby a high voltage potential is applied between two electrodes placed in the water (USGS, 2004). The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), electronarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing was conducted with a SAMUS 725MS portable electrofishing device (DC 12V pulsating). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin *et al*., 1989).

Fish were identified in the field, photographed and released at the point of capture. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001).

Expected fish species

An expected fish species list for the Berg SQR G10F - 8604 and 8658 was obtained from the following sources: Skelton (2001), DWS (2013) and other online sources. Based on this, 11 fish species are expected to occur in the project area (both indigenous and exotic species) (Table 8).

It should be noted that these expected species lists are compiled on a SQR basis and not on a site specific basis. It is therefore highly unlikely that all of the expected species will be present at every site in the SQR with habitat type and availability being the main driver of species present. Therefore, Table 8 should be viewed as a list of potential species rather than an expected species list.

Table 8: Expected species list for the sub-quaternary catchment

Scientific name	Common name	IUCN Status
Barbus andrewi	Berg-Breede River Whitefish	EN
Clarias gariepinus	Sharptooth Catfish	Not endemic (LC)
Cyprinus carpio	Carp	Exotic
Galaxias zebratus	Cape Galaxias	DD
Gambusia affinis	Mosquitofish	Exotic
Lepomis macrochirus	Blue Gill	Exotic
Micropterus dolomieu	Smallmouth Bass	Exotic
Micropterus salmoides	Largemouth Bass	Exotic
Oncorhynchus mykiss	Rainbow Trout	Exotic
Oreochromis mossambicus	Mozambique Tilapia	NT
Sandelia capensis	Cape Kurper	DD
Total number of fish species		**11**

LC – Least Concern; NT – Near Threatened; EN – Endangered; DD – Data Deficient

Presence of Species of Conservation Concern

The conservation statuses of the indigenous fish species were assessed in terms of the IUCN Red List of Threatened Species (IUCN, 2015). Based on this assessment 6 of the expected fish species are currently listed as exotic to the province, a single species as indigenous but not endemic to the province, 2 species as Data Deficient (DD), a single species as Near Threatened (NT) and a single species as Endangered (EN) (Table 8). A taxon is DD when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A species is listed as NT when it does not currently qualify for a Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) status but is close to qualifying or is expected to qualify in the near future. A taxon is listed as EN when it does not currently qualify for a CR, Extinct in the Wild (EW) or Extinct (E) status but faces a very high risk of extinction in the wild (IUCN, 2015).

Barbus andrewi (Berg-Breede River Whitefish) is currently listed as EN. This species is endemic to the Berg and Breede River Systems of the Western Cape Province (Skelton 2001). Originally widespread in both systems, it is now common in less than 5% of its original range and it seems to have gone extinct in the Berg River system. Major threats are invasive alien fishes such as smallmouth bass (*Micropterus dolomieu*) and habitat degradation. The Berg and Breede catchments are characterised by intensive agricultural development, culminating in over-abstracted and polluted rivers that have become a haven for other alien fish species such as *Cyprinus carpio* and *Oreochromis mossambicus*. These two species are competitors to *Barbus andrewi*. CapeNature, the provincial conservation agency, has established a dedicated whitefish fund to capacitate recovery efforts. These efforts involve angler awareness, riparian land-owner education and promoting this species as an angling alternative to bass (*Micropterus*) and trout (*Oncorhynchus mykiss* and *Salmo trutta*) within its distribution range. *Barbus andrewi* have been stocked into several farm dams to create "safe" populations for later recovery efforts. Such efforts will involve the eradication of alien fish species from rivers with suitable *Barbus andrewi* habitat (IUCN, 2015).

Clarias gariepinus (Sharptooth Catfish) is currently listed as Least Concern (LC). It is a very common and abundant fish species across Africa that is capable of living in any type of habitat, favouring slower flow and structure. Although the species is listed as LC and is an indigenous fish species to South Africa, it does not occur naturally in the Western Cape and is therefore an exotic in this region. This large fish species has the ability to breathe air outside of water while crossing dry land in damp conditions between water bodies. *Clarias gariepinus* is tolerant of polluted waters and is both a predator and scavenger of any food item. An important angling and food species. They are known to hunt other fish and may become problematic through predating on fish endemic to the Western Cape.

Cyprinus carpio (Carp) is currently listed as VU. A species is listed as VU when it does not currently qualify for CR or EN status, but is close to qualifying for or is likely to qualify for a threatened category in the near future (IUCN, 2015). It should be noted that although *C. carpio* is listed as vulnerable (in its native waters), it remains an exotic species in South African waters. *Cyprinus carpio* is known to be a habitat modifier through its feeding methods that involve stirring up the sediment in search of plant roots and other sources of protein, often increasing the turbidity of the water body (IUCN, 2015). According to the National Environmental Management: Biodiversity Act (NEMBA) 10 of 2004, the catch and release of *C. carpio* is prohibited in catchments in which they don't occur.

Gambusia affinis (Mosquitofish) is a species of freshwater fish native to the USA and is currently listed as one of the world's worst invasive species. The common name 'mosquitofish' stems from the diet which predominantly consists of mosquito larvae (and other invertebrate larvae). An adult female *G. affinis* can consume hundreds of mosquito larvae in a day. According to NEMBA, *G affinis* falls under Category 1b in national parks, provincial reserves, mountain catchment areas and forestry reserves declared in terms of the Protected Areas Act. NEMBA Category 2 for breeding for the purpose of feeding stock for zoos and animal breeders and NEMBA Category 3 for all other discrete catchment systems in which it occurs (ISSS, 2016a). Adults are known to be extremely aggressive, attacking other fish, shredding their fins or killing them. *Gambusia affinis* are known to prey on eggs, larvae and juveniles of various fishes, including largemouth bass and common carp. They are also known to prey on adults of smaller species. (ISSS, 2016a, Skelton, 2001).

Lepomis macrochirus (Bluegill) was introduced in South Africa in 1938 as a fodder species for bass and is now established in many streams and dams. They are considered a pest species as they tend to overpopulate waters, living for longer than 10 years, preying on invertebrates and indigenous fish species (Skelton, 2001). Habitat includes warm shallow water bodies, and slow-flowing rivers and streams. *Lepomis macrochirus* often are associated with overhanging marginal vegetation and silt, sand, or gravel substrates. They seldom venture deeper than 5 meters. Eggs are laid in nests made in shallow water by males, on bottoms of gravel, sand, or mud that contains pieces of debris (IUCN, 2015).

Oncorhynchus mykiss (Rainbow Trout) are found in cold, well oxygenated water. They are currently listed under NEMBA as a Category 2 invasive species, meaning that this species is restricted by activity. *Oncorhynchus mykiss* have been linked to the decline of some indigenous fish species and they are efficient predators preying on smaller fish species. They are known to feed on amphibians and invertebrates, leading to local declines (ISSS, 2016b).

Oreochromis mossambicus (Mozambique tilapia) is currently listed as NT. The most serious threat facing *O. mossambicus* is hybridization with the rapidly spreading introduced species *Oreochromis niloticus* (Nile tilapia) (IUCN, 2016). Hybridization has already been documented throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River catchment (IUCN, 2016). Given the rapid spread of *O. niloticus* it is anticipated that *O. mossambicus* will qualify as threatened under Criterion A due to rapid population decline through hybridization (IUCN, 2016). *Oreochromis mossambicus* occurs in all but fast flowing waters and is tolerant of high salinities. It feeds on algae and invertebrates. The clearest morphological indicator of hybridization between *O. mossambicus* and *O. niloticus* is barring on the caudal fin.

Micropterus dolomieu (Largemouth bass) is a small introduced predatory fish that has caused a decline in indigenous species through environmental degradation and predation. According to NEMBA, *M. dolomieu* falls under Category 1b in National Parks, Provincial Reserves, Mountain Catchment Areas and Forestry Reserves declared in terms of the Protected Areas Act. NEMBA - Category 2 for release into damns within discrete catchment systems in which it occurs and NEMBA - Category 3 in all rivers, wetlands, natural lakes and estuaries in which it occurs (ISSS, 2016c). *Micropterus dolomieu* has had a devastating effect on indigenous fish species, it is long lived (15 years) becoming primarily piscivorous as adults also eating crabs (Skelton, 2001). Initially introduced in 1937 as an angling species but also for indigenous species control of whitefish and scaly (Skelton, 2001).

Micropterus salmoides (Largemouth bass), is an introduced predatory fish species that was first introduced into South African waters in 1928, originating from Central America (Skelton, 2001). It has since become well established in several South African rivers and dams where it has been shown to have a significant impact on indigenous fish populations and alter invertebrate communities (Skelton, 2001, Weyl *et al.* 2010, Ellender *et al.* 2011). Although it is primarily piscivorous it will voraciously feed on practically any small animals including crabs, frogs, small reptiles and even small mammals (Weyl & Hecht 1998, Skelton, 2001, Weyl & Lewis, 2006, Skelton & Weyl 2011). Spawning occurs in the spring (October to November), during this time the male builds a conical nest on the substrate in which the female lays the eggs. The male defends the nest and fry after hatching (Skelton, 2001). It prefers clear, standing or slow flowing water with aquatic submerged or floating aquatic macrophytes and is known to thrive in dams and impoundments (Skelton, 2001). *Micropterus salmoides* is a very popular angling species with various angling competitions held around the country every year. *Micropterus salmoides* is listed as an "invasive species regulated by area" in the Draft Alien and Invasive Species Regulations, 2009 (DWAF, 2009). The management of invasive fish and conservation of biodiversity is a high priority in NEMA and the NEMBA.

5.2 Wetland assessment

5.2.1 Desktop assessment

The desktop assessment consisted of relevant information as presented by the South African National Biodiversity Institutes (SANBI's) Biodiversity Geographic Information Systems (BGIS) website (http://bgis.sanbi.org). Wetland specific information resources taken into consideration during the desktop assessment of the study area included:

- Aerial imagery (Google Earth);
- The National Freshwater Ecosystem Priority Areas (NFEPAs, 2011);
- The Western Cape Biodiversity Framework (2014); and
- Contour data.

5.2.2 Wetland delineation

The wetland areas were delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 5. The outer edges of the wetland areas are identified by considering the following four specific indicators:

- 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; and
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Vegetation is used as the primary wetland 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.

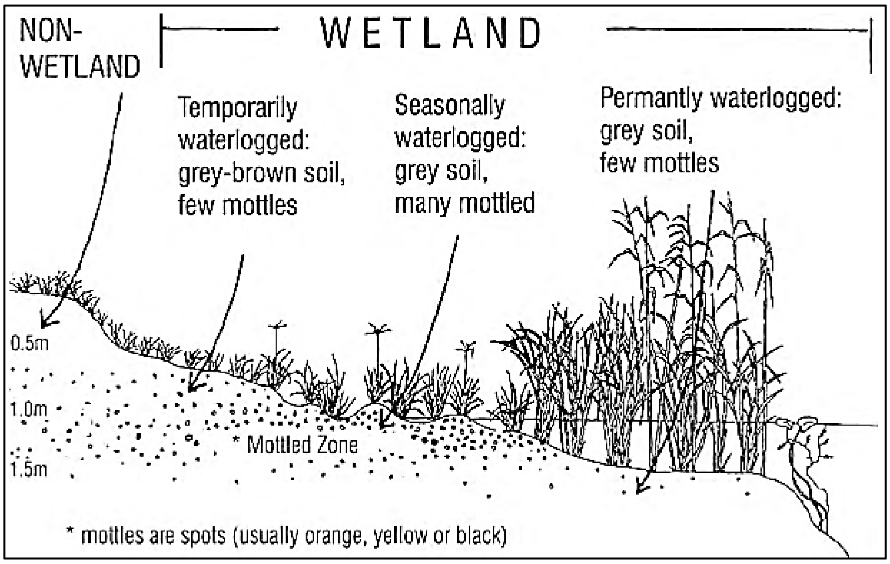

Figure 6: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (DWAF, 2005)

5.2.3 Riparian delineation

NWA defines a riparian habitat as follows: "*Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas*."

The riparian areas are also delineated in accordance with the DWAF (2005) guidelines. The riparian areas are identified by considering the following specific indicators:

- Are associated with a watercourse;
- Contain distinctively different plant species than adjacent areas; and contain species similar to adjacent areas but exhibiting more vigorous or robust growth forms; and
- May have alluvial soils.

5.2.4 Wetland classification

A distinction is made between four Landscape Units for Inland Systems on the basis of the landscape setting in which a hydro-geomorphic (HGM) is situated, which broadly considers (Ollis et al., 2013).:

- Slope;
- Valley floor;
- Plain; and
- Bench.

The HGM Units, which are defined primarily according to:

- Landform, which defines the shape and localised setting of a wetland;
- Hydrological characteristics, which describe the nature of water movement into, through and out of the wetland; and
- Hydrodynamics, which describe the direction and strength of flow through the wetland.

Seven primary HGM units are recognised for Inland Systems on the basis of hydrology and geomorphology (Ollis et al., 2013) namely:

- River: a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water;
- Channelled valley-bottom wetland: a valley-bottom wetland with a river channel running through it;
- Unchannelled valley-bottom wetland: a valley-bottom wetland without a river channel running through it;
- Floodplain wetland: the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank;
- Depression: a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates;
- Wetland Flat: a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat; and
- Seep: a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used in order to ensure consistency with the wetland classification terms in South Africa.

5.2.5 Wetland – Present Ecological Status (PES)

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. The ecological status categories and descriptions are provided in Table 9.

Table 9: The PES categories and descriptions for WET-Health (Macfarlane et al, 2008)

Category	Description	Range
A	Unmodified,natural	0-0.9
B	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
C	Moderately modified. A moderate change in ecosystem process and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9
D	Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9
E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9
F	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

5.2.6 Riparian – PES

The PES assessment determines the level of disturbance to or modification of riparian habitats relative to their natural state or reference condition. Systems are rated on a scale of A to F, with A being a natural or unimpacted system and F being a completely modified and disturbed system (Table 10).

A level 3 Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et. al., 2007) assessment was undertaken to determine the status of the riparian habitats. This method assesses the current condition of riparian habitats based on the response of riparian vegetation to observed impacts.

Table 10: Generic ecological categories for EcoStatus components (modified from Kleynhans 1996 & Kleynhans 1999)

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

5.3 Risk assessment

The risk assessment was conducted in accordance with the DWS risk-based water use authorisation approach and delegation guidelines.

The matrix assesses impacts in terms of consequence and likelihood. Consequence is calculated based on the following formula:

Consequence = Severity + Spatial Scale + Duration

Whereas likelihood is calculated as:

Likelihood=Frequency of Activity + Frequency of Incident +Legal Issues + Detection.

Significance is calculated as:

Significance \Risk= Consequence X Likelihood.

The significance of the impact is calculated according to Table 11.

Table 11: Significance ratings matrix

Rating	Class	Management Description
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands may be excluded.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Wetlands are excluded.
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.

6. RESULTS & DISCUSSIONS

6.1 Desktop aquatic ecology

6.1.1 NFEPA's for sub-quaternary catchments G10F -8604 and G10F - 8658

The two Sub-Quaternary Catchment (SQR) have no freshwater priority areas designated to them.

Table 12 and Table 13 provides further desktop information regarding the Berg SQR G10F-8604 and G10F-8658 with regards to the PES including the Ecological Importance, Ecological Sensitivity and anthropogenic impacts within the SQR.

Table 12: Present Ecological Status for the Berg Sub-quaternary reach G10F-8604 (Sites BR1, BR2) (DWA, 2013)

Present Ecological State		**Ecological Importance**		**Ecological Sensitivity**	
D (Largely Modified)		**Low**		**High**	
Variable	**Status**	**Variable**	**Status**	**Variable**	**Status**
Modifications to Instream Habitat Continuity	Moderate	Fish species per sub quaternary catchment	Unassessed	Fish Physico-Chemical sensitivity description	Unassessed
Modifications to Riparian/ Wetland Zone Continuity	Serious	Invertebrate taxa per sub quaternary catchment	12	Fish No-flow sensitivity description	Unassessed
Potential Instream Habitat Modifications	Large	Habitat Diversity Class	Low	Invertebrate Physico-Chemical sensitivity	Moderate
Modifications to Riparian/ Wetland Zones	Large	Instream Migration Link Class	High	Invertebrate velocity sensitivity	Very High
Potential Flow Modifications	Serious	Riparian-Wetland Zone Migration Link	Low	Stream size sensitivity to modified flow/water level changes description	High
Potential Physico-Chemical Modifications	Large	Instream Habitat Integrity Class	Moderate	Riparian-Wetland Vegetation intolerance to water level changes description	High
Anthropogenic Impacts					
The following impacts/activities were identified: Berg River in this SQR has floodplain infilled to create vineyards; River channelized; Riparian zone heavily invaded with Eucalyptus, but some remnant indigenous species; Construction of new offtake to Voëlvlei Dam for Cape Town water supply advanced; and Flow highly regulated by the DWS.					

Table 13: Present Ecological Status for the Berg Sub-quaternary reach G10F-8658 (Sites ALT1, ALT2, ALT3) (DWA, 2013)

Present Ecological State		**Ecological Importance**		**Ecological Sensitivity**	
D (Largely Modified)		**Moderate**		**High**	
Variable	**Status**	**Variable**	**Status**	**Variable**	**Status**
Modifications to Instream Habitat Continuity	Moderate	Fish species per sub quaternary catchment	Unassessed	Fish Physico-Chemical sensitivity description	Unassessed
Modifications to Riparian/ Wetland Zone Continuity	Large	Invertebrate taxa per sub quaternary catchment	24	Fish No-flow sensitivity description	Unassessed
Potential Instream Habitat Modifications	Moderate	Habitat Diversity Class	Very Low	Invertebrate Physico-Chemical sensitivity	Very High
Modifications to Riparian/ Wetland Zones	Large	Instream Migration Link Class	High	Invertebrate velocity sensitivity	Very High
Potential Flow Modifications	Serious	Riparian-Wetland Zone Migration Link	Moderate	Stream size sensitivity to modified flow/water level changes description	High
Potential Physico-Chemical Modifications	Large	Instream Habitat Integrity Class	High	Riparian-Wetland Vegetation intolerance to water level changes description	High
Anthropogenic Impacts					
The following impacts/activities were identified: Voëlvlei Dam for Cape Town water supply; and Flow highly regulated by the DWS.					

6.2 Aquatic ecology

6.2.1 *In situ* water quality

In situ water quality analyses was conducted at in the Berg River. These results are important to assist in the interpretation of biological results due to the direct influence water quality has on aquatic life forms. The results of the survey are presented in Table 14.

Table 14: *In situ* water quality results for the site with reference to the Target Water Quality Requirements (TWQR)

Site	pH	Conductivity (µS/cm)	DO (mg/l)	DO Saturation (%)	Temperature (°C)
TWQR	**6.5-9.0**	**<700**	**>5.00**	**80-120**	**5-30**
BR1	**10.37**	365	**10.2**	**178**	27.9

Red – exceeded TWQR

pH

Most fresh waters are usually relatively well buffered and more or less neutral, with a pH range from 6.5 to 8.5, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (Barbour *et al*, 1996). The pH target for fish health is presented as ranging between 6.5 and 9.0 (Table 14).

An elevated pH value of 10.37 was measured in the Berg River. This exceeded the recommended guideline range having a limiting effect on local aquatic biota at the time of the survey. This high pH value may be a concern to the Berg River biota and potentially the Voëlvlei Dam and aquatic biota if it persists at elevated levels once the water pipeline is operational.

Electrical Conductivity (EC)

EC is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge.

The EC value measured in the Berg River (365 µS/cm) was below the recommended guideline value and would not be a limiting factor of aquatic biota at the time of the survey.

Dissolved Oxygen (DO)

The maintenance of adequate DO is critical for the survival of aquatic biota as it is required for the respiration of all aerobic organisms (DWS, 1996). Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWS, 1996). The median guideline for DO for the protection of freshwater fish, determined by a variety of fish faunas is > 4 - 5 mg/ℓ (Doudoroff &

Shumway, 1970 and DWS, 1996). Exposure to DO concentrations below 2 mg/ℓ will lead to death of most fishes (UNESCO, 1996). Percentage saturation (% sat) is the amount of oxygen (O_2) in a litre of water relative to the total amount of oxygen that the water can hold at that temperature. DO levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWS, 1996). The South African Water Quality Guidelines (1996), state that the TWQR for DO to protect aquatic biota through most life stages is 80% - 120% of saturation, and that saturation levels below 40% would be lethal.

During the survey DO levels in the Berg River were above the maximum prescribed limits with a measurement of 178% recorded. This high reading is in excess of saturation (super-saturation of oxygen) which usually indicates eutrophication in a water body (DWAF, 1996). The conditions in the Berg River at the time of sampling were in agreement that the river was eutrophic (green in colour) which may stem from nutrient input from both WTW discharges and agricultural input in the catchment (Figure 7). Elevated oxygen concentrations (super saturation) may cause gas bubble disease in fish. Supersaturated conditions also tend to inhibit photosynthesis in green algae, favouring instead bluegreen algae, which are more tolerant of supersaturation, but which may become a nuisance to other water users (DWAF, 1996). Therefore, DO would have been a limiting factor of aquatic biota at the time of the survey if these high DO levels persist for extended periods (Table 14).

Figure 7: Eutrophic conditions experienced in the Berg River

Water Temperature

Water temperature plays an important role in aquatic ecosystems by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms (DWS, 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (DWS, 2005b). Temperature varies with season and the life cycles of many aquatic macroinvertebrates are cued to temperature (DWS, 2005b).

During the survey, a water temperature of 27.9°C was measured (Table 14). The water temperature was considered to be within recommended guideline levels and was not expected to have a negative effect on the aquatic ecosystem.

Conclusion

If the elevated pH and DO values persist for extended periods of time in the Berg River together with strong sunlight and vigorous photosynthetic activity, they may give rise to gas bubbles disease, fish kills and algal blooms (Alabaster and Llyod, 1982). These algal blooms may produce toxic by-products which may be an issue once water is pumped into the Voëlvlei Dam.

6.2.2 Habitat assessment

Invertebrate Habitat Assessment System (IHAS)

The IHAS index was developed by McMillan (1998) for use in conjunction with the SASS5 protocol. The IHAS results for the survey are presented in Table 15.

Table 15: IHAS score at the two sites during the survey

Site	Berg River	Voëlvlei Dam
Score	79	N/A
Suitability	**Good**	**N/A**
Flow	**0.2 - 0.4 m/s**	**Dam (75% full)**
Clarity (cm)	**35cm (Eutrophic)**	**20cm (Turbid)**

According to the IHAS results, habitat availability for aquatic macroinvertebrates was **Good** in the Berg River (Table 15). The Berg River reach sampled was characterised mostly by deep slow water with adequate marginal vegetation. These deep runs were mostly too deep to sample. A short section of shallow water was sampled. This section consisted of alternating areas of slow to fast flowing waters over stones, sand and gravel with some mud parches. Fair marginal vegetation was present. The section was characterised by a variety of riffles, runs and pools. The water clarity was somewhat limited due to eutrophic conditions experienced, blocking light penetration through the water column.

Intermediate Habitat Integrity Assessment (IHIA)

The IHIA assesses the intensity and extent of anthropogenic changes to interpret the impact on the habitat integrity of the system. Modifications of the interrelated abiotic factors such as hydrology, geomorphology and physico-chemical conditions influence river habitat integrity. Therefore, modifications to instream and riparian habitat are rated based on survey data and available data sources that include Google Earth mapping.

The results of the instream and riparian habitat integrity assessment for the systems associated with the Berg River-Voëlvlei Augmentation Scheme are presented in Table 16 and Table 17, respectively.

Table 16: Results for the IHIA

Instream	Average	Score
Water abstraction	15	8.4
Flow modification	6	3.12
Bed modification	9	4.68
Channel modification	13	6.76
Water quality	19	10.64
Inundation	11	4.4
Exotic macrophytes	2	0.72
Exotic fauna	21	6.72
Solid waste disposal	4	0.96
Total Instream		**53.6**
Category		**D**

Table 17: Results for the riparian habitat integrity assessment

Riparian	Average	Score
Indigenous vegetation removal	8	4.16
Exotic vegetation encroachment	8	3.84
Bank erosion	6	3.36
Channel modification	15	7.2
Water abstraction	14	7.28
Inundation	13	5.72
Flow modification	14	6.72
Water quality	16	8.32
Total Riparian		**53.4**
Category		**D**

According to the IHIA results both instream and riparian habitat integrity in the Berg River reach are considered to be a Class D, or largely modified: A large loss of natural habitat, biota and basic ecosystem functions has occurred. Impacts arising in the catchment are due to amongst others, agricultural influence upstream (nutrient, pesticide and fertilizer input), rural use of the river, alien invasive vegetation, thinning of riparian vegetation buffer along the entire Berg River, sedimentation, altered instream habitat through inundation of shallow sections, along with the loss of indigenous fish species and introduction of alien species.

6.2.3 Aquatic macroinvertebrates

The aquatic macroinvertebrate results for the Berg River sampling reach is presented in Table 18. Based on the ASPT scores, the aquatic macroinvertebrate communities for the sampling reach comprised primarily of tolerant taxa (Intolerance Rating < 5) in high abundances. The macroinvertebrate communities also included some semi-intolerant taxa (Intolerance Rating 5 - 10) in low abundances:

Tolerant taxa:

- Oligochaeta (Earthworms, Order Annelida, Intolerance Rating 1);
- Veliidae (Ripple bugs, Order Hemiptera, Intolerance Rating 5),
- Gyrinidae (Whirligig beetles, Order Coleoptera, Intolerance Rating 5),
- Chironomidae (Midges, Order Diptera, Intolerance Rating 2);
- Simuliidae (Blackflies, Order Diptera, Intolerance Rating 5); and
- Physidae (Pouch snails, Order Gastropoda, Intolerance Rating 3).

Semi-tolerant taxa:

- Caenidae (Squaregills/Cainflies, Order Ephemeroptera, Intolerance Rating 6);
- Baetidae 2 species (Mayflies, Order Ephemeroptera, Intolerance Rating 6); and
- Hydropsychidae 2 species (Caddis flies, Order Trichoptera, Intolerance Rating 6).

Table 18: Macroinvertebrate assessment results

Site	Berg River
SASS Score	50
No. of Taxa	12
ASPT*	4.17
Category	**C**

*ASPT: Average score per taxon

Findings from aquatic macroinvertebrate assessment indicated the community comprised primarily of tolerant taxa, suggesting a level of water quality impairment for the system. The status of the macroinvertebrate community was determined to be moderately modified.

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6.2.4 Biotic Integrity based on SASS5 Results

Biotic integrity of the Berg River was categorised as moderately modified (PES Class C) (Table 18). This indicates that the macroinvertebrate assemblage is in an impacted state. The low diversity of Ephemeroptera, Plecoptera and Trichoptera taxa indicates poor water quality which is in agreement with the low ASPT score indicating a high percentage of tolerant taxa were recorded. The instream habitat diversity and availability, such as stones in riffles, runs and pools was not a limiting factor as IHAS scores were good for the river reach. The sampled macroinvertebrate assemblage indicates that the biotic integrity of the Berg River system is moderately modified.

6.2.5 Fish

The intolerance ratings of the fish sampled is presented in Table 19. Seven species of fish were collected during the survey (Table 20). Photographs are presented in Table 21.

Table 19: Intolerance rating and sensitivity of fish species

Sensitivity Score	Tolerance/Sensitivity Level
1-2	Tolerant = Low/very low sensitivity
2-3	Moderately tolerant = Moderate sensitivity
3-4	Moderately intolerant = High sensitivity
4-5	Intolerant = Very high sensitivity

Table 20: Fish species recorded during the October 2016 survey

Scientific name	Common name	IUCN status	Site		Sensitivity	
			Berg River	Voëlvlei Dam	No-flow	Phys-chem
Clarias gariepinus	Sharptooth Catfish	Not endemic (LC)	35	Obs (>300)	1.7	1.0
Cyprinus carpio	Carp	Exotic	6	Obs (>60)	2.1	1.1
Gambusia affinis	Mosquitofish	Exotic	58	0	2	2
Micropterus dolomieu	Smallmouth Bass	Exotic	Present	2	2.3	
Micropterus salmoides	Largemouth Bass	Exotic	Present	0	1.1	2.3
Oreochromis mossambicus	Mozambique Tilapia	Not endemic (NT)	15	0	0.9	1.3

Tilapia sparrmanii	Banded Tilapia	Not endemic	25	0	0.9	1.4
Number of species expected (Incl. exotics)			11	11		
Number of species observed			7	3		

NT - Near Threatened; Obs – Observed; Red - Exotic

Fish have different sensitivities or levels of tolerance to various aspects that they are subjected to within the aquatic environment. These tolerance levels are rated with a sensitivity score as presented in Table 19. These tolerance levels are scored to show each fish species sensitivity to flow and physico-chemical modifications.

The fish species present at site during the October 2016 survey range from tolerant (*O. mossambicus*) to intolerant (*Micropterus dolomieu*) of flow and physico-chemical modifications.

Table 21: Fish species collected during the October 2016 survey

	
Clarias gariepinus	*Cyprinus carpio*
	
Gambusia affinis	*Micropterus dolomieu* (underwater footage)
	
Oreochromis mossambicus	*Tilapia sparrmanii*

Fish were collected from and observed in a number of habitat types including rapids, riffles, runs and pools with a variety of stones, gravel, sand and mud substrate with marginal vegetation. A range of water depth and flow velocities were sampled. Fish were collected in the Berg River by means of electrofishing at a rate of 2.1 fish per minute while the most productive method in the Voëlvlei Dam was visually observing fish at a rate of 15 fish per minute. The reason why visual observation yielded such great results in the dam may be attributed to the feeding habit of *C. carpio* that bring them into the shallows in search of food, while *C. gariepinus* were spawning in the shallows which brings them in their masses to these areas.

Table 22: Catch per unit effort (CPUE) during the October survey

Site	**Berg River Reach**		**Voëlvlei Dam**		
Method	Electrofishing	Gill Net	Visual Obs	Seine netting	Rod & Reel
Effort	50 min	Overnight (900 min)	240 min	15 min	45 min
Sample size	105	29	360	0	3
CPUE (catch per minute)	2.1	0.03	15	0	0.07

Figure 8: Fish seen feeding and spawning in the Voëlvlei Dam

Based on the results of the fish survey, 5 of the 11 potential species were absent from the Berg River and Voëlvlei Dam at the time of the survey. It should be noted that of the 7 species recorded during the survey, all 7 were exotic or non-endemic species that have been introduced at some point in catchment. Further, 3 of the 7 are indigenous species (to South Africa) that do not occur naturally in the Western Cape. These 3 species include *Clarias gariepinus, Oreochromis mossambicus* and *Tilapia sparrmanii.* The absence of all native species from the Berg River is alarming, showing the effects of alien fish introductions and altered water quality. The only species of special concern captured during this survey was *Oreochromis mossambicus,* due to the NT status of the species*. Cyprinus carpio, Clarias gariepinus* and *Micropterus sp.* Are an environmental concern due to the impact these species have on endemic fish population structures.*Clarias gariepinus* together with *Micropterus sp.* are predatory fish known to actively hunt other fish often changing fish community structures. *Clarias gariepinus* have become problematic through predating on fish endemic to the Western Cape and are spreading across the province. *Cyprinus carpio* is known to be a habitat modifier through its feeding methods that involve stirring up the sediment in search of plant roots and other sources of protein, often increasing the turbidity of the water body (IUCN, 2015). The fish species that were found are representative of the available habitat found at each site. Further, habitat availability was not considered a limiting factor for indigenous fish species but rather the presence of exotics have resulted their absence. The results from the fish assessment indicate the fish community structure in both the Berg River and Voëlvlei Dam is in poor condition based on the conditions found at each site.

Although not all of the expected fish species were recorded during the October 2016 survey, it should be noted that the results are based on a single survey of relatively short duration. It is likely that some more but not all of the expected fish species will be recorded with additional sampling effort. It is imperative that fish migration be considered during the design and construction phases of this project, due to the presence of Whitefish species potentially occurring within the catchment. Whitefish rely on migration over large distances to complete their lifecycle. Migration barriers such as weirs are a limiting factor that block Whitefish from reaching their spawning grounds, resulting in less offspring and lower population numbers.

6.2.6 Current Ecological Status

The Current Ecological Status results for the October 2016 survey are presented in Table 23. The PES result is shown for each of the assessment components. Based on this assessment, the Current Ecological Status of the Berg River reach is considered to be seriously modified (Class E), while the Voëlvlei Dam is considered to be largely modified (Class D). However, it should be noted that, as the results are based on single survey, the confidence level for the Current Ecological Status assessment is considered to be low.

Table 23: Current Ecological Status assessment based on the PES of the various assessment components

Assessment Components	PES Score	
	Berg River	Voëlvlei Dam
Instream Habitat	D	N/A
Riparian Habitat	D	N/A
Macroinvertebrates	C	N/A
Fish	Seriously modified	Seriously modified
Current Ecological Status	E	D

6.3 Wetland assessment

The estuary and floodplain environment report (DWAF, 2007), completed for the Berg River baseline monitoring programme was considered for this study. Cape Nature indicated the ecological significance of the floodplain and supporting wetlands (pers comms, D. Impson), which was a focus for the review of the DWAF (2007) report. According to the DWAF (2007) report, the floodplain begins at the farm Caledonia near Hopefield, which is in excess of 100km downstream of this project area. Based on this, it is with reasonable confidence that it can be concluded, due to the distance and nature of this project, no risks to the Berg River floodplain (and estuary) are expected.

6.3.1 Desktop assessment

The desktop delineation attempted to identify the location of wetland areas associated with the project area. Contour data and Google Earth imagery were also considered to identify any potential wetland areas. The following information is summarised for the desktop assessment:

- The project area is associated with the Db39, Db47, Db98 and Fb95 land types (Figure 8), of which Db47 and Fb95 are the most dominant for the project.
  - Db47: Phyllite shale, schist, greywacke and quartzite of the Porterville and Norree Formations, Malmesbury Group. Valley floor covered by alluvium and terrace gravel.
  - Fb95: Mainly greywacke, shale, schist and phyllite of the Porterville and Moorreesburg Formations, Malmesbury Group, as well as conglomerate, grit and sandstone of the Magrug Formation, Klipheuwel Group; occasional alluvium.
- The area is associated with the Swartland Shale / Silcrete Renosterveld vegetation types. The ecological status of the vegetation type is CR (Figure 9), with the general area vary in a protection level from Hardly protected to Poorly protected (Figure 10).
- The project area is associated with numerous NFEPA wetland types, these are largely associated with the Berg River and the Voelvlei Dam (Figure 11). Other NFEPA wetlands are interspersed in the project area. None of the local NFEPA wetlands are classified as ecological priority areas.

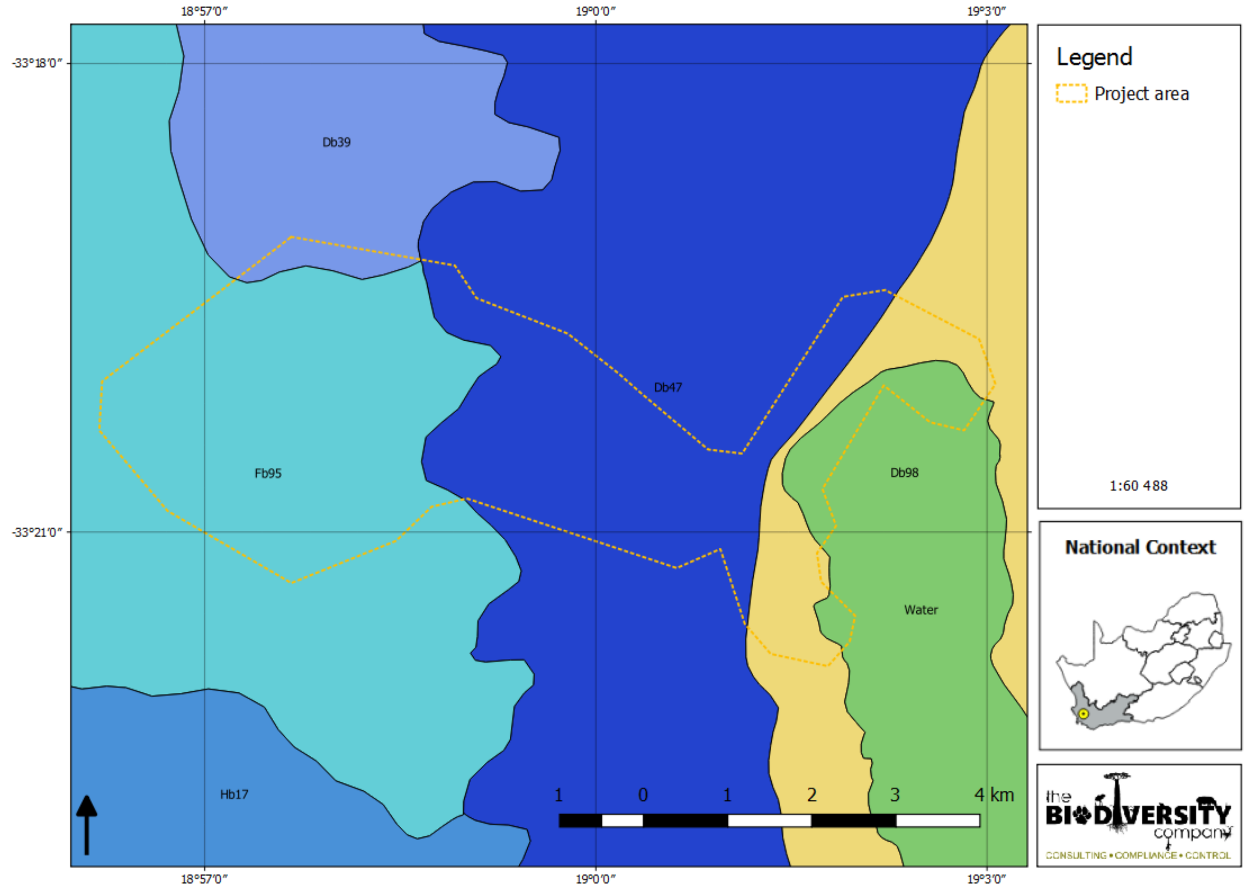

Figure 9: The land types associated for the study area

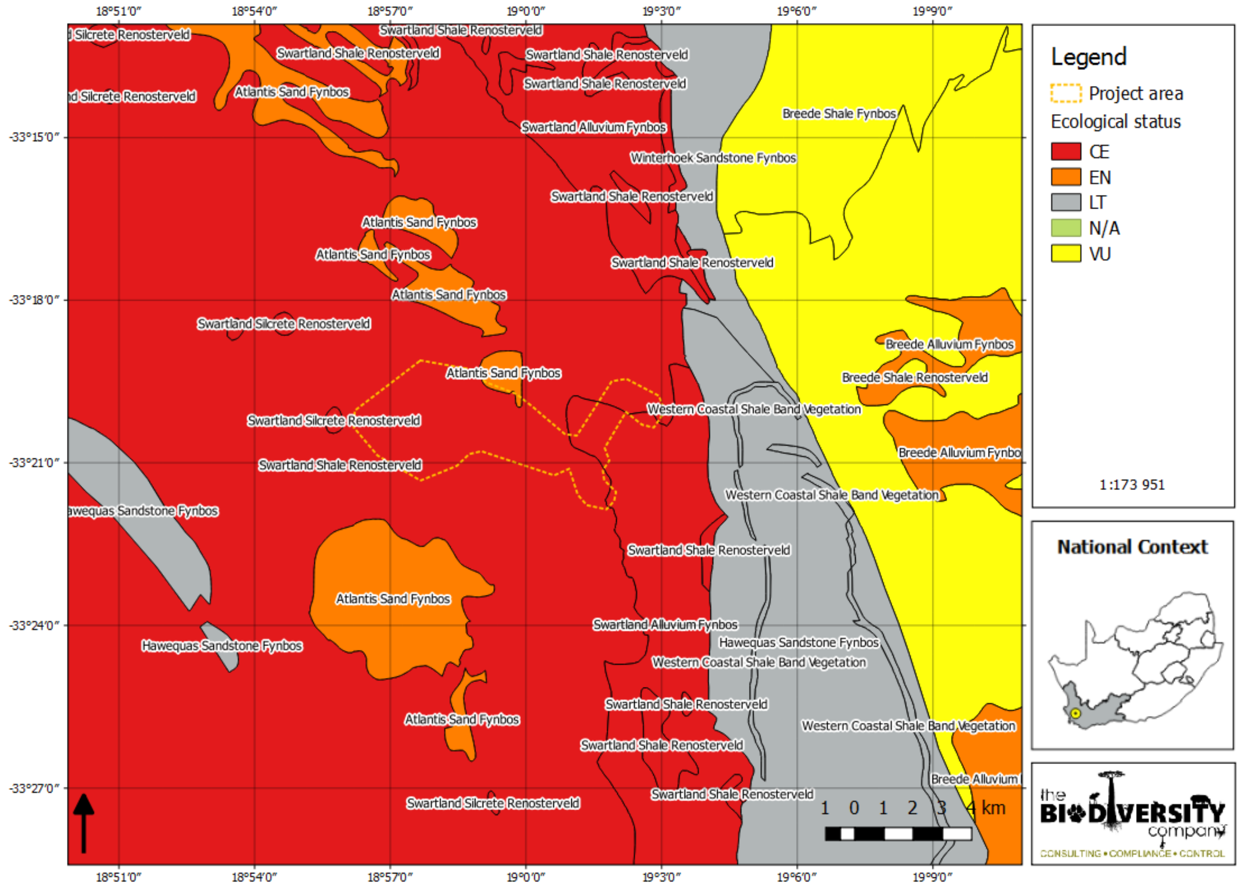

Figure 10: The ecological status of the local vegetation types for the study area

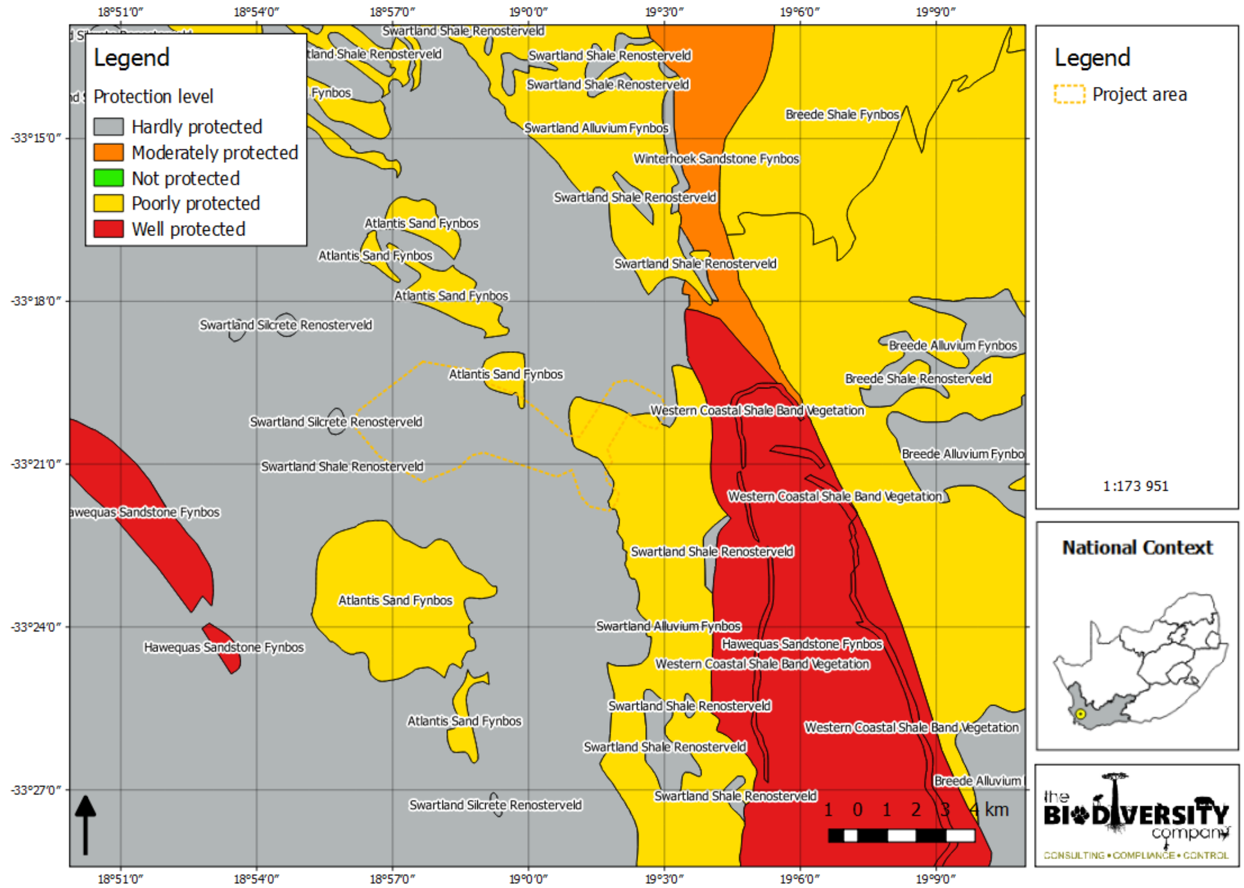

Figure 11: The level of protection afforded to the local vegetation types

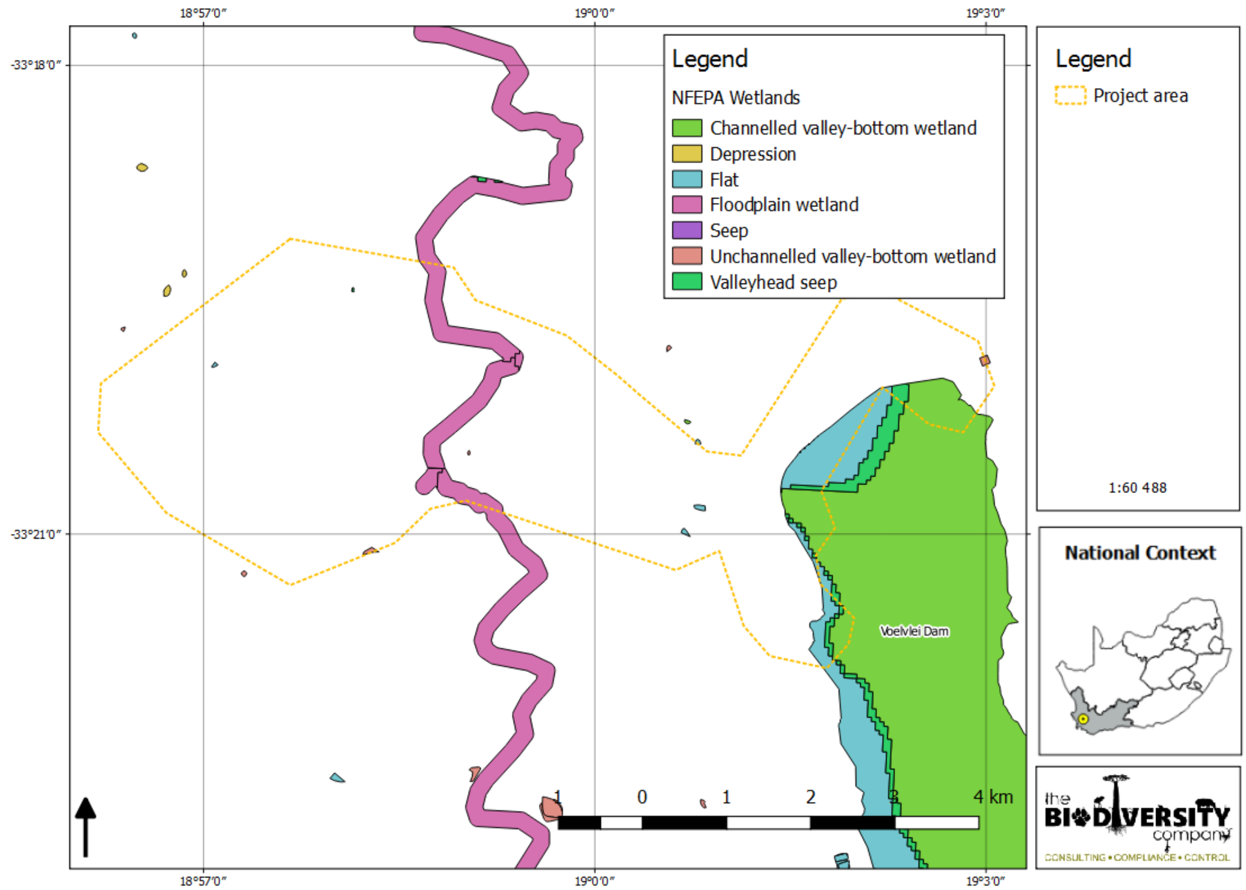

Figure 12: The extent of NFEPA wetlands associated with the project area

6.3.2 Wetland delineation

The desktop findings were ground truthed and the DWAF (2005) wetland guidelines implemented. Wetland boundaries were ground truthed based on soil forms, soil wetness, and vegetation. Photographs of some wetland indicators considered for the study are presented in Figure 12. The extent of the delineated wetland (and riparian) areas for the project, and the corresponding HGM types is presented in Figure 13 and listed in Table 24.

The channel network is typically divided into three types of channels in order to aid the delineation process, namely A Section, B Section, or C Section channels (DWAF, 2005). The notable difference between the channel Sections is the respective position relative to the zone of saturation in the riparian area. According to the DWAF (2005) guidelines, the saturated zone must be in contact with the channel network for baseflow to take place, with the classification separating the channel sections that do not have baseflow (A Sections) from those that sometimes have baseflow (B Sections) and those that always have baseflow (C Sections). The following summary is provided for the respective channels:

- A Sections: Headward channels situated well above the zone of saturation and the channel bed is never in contact with the zone of saturation. These channels carry storm runoff but the flow is of short duration. These steep, eroding, headward watercourses do not have a riparian habitat due to limited deposition of alluvial (or hydromorphic) soils and are not flooded with sufficient frequency to support vegetation of a type that is distinct from the adjacent land areas.

- B Sections: Channels in the zone of the fluctuating water table with baseflow at any point in the channel when the saturated zone is in contact with the channel bed. The gradient of the channel bed is flat enough for deposition of material to take place and initial signs of flood plain development observed.

- C Sections: Always in contact with the zone of saturation and therefore always have baseflow. Channel gradients in these sections are very flat and a flood plain is usually present.

The setting of the project area is characterised by all three channel networks. The project has attempted to identify and distinguish between these channels, delineating the wetland areas in the process.

Figure 13: Photographs of some wetland indicators considered for the study. A: Vegetation, *Zantedeschia aethiopica*. B: Vegetation: *Phragmites sp* & *Typha capensis*. C: Topography, channel. D: Topography, depressions

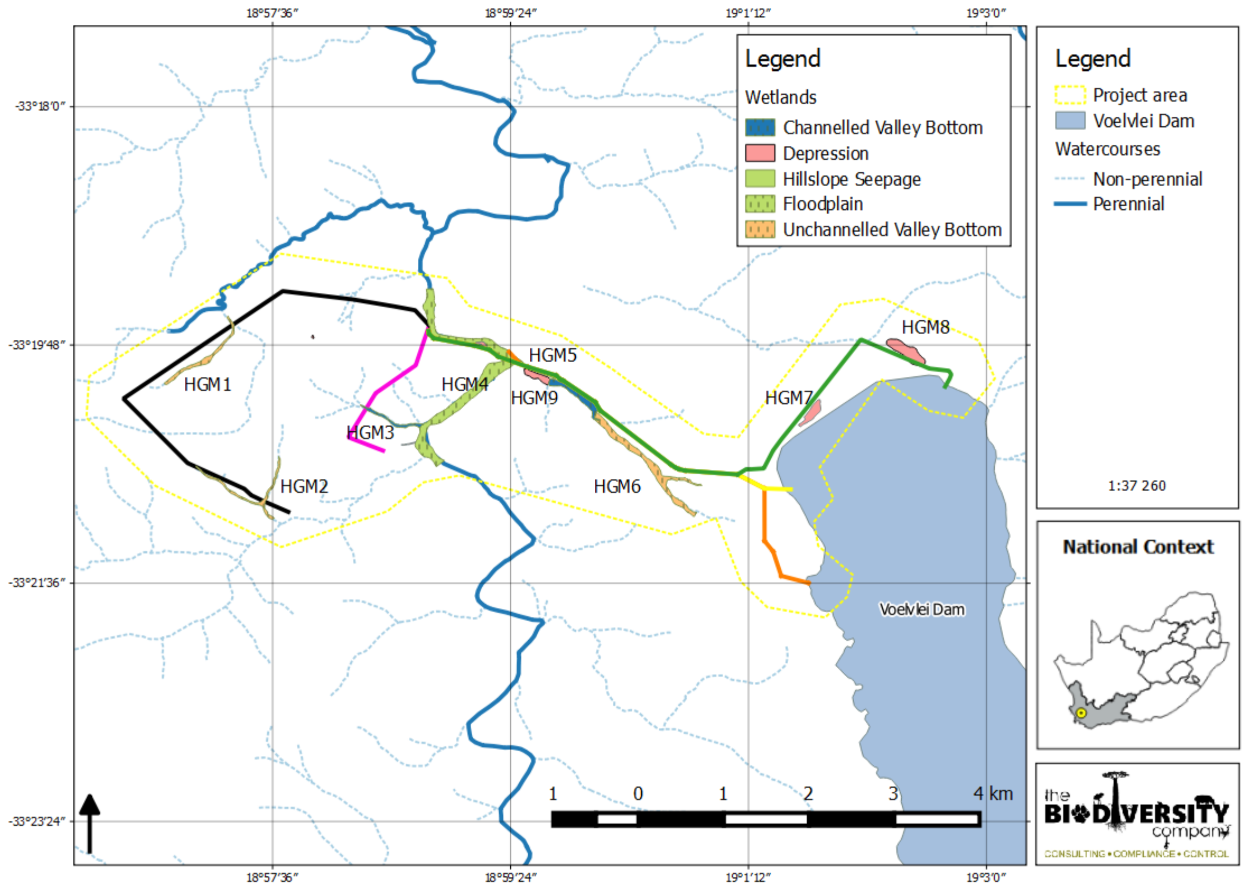

Figure 14: The delineated wetland HGM units for the study

Table 24: An indication of the identified wetland types for each HGM unit

System	HGM Type
HGM1	Unchannelled valley bottom wetland
HGM2	Unchannelled valley bottom wetland
HGM3	Channelled valley bottom wetland
HGM4	Floodplain
HGM5	Hillslope Seepage
HGM6	Unchannelled valley bottom wetland
HGM7	Depression
HGM8	Depression

HGM9	Depression

6.3.4 Wetland functional description

The expectant services associated with each of the delineated HGM units is discussed below, this is in accordance with WET-EcoServices (Kotze et al., 2007).

Floodplains

The general features that are typical of floodplain wetlands such as oxbows, levees and point bars were identified in floodplains on site. Flood attenuation is likely to be high early in the season until the floodplain soils are saturated (McCartney, 2000 in Kotze et al., 2005; McCartney et al., 1998 in Kotze et al., 2005), and the oxbows and other depressions are filled. In the late season, the flood attenuation capacity is usually reduced, but is nevertheless still likely to be achieved to some extent, particularly in drier years (Kotze et al., 2005). The floodplains are generally unlikely to contribute significantly to stream flow augmentation. The generally clayey nature of floodplain soils retains water which is likely to be lost through evapotranspiration, thereby limiting their contribution to stream flow augmentation and groundwater recharge (Kotze et al., 2005). In general, once the flood overflows the river banks, the velocity of flow decreases laterally, permitting the deposition of particles within the floodplain landscape. Phosphorous and any toxicants bound to trapped sediments are therefore likely to be effectively retained on the floodplains, and this is a key mechanism through which wetlands trap phosphates (Boto and Patrick, 1979 in Kotze et al., 2005; Hemond and Benoit, 1988 in Kotze et al., 2005). Generally, the inundation period in floodplains is short, but in the oxbow depression portions of the floodplain inundation is more prolonged and some of the deposited phosphates may be released as a consequence of change in redox potential, given that phosphorus is held more tightly to soil particles under oxidized conditions than under reduced conditions (Cronk and Siobhan Fennessy, 2001; Keddy, 2002).

Channelled valley bottom wetlands

Channelled valley bottom wetlands resemble floodplains, however, they are characterized by less active deposition of sediment and also the absence of oxbows and other floodplain features such as natural levees and meander scrolls (Kotze *et al*., 2007). These systems are generally narrower and have a steeper gradient, with the contribution from lateral groundwater input relative to the main stream channel being generally greater. These systems contribute less towards flood attenuation and sediment trapping. Some nitrate and toxicant removal potential would be expected, particularly from the water being delivered from the adjacent hillslopes.

Unchannelled valley bottom wetlands

The valley bottom wetlands without channels are located at the lowest position in a landscape where the water drained from the local slopes accumulate. These wetland systems play important functions such as sediment trapping, flood attenuation and nutrient-cycling. The valley bottom without a channel wetland on site receives extensive amounts of sediment and flow from the surrounding slopes. This allows an opportunity for contact between solute-laiden water and the wetland vegetation, thus providing an opportunity for flood and contaminant (nutrients, pesticides, herbicides) attenuation. Extensive areas of these wetlands remain saturated as stream channel input is spread diffusely across the valley bottom, even at low flows (Kotze et al., 2007). These wetlands also tend to have a high organic content (Kotze et al., 2007).

Hillslope seepages

According to Kotze *et al.* (2007), hillslope systems are normally associated with groundwater discharges, although flows through them may be supplemented by surface water contributions. The accumulation of organic matter and fine sediments in the wetland soils results in the wetland slowing down the sub-surface movement of water down the slope. Some general ecological services of the unit include the following:

- Contribute to some surface flow attenuation;
- Contribution of water to the stream during dry seasons;
- Provide water quality enhancement benefits; and
- High potential to remove nitrogen and nitrates.

Seepage wetlands provide a variety of water quality enhancement benefits, such as, removing excess nutrients and inorganic pollutants produced by agriculture, industry and domestic waste (Postel and Carpenter, 1997). Sub-surface flow that is characteristic of hillslope wetlands enables the systems to be effective in removing nitrates (Muscutt *et al*. 1993).

Depressions

According to Goudie and Thomas (1985) and Marshal and Harmse (1992) depressions can receive both surface and groundwater flows, which then accumulate due to a generally impervious Layer, preventing the drainage of water. The ability of these systems to attenuate flows is limited, however, these systems do capture runoff, reducing the volume of surface water draining to the river reach during storm events (Kotze et al., 2007). Depressions are also unlikely to regulate streamflow. Additionally, depressions are also not considered effective for sediment trapping. The water quality in depressions is influenced by the pedology, geology, and local climate (Allan et al., 1995).

6.3.5 Riparian assessment

Riparian areas were delineated primarily based on alluvial soils and vegetation structure. Additionally, for the purpose of the ground truthing exercise, the extent of the riparian areas also considered the following:

- The ability of the systems to receive run-off flow following precipitation events under natural conditions, with limited base flow present for the project area;

- The presence of wetland indicators consistent with the definition of a natural (non-artificial) wetland; and

- Supporting drainage areas (channels) are not consistent with the definition of a channel-associated watercourse due to the absence of a natural channel or channel features that may contain regular or intermittent flow (NWA, 1998, Act No. 36 of 1998).

According to Ollis et al. (2013) riparian areas that are not too well drained and saturated or flooded for prolonged periods should be classified as wetlands, for example 'floodplain wetland' or 'channelled valley-bottom wetland'. In this instance, the Berg River has been classified as a floodplain system.

Figure 15: Photographs of the riparian areas assessed for the study

6.3.6 Riparian – Present Ecological Status

The scores calculated for the PES assessment are presented in Table 25. The riparian habitat associated with the Berg River was determined to be largely modified (PES category D) indicating a system that has experienced a large loss of natural habitat, biota and basic ecosystem function. Some of the noted impacts and disturbances to the riparian habitat include:

- Clearing of vegetation to accommodate large-scale agricultural activities on either side of the river, resulting in the narrowing and the loss of riparian habitat;
- Alien vegetation encroachment within the riparian zone. These species are outcompeting endemic species and becoming well established in the habitat; and
- The flooding regime of the Berg River has been altered as a result of surrounding land-uses, local water schemes and the development of the catchment. This has had an impact on the structuring and support of the riparian area.

Table 25: VEGRAI score for the riparian vegetation of the Berg River

Component	Results
LEVEL 3 VEGRAI (%)	49.3
VEGRAI EC	**D**
Category	Largely Modified
AVERAGE CONFIDENCE	3.1
MARGINAL	48.9
NON MARGINAL	49.6

6.3.7 Wetland – Present Ecological Status

A total of nine (9) HGM units were identified and delineated for the study. The locations of the HGM units with respect to the proposed project components are presented in Figure 15. The PES for the assessed wetland systems is presented in Table 26.

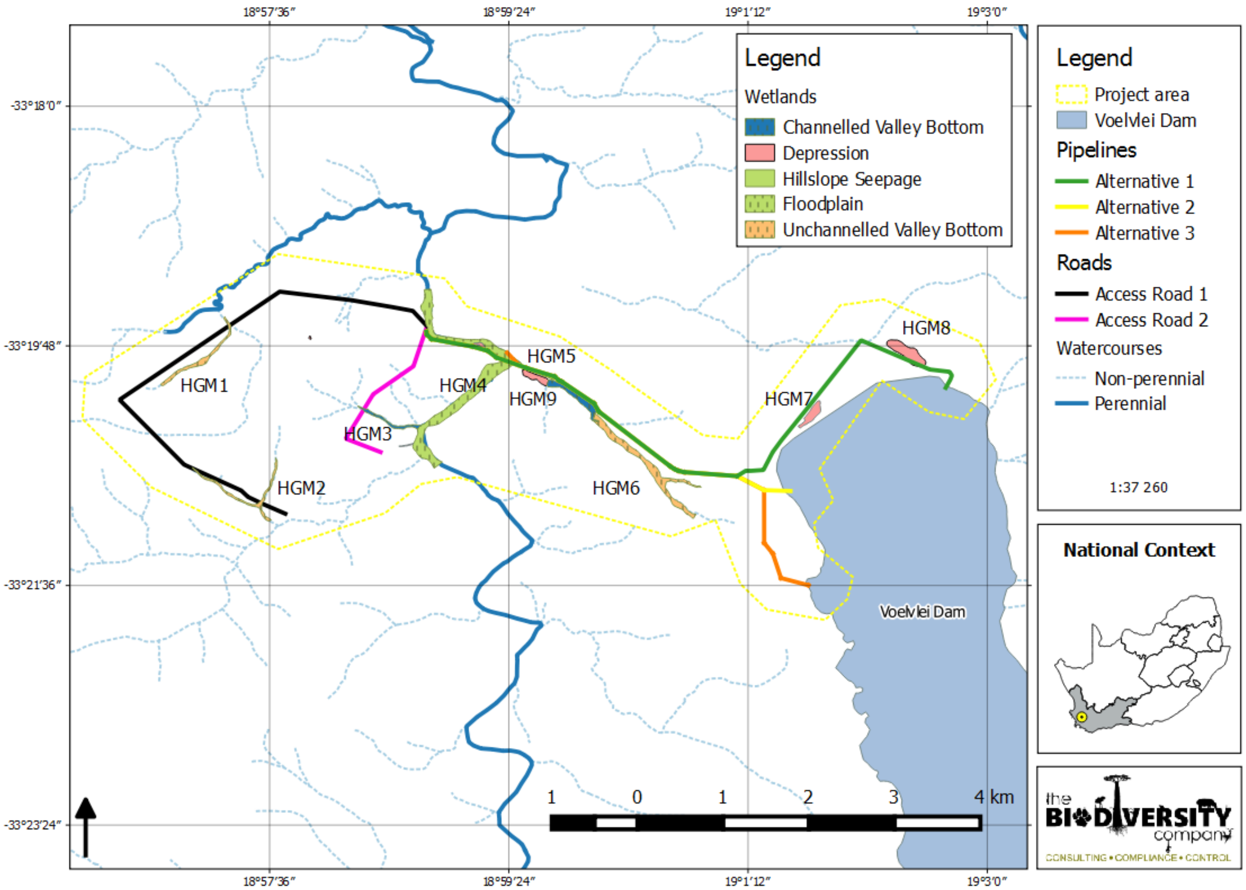

Figure 16: The delineated HGM units in relation to the proposed project components

Table 26: Summary of the scores for the wetland PES

Wetland	Hydrology		Geomorphology		Vegetation	
	Rating	**Description**	**Rating**	**Description**	**Rating**	**Description**
HGM1	C	Moderately Modified	B	Largely Natural	B	Largely Natural
Overall PES Class					C: Moderately Modified	
HGM2	C	Moderately Modified	C	Moderately Modified	D	Largely Modified
Overall PES Class					C: Moderately Modified	
HGM3	D	Largely Modified	C	Moderately Modified	D	Largely Modified
Overall PES Class					D: Largely Modified	
HGM4	C	Moderately Modified	C	Moderately Modified	D	Largely Modified
Overall PES Class					C: Moderately Modified	
HGM5	C	Moderately Modified	C	Moderately Modified	E	Seriously Modified
Overall PES Class					D: Largely Modified	
HGM6	B	Largely Natural	C	Moderately Modified	D	Largely Modified
Overall PES Class					C: Moderately Modified	
HGM7	C	Moderately Modified	C	Moderately Modified	C	Moderately Modified
Overall PES Class					C: Moderately Modified	
HGM8	C	Moderately Modified	C	Moderately Modified	C	Moderately Modified
Overall PES Class					C: Moderately Modified	
HGM9	C	Moderately Modified	C	Moderately Modified	C	Moderately Modified
Overall PES Class					C: Moderately Modified	

The PES of the wetland systems varied from largely moderately modified (Class C) to largely modified (Class D), with none of the systems considered to be natural or largely modified. The following summaries are provided for the respective classes:

- **Moderately modified:** A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.
- **Largely modified:** A large change in ecosystem processes and loss of natural habitat and biota and has occurred.

7. RISK ASSESSMENT

The project is for the proposed Berg River-Voëlvlei Augmentation Scheme, and the associated low level weir and fishway. The Augmentation Scheme will involve the construction of a water pipeline (5 to 8.1 km in length (depending on the alternative authorised) and 1.7m in diameter) and an instream weir that will pump water from the weir in the Berg River to the release point in the Voëlvlei Dam. Due to the fact that this project is for the construction of new infrastructure, a number of impacts are expected to result in modified conditions in both the Berg River and local wetlands (and watercourses), as well as the Voëlvlei Dam.

The existing canal is concrete and does not sustain any of the adjacent wetland systems. Seepage and interflow is not facilitated by the current canal, and the proposed project does not pose a risk to the wetlands, due to the loss of these water movements.

The baseline assessment has concluded that the assessed water resources are predominantly in a modified state, largely as a result of local large-scale commercial farming activities, and also the development of the area.

Some of the potential impacts (or risks) that have been identified for the study and that will be considered for the risk assessment include the following:

- Erosion and scouring at the discharge area in the dam.
- The construction of a weir will result in modified flows across the Berg River system. This will include modifications to the flooding regime of the system.
- The weir may also create a migratory barrier for the movement of fish across the system.
- Inadequate measures to allow fish movement upstream of the weir, especially smaller species that cannot navigate strong flows (*Galaxias zebratus* and *Sandelia capensis* – if present).
- Inadequate measures to protect river bed material from flows immediately downstream of the weir resulting in scouring and erosion of substrates from below the structure.
- Exotic vegetation encroachment into the marginal and riparian zones may occur in cleared areas, resulting in competition and loss of indigenous vegetation.

- The placement of infrastructure within wetlands which will result in the loss of wetland resources.
- The traversing of wetlands by linear structures which may impact on these systems, potentially resulting in the partial loss of these systems. However, there is also the opportunity to improve upon existing crossings which will in turn improve the status and functioning of traversed wetlands.

Findings from the DWS aspect and impact register / risk assessment are provided below:

Table 27: Potential risks associated with the project

Phase	Activity	Aspect	Impact
Construction	Construction of low level weir Construction of pump station Digging of trenches Laying of pipelines Upgrade of roads Construction of roads Upgrade of watercourse crossings	Damming and diversion of the Berg River for the weir Cutting/reshaping of river banks Construction and upgrade of access routes Construction (and upgrade) of crossings / causeways Clearing of areas for infrastructure Interception of interflow by trenches Additional associated infrastructure for staff Operation of equipment and machinery Excavations in and across watercourses Use of temporary structures for river crossings Construction of fishway in the system	Impeding the flow of water Fish migration barrier Loss of aquatic habitat Siltation of watercourse Erosion of watercourse Flow sediment equilibrium change Altered flow dynamics Loss of wetland (seepage) areas Damage to wetlands (or loss) Impaired water quality
Operation	Weir and fishway Pumping of water Discharge of water Vehicle access	Weir structure Drainage patterns change due to road extent and levels Drainage patterns change due to crossing upgrades Increased extent of hardened surfaces Loss of infiltration and seepage areas Operation of equipment and machinery Increased developed footprint area for the catchment Water abstraction from the Berg River Discharge of water into Voelvlei Dam	Impeding the flow of water Fish migration barrier Loss of aquatic habitat Siltation of watercourse Erosion of watercourse Flow sediment equilibrium change Altered flow dynamics Loss of wetland (seepage) areas Impaired water quality

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Table 28: Risk rating assessment

Severity								
Aspect	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**
Construction Phase								
Damming and diversion of the Berg River for the weir	4	2	4	3	**3.25**	**3**	**3**	**9.25**
Cutting/reshaping of river banks	2	2	3	2	**2.25**	2	2	**6.25**
Construction and upgrade of access routes	2	1	1	2	**1.5**	1	2	**4.5**
Construction (and upgrade) of crossings / causeways	3	3	2	2	**2.5**	2	2	**6.5**
Clearing of areas for infrastructure	1	1	2	2	**1.5**	1	2	**4.5**
Interception of interflow by trenches	3	1	1	1	**1.5**	1	2	**4.5**
Additional Associated Infrastructure for staff	1	1	2	1	**1.25**	1	1	**3.25**
Operation of equipment and machinery	1	3	1	2	**1.75**	1	2	**4.75**
Excavations in and across watercourses	3	4	3	3	**3.25**	2	2	**7.25**
Use of temporary structures for river crossings	3	2	2	2	**2.25**	2	2	**6.25**
Construction of fishway in the system	4	4	2	3	**3.25**	2	2	**7.25**
Operation Phase								
Weir structure	5	2	3	3	**3.25**	3	5	**11.25**
Drainage patterns change due to road extent and levels	2	1	1	1	**1.25**	1	5	**7.25**
Drainage patterns change due to crossing upgrades	2	2	1	2	**1.75**	2	5	**8.75**
Increased extent of hardened surfaces	2	1	1	1	**1.25**	2	4	**7.25**
Loss of infiltration and seepage areas	1	1	1	1	**1**	1	5	**7**
Operation of equipment and machinery	1	1	1	1	**1**	1	3	**5**
Increased developed footprint area for the catchment	2	1	1	1	**1.25**	2	5	**8.25**
Water abstraction from the Berg River	3	1	1	2	**1.75**	2	3	**6.75**
Discharge of water into Voelvlei Dam	1	2	1	2	**1.5**	1	3	**5.5**

Table 29: Risk rating assessment continued

Aspect	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Sig.	Risk Rating
Construction Phase							
Damming and diversion of the Berg River for the weir	**3**	**3**	**5**	**1**	**12**	**111**	**Moderate**
Cutting/reshaping of river banks	2	2	5	2	**11**	**68.75**	**Moderate***
Construction and upgrade of access routes	2	2	1	2	**7**	**31.5**	**Low**
Construction (and upgrade) of crossings / causeways	2	2	5	2	**11**	**71.5**	**Moderate***
Clearing of areas for infrastructure	2	2	1	2	**7**	**31.5**	**Low**
Interception of interflow by trenches	3	1	1	3	**8**	**36**	**Low**
Additional associated infrastructure for staff	1	1	1	1	**4**	**13**	**Low**
Operation of equipment and machinery	2	2	1	2	**7**	**33.25**	**Low**
Excavations in and across watercourses	2	2	5	2	**11**	**79.75**	**Moderate***
Use of temporary structures for river crossings	2	2	1	2	**7**	**43.75**	**Low**
Construction of fishway in the system	3	3	5	3	**14**	**101.5**	**Moderate**
Operation Phase							
Weir structure	4	4	1	3	**12**	**135**	**Moderate**
Drainage patterns change due to road extent and levels	3	1	1	2	**7**	**50.75**	**Low**
Drainage patterns change due to crossing upgrades	3	2	1	2	**8**	**70**	**Moderate***
Increased extent of hardened surfaces	3	2	1	1	**7**	**50.75**	**Low**
Loss of infiltration and seepage areas	3	1	1	3	**8**	**56**	**Moderate***
Operation of equipment and machinery	2	1	1	2	**6**	**30**	**Low**
Increased developed footprint area for the catchment	3	2	1	1	**7**	**57.75**	**Moderate***
Water abstraction from the Berg River	2	2	5	2	**11**	**74.25**	**Moderate***
Discharge of water into Voelvlei Dam	2	2	5	2	**11**	**60.5**	**Moderate***

(*) denotes - In accordance with General Notice 509 "Risk is determined after considering all listed control / mitigation measures. Borderline Low / Moderate risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to listing of additional mitigation measures detailed below."

The risk assessments indicated that the largest risks are associated with the weir structure specifically, and not the supporting activities and structures. The most significant risks were determined to be moderate, with the remaining risks determined to be low. The two moderate risks for the construction phase are associated with the damming and diversion of the Berg River, and also the construction of the fishway structure. The most significant risk (moderate) considered for the operational phase of the project is the weir structure itself.

The relatively low risk rating for the project may be attributed to the modified statuses of the assessed watercourses. In addition to this, the extent of the impacts, except for the formal weir structure, are generally expected to be both site and area specific.

Mitigations measures have been prescribed for the assessed risks, with due consideration for the moderate risks associated with the project.

7.1 Low level weir construction mitigation measures

The following weir construction specific mitigation measures are provided:

- The footprint area of the weir should be kept a minimum. The footprint area must be clearly demarcated to avoid unnecessary disturbances to adjacent areas;
- Exposed river banks / soils must be stabilised to prevent the erosion of these surfaces. Signs of erosion must be addressed immediately to prevent further erosion of the area;
- The weir should not concentrate flows at the overspill area. It is important to spread flows across the river system by having a wider overspill area, avoiding concentrated flows. Care must be taken not to spread flows outside of the existing channel path;
- It is imperative that the new low level weir cater for fish migration, especially during very low flows;
- A V-shaped centre positioned spillway is recommended for the weir design. This will allow for fish migration over the weir under different flow levels (see diagram Figure 17 and Figure 18); and
- Large aggregate outsourced or from the project area (if available) can be used for energy dissipation in the channel downstream of the weir to reduce the likelihood of scouring the river bed and sedimentation of the catchment. It is preferable that larger aggregate be used to avoid flows removing aggregate material from the site.

7.2 Fishway construction mitigation measures

A rock-ramp type of fishway is preferred over the vertical slotted fishway. The rock-ramp type of fishway is self-cleaning requiring little to no maintenance compared to the vertical slotted fishway.

It caters for all fish types with different swimming abilities and is aesthetically pleasing due to its natural look. From a construction point of view, it requires less complex calculations for design dimensions and simulates a natural river type of environment that fish will adopt more easily thus having a higher success rate.

The following fishway construction specific mitigation measures are provided:

- The fishway should have water passing through it during both high flows and low flows to encourage fish to make use of the fishway no matter the flow levels. It may be required that an Instream Flow assessment be conducted for the project in order to prescribe water allowances for the system;

- The fishway should cater for both rheophilic (fast moving water) and anti-rheophilic (slow moving water) fish species. This can be achieved through having several different flow velocity areas across the fishway;

- It is recommended that a rough stone surface be cast into the fishway channel floor to cater for climbing and crawling species;

- Rocks used for the fishway should have flat sides with rounded edges (typical of quarried rock) rather than rounded rocks, as they provide a variety of water velocity and depths that easy for fish to navigate;

- Rock material needs to be concreted in place to prevent them from washing away during high flows;

- Rock should be placed with a cascade pattern creating numerous step-like riffles, but should also incorporate a large variety of rock sizes placed at random to create a diversity of hydraulic conditions (microhabitats) within the fishway;

- Pools or depressions of varying sizes and depths should be created at random throughout the length and width of the fishway and should be placed behind large rocks to create lower velocity resting areas (eddies) for fish. The more pools incorporated in the design, the more successful the fishway will be;

- Guidelines for fishway design:
  - **Channel slope –** between 1/8 and 1/10 is recommended for South African fish;
  - **Fishway entrance –** furthest point upstream that the fish can penetrate, usually in a suitable pool (low turbulence with sufficient depth) located at the base of the low level weir;
  - **Fishway exit** – located in a quiet area, sheltered, low velocity to prevent fish from being swept downstream and to afford protection from predators:

- The invert level of the exit (i.e. water inflow) should be lower than that of the weir overflow to ensure the low flows are directed down the fishway;
  - **Depth of pool** – small fish (20 to 200 mm in length: at least 300 mm to reduce predation and limit turbulence;
    - Larger fish (>200 mm): at least 500 mm can be deeper to reduce turbulence, if necessary;
  - **Length of pool** – at least 2.5 times the length of the largest fish catered for;
  - **Drop height between pools/rock levels** – maximum of 100 mm to cater for small fish;
- The fishway should take into consideration the jumping and swimming abilities of the different species, allowing the smallest and weakest swimmers passage through the fishway without undue stress;
- The fishway should take into consideration that the migratory *Barbus andrewi* may be present in the Berg River while further introduction by Cape Nature will commence;
- Cape Nature are in the process of reintroducing Whitefish to the Berg River and recommend the introduction of the natural type rock ramp fishway on the proposed weir to aid in migration of the Whitefish across the proposed barrier; and
- An aquatic biomonitoring programme should be conducted after the construction phase has been completed in order to determine the effect, if any, on the local biota and migration of the fish species.

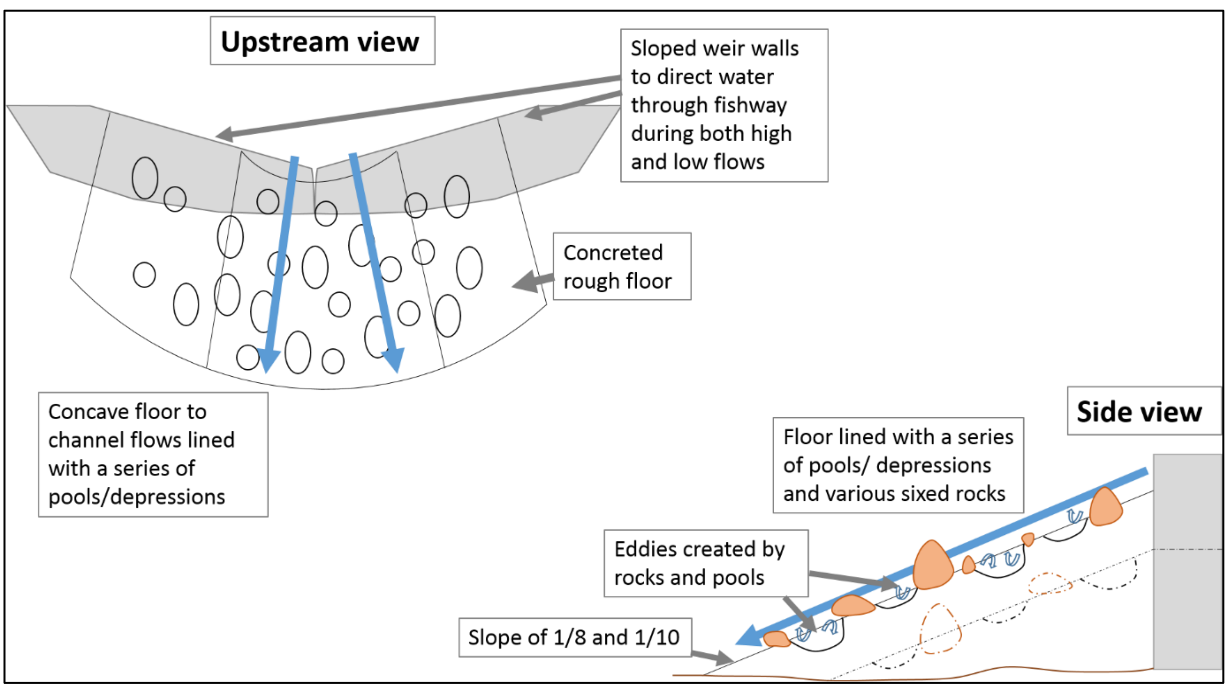

Figure 17: Different views of the rock ramp type of fishway

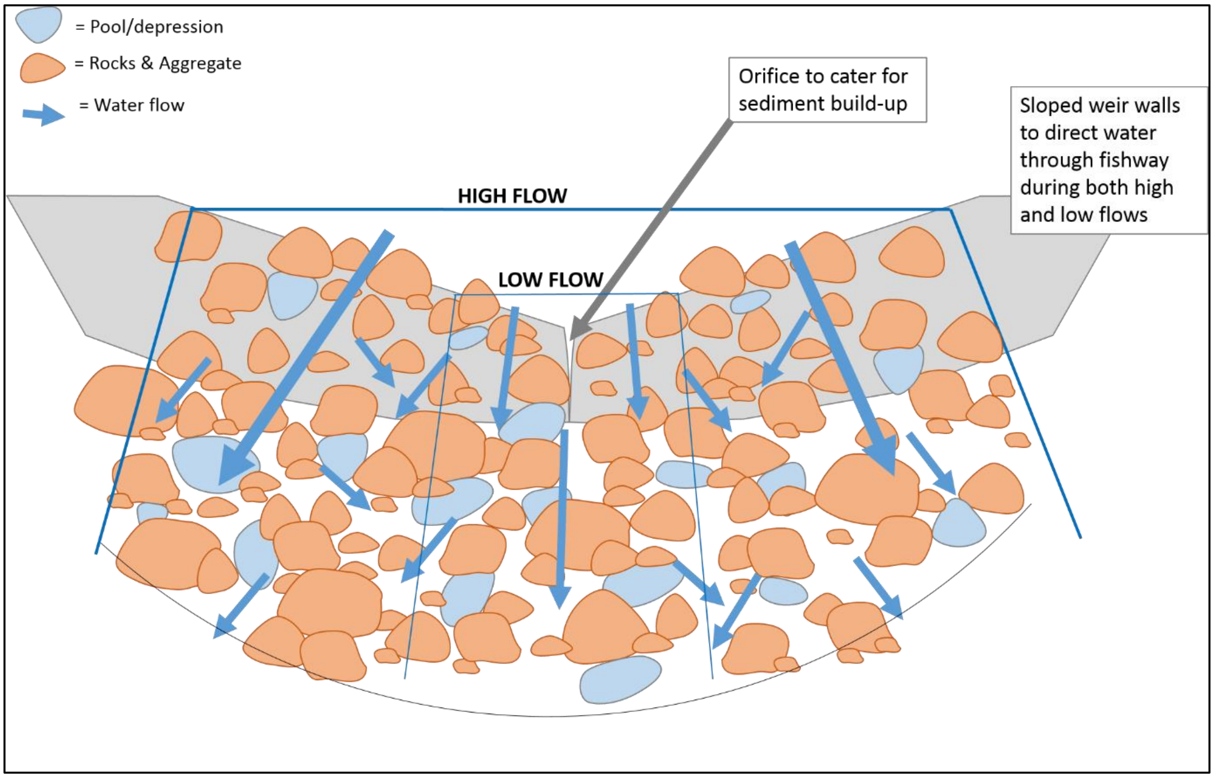

Figure 18: Diagram of rock ramp type fishway

7.3 Fishway specifics to be changed

The following fishway construction designs stemming from the supplied document titled "Pages from Berg River Abstraction Works Report May 2012 – rev01" need to be addressed due to a number of concerns:

- The proposed "u" shaped fishway has a main channel width of 0.9 meters;
  - This channel width is inadequate for the protection of fish traversing the fishway. This narrow channel width concentrates fish making them vulnerable to predation (between fish species, birds and local people);
  - Local people were seen at Voëlvlei Dam during the site visit, successfully stabbing fish for food with a pitchfork;
  - A wider channel width is proposed. A wider fishway will ensure sufficient flow through the fishway to attract fish to the fishway entrance while preventing overcrowding in the fishway;
  - A wider channel should lower flow velocities, offering a greater variety of flow dynamics due to the spreading of flows in each pool step;
  - A wider channel will cater for the largest fish species such as *C. gariepinus* which usually reach a length in excess of a meter. A channel width of 0.9 meters may cramp these fish once in the fishway.

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- There is no mention of the depth of the fishway design;
    - A minimum depth of 500mm is recommended.
- The entrance to the fishway should not be a barrier during the lowest of flows. Rather the entrance opening should be at the same level as the lowest water level to cater for fish migration.
- A fatal flaw in many fishway designs is insufficient flow discharge from the fishway entrance. Without sufficient discharge, fish are not attracted to the fishway entrance.

In order for the fishway to be successful, the raised issues need to be addressed. Raised issues and recommendations are based on fishway guidelines and South African case studies (Bok *et al*., 2007).

7.4 Pipeline mitigation measures

The following pipeline mitigation measures are provided:

- It is not advisable to only set a mesh on the pipeline at the abstraction point, due to the mesh becoming clogged with debris. It is recommended that an abstraction sump be considered for the design, in addition to the mesh. The sump will ensure no blockages of the pipeline, and the mesh will prevent the transfer of fish which may result in fish fatalities;

- Pipeline trenches and sandy bedding material may produce preferential flow paths for water across the project area perpendicular to the general direction of flow instead of angle. This risk can be reduced by installing clay plugs at intervals down the length of the trench to force water out of the trench and down the natural topographical gradient;

- Pipelines crossing watercourses should preferably span the systems above ground. This prevents disruptions to sub surface flow dynamics;

- When a pipeline spans a river, it should be attached to any existing crossing or bridge structures (if present). If pier support structures are needed for the pipeline to span a system, then piers should be placed outside of preferential flow paths with the least number of pier structures used as possible;

- Trenches and foundations should be side dug (where possible) from the existing access routes. In the absence of access routes, temporary routes may be considered;

- Trenches should be dug on-line (where applicable) creating narrower trenches;

- Where trench breakers are required, these must be imported appropriately and installed by the backfill crew, ahead of backfilling;

- Ensure careful separation of soil types/ strata as identified for the removal of soil. The soils must be removed in such a way that they can be easily reinstated in the reverse order for backfilling;

- To ensure correct backfilling, the soil that is removed from the trench at its deepest point must be laid closest to the trench. The first layer of topsoil must be laid furthest away from the trench;
- It may be necessary to import small amounts of padding material upon which the pipe safely rests in the trench prior to backfilling. This material must be stored outside the wetland areas until it is required to be placed within the trench, and bunded with sandbags;
- Any large boulders encountered during trenching operations must not be returned to the trench, but removed off site; and
- If any spoil is generated this can be transported to another location and re-used if it is required, removed correctly to a licensed facility, or offered to the landowner.

7.5 General mitigation measures

The following general mitigation measures are provided:

- The delineated aquatic and wetland areas outside of the specific project site area must be avoided where possible;
- The construction vehicles and machinery must make use of existing access routes as much as possible, before adjacent areas are considered for access;
- Laydown yards, camps and storage areas must be beyond the aquatic and wetland areas;
- The contractors used for the project should have spill kits available to ensure that any fuel or oil spills are clean-up and discarded correctly;
- It is preferable that construction takes place during the dry season to reduce the erosion potential of the exposed surfaces;
- Temporary storm water channels and preferential flow paths should be filled with aggregate and logs (branches included) to dissipate and slow flows limiting erosion;
- Contamination of the Berg River system with unset cement or cement powder should be negated as it is detrimental to aquatic biota. Pre-cast structures should be made use of (where possible) to avoid the mixing of these materials on site, reducing the likelihood of cement in the river system;
- All chemicals and toxicants to be used for the Augmentation Scheme construction must be stored outside the channel system and in a bunded area;
- All machinery and equipment should be inspected regularly for faults and possible leaks, these should be serviced off-site;

- All contractors and employees should undergo induction which is to include a component of environmental awareness. The induction is to include aspects such as the need to avoid littering, the reporting and cleaning of spills and leaks and general good “housekeeping”;

- Adequate sanitary facilities and ablutions on the servitude must be provided for all personnel throughout the project area. Use of these facilities must be enforced (these facilities must be kept clean so that they are a desired alternative to the surrounding vegetation);

- Have action plans on site, and training for contractors and employees in the event of spills, leaks and other impacts to the aquatic systems;

- All removed soil and material must not be stockpiled within the system. Stockpiling should take place outside of the riparian and wetland areas. All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised, and be surrounded by bunds;

- Erosion and sedimentation into the channel must be minimised through the effective stabilisation (gabions and Reno mattresses) and the re-vegetation of any disturbed banks;

- Temporary and permanent erosion control methods may include silt fences, flotation silt curtains, retention basins, detention ponds, interceptor ditches, seeding and sodding, riprap of exposed embankments, erosion mats, and mulching;

- Any exposed earth should be rehabilitated promptly by planting suitable vegetation (vigorous indigenous grasses) to protect the exposed soil;

- No dumping of construction material on-site may take place;

- All waste generated on-site during construction must be adequately managed. Separation and recycling of different waste materials should be supported; and

- An alien invasive plant management plan needs to be compiled and implemented post construction to prevent the growth of invasives on cleared areas.

7.6 Summer release installation options

The summer release point into the Berg River has two gabion-type structure options to mitigate further erosion of the receiving system. The outlet will be via a short T-connection or Y-connection. This installation may provide opportunities to rehabilitate this portion of the river. The summer release point location is provided in Figure 19 and a photo showing the highly-eroded area is presented in Figure 20.

A Y-connection may be better suited as the discharged flow velocity will be deflected and dissipated as it hits and flows against the Y-shape. A T-shape connection may result in the flows being redirected into the channel banks, further eroding them.

Figure 19: Summer release discharge point into the Berg River with proposed pipeline (Blue)

Figure 20: Highly eroded discharge point (photo courtesy Nemai Consulting)

7.7 Project options

A total of two (2) road options and two (2) pipeline alternatives have been proposed for the study. The preference for each option / alternative for the two respective specialist components is provided in Table 30.

Table 30: The list of project preferences for the aquatic and wetland studies for the project option and alternatives

	Preference	
Roads	**Aquatics**	**Wetlands**
Option 1	No preference	First preference
Option 2	No preference	Second preference
Pipelines		
Alternative 1	Least preferred	Not recommended
Alternative 2	Second preference	No preference
Alternative 3	First preference	No preference

- In terms of the road options, there is no preference for any of the proposed road options in terms of the aquatic assessment;

- With regards to local wetlands, Option 1 is the most preferred option, due to the route being predominantly aligned with existing access routes. It is likely that four (4) crossings may have to be upgraded for this option, which includes one wetland system;
- The second preferred road option is Option 2 for the roads, which is expected to require the crossing of three (3) watercourses, with one wetland system being traversed;
- Alternative 3 has a discharge area with existing excavation scars with a gentle gradient which is expected to mitigate any likely scouring (desirable). Owing to this, this alternative is the preferred alternative for the aquatic assessment;
- Alternative 2 has the shortest route path (desirable) and the discharge point enters the dam at a steep gradient that would result in large scale scouring with subsequent increase in turbidity (not desirable), and due to this risk, this alternative is the second preference for the aquatic assessment;
- Alternative 1 has the longest route path (not desirable) and will discharge into an area of the dam that received clean water from surrounding systems. Owing to the length of this pipeline, and the potential mixing of clean water, this is the least preferred option for the aquatic assessment;
- With regards to the wetland study, Alternative 1 for the pipelines is not recommended owing to the fact that the structure will transect a depression system, resulting in impacts to the system; and
- Further to the wetland study, there is no preference for either Alternative 2 or Alternative 3 as no risks to wetlands are posed by either alternative.

8. MONITORING

An aquatic ecologist with fishway experience should monitor the construction phase of the project, in order to assess compliance and to also provide guidance for riparian and fishway related matters that arise.

Should the construction phase be monitored and guided by a specialist, the expected impacts for the phase of the project will be mitigated and the operational phase concerns pro-actively managed to reduce the overall negative ecological impact of the project.

An aquatic monitoring survey needs to be conducted after the construction activities have been completed, in the operation phase of the project so that impacts can be assessed and adaptive management practices implemented if necessary. A number of sensitive aquatic biota should be specifically monitored to identify fluctuation in abundances and diversity, including fish and macroinvertebrates. The frequency of the monitoring programme should be as follows:

- Shortly after construction of the weir, pipelines and fishway.
- Bi-annually for at least one year after the first monitoring survey.

9. BUFFER ZONE

Buffer zones have been used in land-use planning to protect natural resources and limit the impact of one land-use on another. A buffer zone has been prescribed for this project to server as a "barrier" between the proposed development and the wetland systems.

Provincial guidelines that have been considered for defining the buffer zone are discussed below. The buffer zone was predominantly determined with a detailed methodology currently developed by Graham and de Winnaar (2009). The following guideline was considered:

- In the Western Cape, several watercourses of significance have been identified and buffers of 10 m to 40 m determined for selected watercourses.

A method developed by Macfarlane et al. (2014) to define an appropriate buffer width for the proposed project was applied for the study. The proposed buffer zone for the project are as follows:

Project Component	Buffer Width (m)
Construction Phase	15
Operation Phase	21

10. CONCLUSIONS

Results showed that the sampled reach of the Berg River is in a largely to seriously modified state. This was predominantly due to the modified state of the local aquatic biota and instream and riparian habitats. The Berg River showed great habitat availability, however poor water quality has resulted in modified macroinvertebrate and fish community assemblages.

A number of watercourses were identified and assessed for the project. These systems include the Berg River floodplain, valley bottom wetlands, hillslope seeps, depressions and numerous drainage channels. The ecological integrity of these systems varied from moderately to largely modified, with no systems determined to be in a natural or largely natural state.

The proposed project will have both direct and indirect impacts on the local watercourses. The most significant risks are associated with the weir and fishway structures, with the level of risk determined to be moderate. These moderate risks are expected for the construction and operation of the project. The risks associated with the supporting activities and linear structures was determined to be low.

In terms of the road options, Option 2 is the most preferred for the study. The least preferred road option is Option 1. With regards to the pipeline alternatives, Alternative 1 is not recommended, and the preferred alternative is Alternative 3.

It is recommended that an aquatic monitoring programme be implemented after construction activities should the proposed project commence. A buffer zone of 15m and 21m has been prescribed for the construction and operational phase respectively.

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