HYDROLOGICAL IMPACT ASSESSMENT OF THE PROPOSED BLIKANA RIVER BULK WATER SUPPLY SCHEME, SENQU MUNICPALITY, EASTERN CAPE

MAY 2026

Prepared for:

Abantu Environmental Services (Pty) Ltd

Prepared by

Solomon Owolabi

Zamakhe Consulting and Engineering Services (Pty) Ltd

SPECIALIST REQUIREMENTS

Specialists' reports must comply with Appendix 6 of Government Notice No. 326 of 07 April 2017 as published under sections 24(5), and 44 of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended **Table 1**.

Table 1. Requirement from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	**Section in the report**
• The details of:	
• The specialist who prepared the report; and	• Before section 1
• The expertise of that specialist to compile a specialist report including curriculum vitae.	• Before section 1
• A declaration that the specialist is independent in a form as may be specified by the competent authority;	• Appendix 1
• An indication of the scope of, and the purpose for which, the report was prepared;	• Section 3
• The date and season of the site investigation and the relevance of the season to the outcome of the assessment;	• Section 5.5
• A description of the methodology adopted in preparing the report or carrying out the specialised process; the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	• Section 5.5
• An identification of any areas to be avoided, including buffers;	• Section 5
• A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	• Section 5.1
• A description of any assumptions made and any uncertainties or gaps in knowledge;	• Section 6
• A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	• Section 7
• Any mitigation measures for inclusion in the Environmental Management Programme (EMPR);	• Section 9
• Any conditions for inclusion in the environmental authorisation;	• Section 9
• Any monitoring requirements for inclusion in the EMPR or environmental authorisation;	• Section 9
• A reasoned opinion-	
• As to whether the proposed activity or portions thereof should be authorised;	• Section 10
• If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPR, and where applicable, the closure plan;	• Section 10
• A description of any consultation process that was undertaken during preparation of the specialist report;	• N/A
• A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	• N/A
• Any other information requested by the competent authority.	N/A

SPECIALIST DETAILS

The appointed specialist is registered with the South African Council for Natural Scientific Professions (SACNASP). Refer to **Table 2** below for specialist's details:

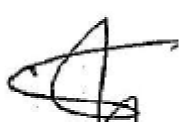
Table 2. Environmental Specialist details

Specialist:	Dr Solomon Owolabi (Pr. Sci.Nat)
Email	solomonowolabi11@gmail.com
Cell	078 385 7662
Expertise:	Dr. Solomon T. Owolabi is open to any opportunity within the field of geo-environmental studies. He is currently serving as a researcher/lecturer of GIS and remote sensing in the Disaster Management Training and Education Centre, University of the Free State, South Africa. He served as a principal environmental geologist at Zamakhe Consulting and Engineering Service. He developed a novel geostatistical approach for identifying groundwater capture zones in a complex geologic environment and a geodynamic approach for exploring the 3-D subsurface profile of the complex geologic environment. He was responsible for the geo-tagging and rejuvenation of groundwater boreholes across Oyo State, Nigeria, as a project supervisor at Male Integrated Science Nigeria Limited. He was responsible for the development of groundwater quality atlas in Botswana as a researcher at the University of Botswana. With more than seven years of teaching, research, and industrial experience in Environmental Geology, Solomon Owolabi has carved out a career track that believes in an environmentally stable future. **Qualifications:** • PhD Geology (Geohydrology, Remote Sensing & GIS) o Conceptualisation of a novel integrated geoscience desktop-approach for regional groundwater exploration. o Development of a novel geodynamic-geoinformatic approach for a holistic 3-D environmental prognosis. o Conception of a novel stochastic approach for assessing the hydrodynamic attributes of streamflow for river basin management. o Proposition of scientific theories influencing interdependence of stormflow and streamflow at the watershed level. • MSc Hydrogeology o Hydrogeochemical analysis and Hydrogeological characterization • BSc Geology o Environmental and Engineering Geology **Registrations and memberships:** • Professional Environmental Assessment Practitioner (EAPASA) Registration No. 130604 • Water Institute of Southern Africa (ACWISA) • Commission for the Management and Application of Geoscience Information, Canada (CGI).

DECLARATION

I, **Dr Solomon Owolabi**, in my capacity as specialist, hereby declare that I –

- Act as an independent consultant
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed
- Have and will not have vested interest in the activity
- Have no, and will not engage in, conflicting interests in the undertaking of the activity
- Undertake to disclose any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan, or document
- Will provide the competent authority with access to all information at my disposal regarding the report, whether such information is favourable to the Client or not
- Based on information provided to me by the Client and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability
- Reserve the right to modify aspects pertaining to the present investigation should additional information become available through on-going research and/or further work in this field
- Undertake to have my work peer reviewed on a regular basis by a competent specialist.



Hydrogeological Specialist

04/05/2026

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1. INTRODUCTION

Abantu Environmental Services (Pty) Ltd has been appointed by GIBB (Pty) Ltd on behalf of the Joe Gqabi District Municipality (JGDM) to apply for an environmental authorisation for the proposed Blikana Dam BWSS planned to mainly source water from the eastern and western tributaries of the Blikana river, northern parts of Senqu Local Municipality. The project aims to address critical water service backlogs in Wards 2, 3, 4, 5 and 6 by providing a sustainable, reliable, and equitable bulk water supply to approximately 42 000 people, with demand projected to increase to over 52 000 by 2053.

This report presents the hydrology impact assessment for the proposed development to address the environmental sensitivity of the proposed works as recommended by the DFFE National Screening Tool. The report has been compiled with the requirements of Appendix 6 of Government Notice No. 326 of 07 April 2017 as published under sections 24(5), and 44 of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended.

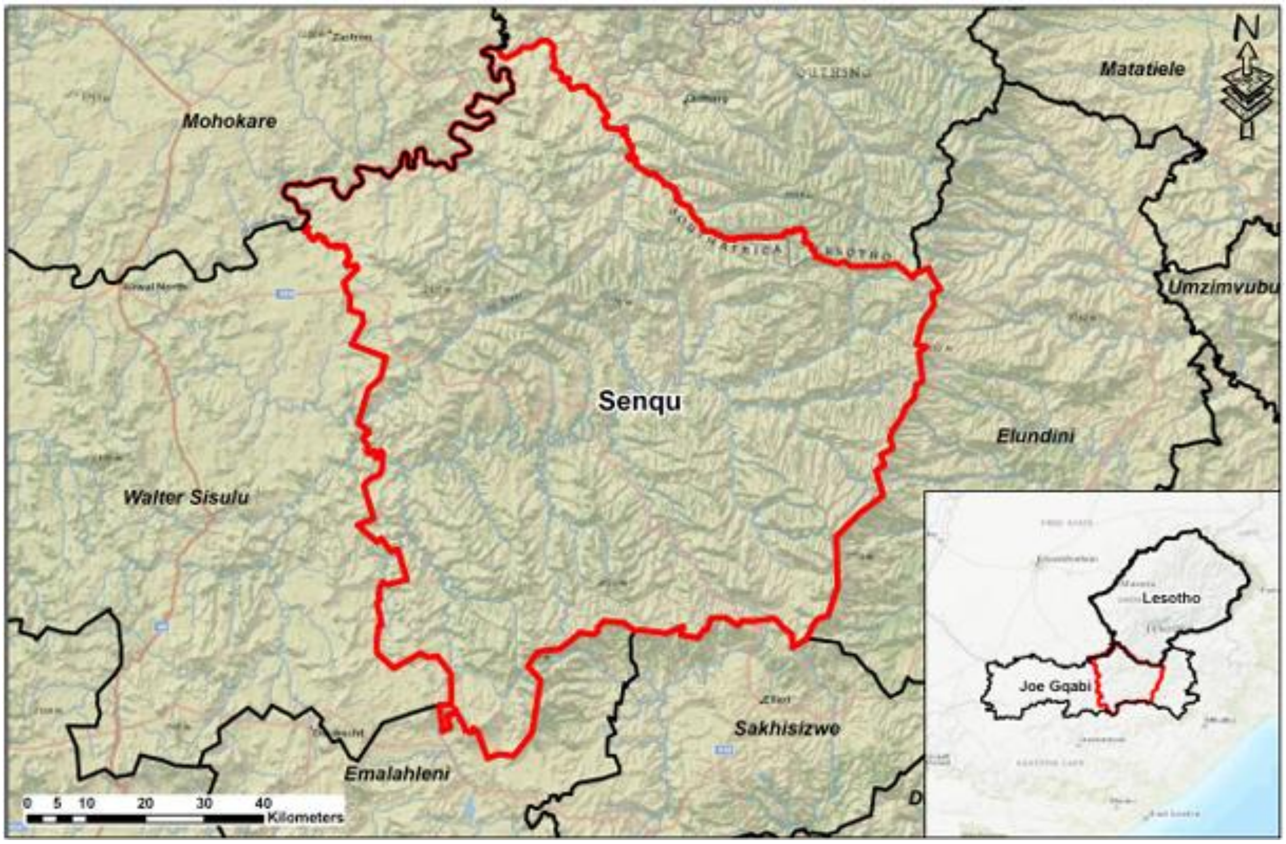

Figure 1.Locality map of Senqu Local Municipality.

1.1 BACKGROUND

Joe Gqabi District Municipality is proposing the Blikana Dam BWSS planned to mainly source water from the eastern and western tributaries of the Blikana river, northern parts of Senqu Local Municipality. The BWSS will serve communities in an area of approximately 700km^2 that lies between the town of Sterkspruit and the border with Lesotho within the Local Municipality. The proposed development entails;

- The Blikana river's eastern and western tributaries will supply water for this development
- A dam will be constructed 300m upstream of the Pelandaba river which is a perennial stream.
- A water treatment works (**WTW) (7.5Mℓ/d)** will be constructed downstream of the proposed dam, where water will be treated, stored and pumped to the various reservoirs.

<u>The reservoir supply areas and sizes are indicated below:</u>

- Supply reservoirs; SR 1 and SR 2
- Command reservoirs: CR 1 & CR 2

<u>Pipelines for this option include the following:</u>

- Gravity main from Dam to Raw water reservoir
- Rising main from WTW to CR 1

- Gravity main from CR 1 to Booster Pumpstation
- Gravity main from BPS to CR 2
- Rising main from Booster Pumpstation to SR 5
- Gravity main from CR 1 to SR 12
- Gravity main from CR 1 to SR 11
- Gravity main from CR 1 to SR 10
- Gravity main from CR 1 to SR 6
- Gravity main from CR 1 to SR 7
- Gravity main from CR 1 to SR 8
- Gravity main from CR 1 to SR 9
- Gravity main from CR 1 to CR 2
- Gravity main from CR 2 to SR 1
- Gravity main from SR 1/CR 2 to SR 2
- Gravity main from SR 1/CR 2 to SR 3
- Gravity main from SR 1/CR 2 to SR 4

2. PURPOSE AND OBJECTIVES

This Hydrology Impact Assessment (HIA) is conducted in accordance with the Procedures for the Assessment and Minimum Criteria for Reporting on identified Environmental Themes, as stipulated in Section 24(5) (a) and (h) and Section 44 of the National Environmental Management Act, 1998 (NEMA) (Act No. 107 of 1998). These procedures were formalized in Government Notice No. 320, published in Government Gazette No. 43110 on 20 March 2020, and became effective on 09 May 2020, alongside Government Notice No. 1150 in Government Gazette No. 43855 on 30 October 2020.

Applicability of Protocols

The Hydrology Impact Assessment report has been done in accordance with Appendix 6 of the EIA Regulations.

The primary objectives of this Hydrology Impact Assessment are as follows:

1. Evaluate existing conditions: Assess the current hydrological and geomorphological conditions of the site, including surface water and groundwater dynamics.
2. Impact Assessment: Identify and assess potential hydro-geomorphological impacts associated with the proposed stabilization structures, including the dam and associated infrastructure.
3. Mitigation Recommendations: Provide recommendations for mitigation measures addressing identified risks and impacts, while enhancing positive opportunities associated with the project.
4. Input for Environmental Authorization: Contribute comprehensive and scientifically-informed input to the Environmental Authorization (EA) application process, ensuring that all relevant hydrological considerations are in compliance with South African environmental regulations.

3. HYDROLOGICAL RECEIVING ENVIRONMENT

This section describes the baseline description of the proposed development's environment, which provides a fundamental understanding of the hydrological impact assessment.

3.1 CLIMATE

The Senqu Local Municipality is characterized by a temperate climate with distinct seasonal variations, including cold winters and occasional snowfall at higher altitudes. According to the South African National Standard (SANS 204-2), the municipality primarily falls under the Cold Interior climatic region, with some areas transitioning into the Temperate Interior climatic region (Conradie, 2012).

Temperature variability

Temperature fluctuations in the municipality are significant, with maximum summer temperature approximately 42°C and winter temperatures dropping to as low as -16°C (Senqu Local Municipality,

2023) (Figure 3). This wide temperature range influences the hydrological cycle, particularly evaporation rates, which can impact water availability during critical periods. The observed temperature trends reveal a pattern of increasing maximum temperatures over the decades, suggesting potential implications for streamflow dynamics in the Blikana Dam.

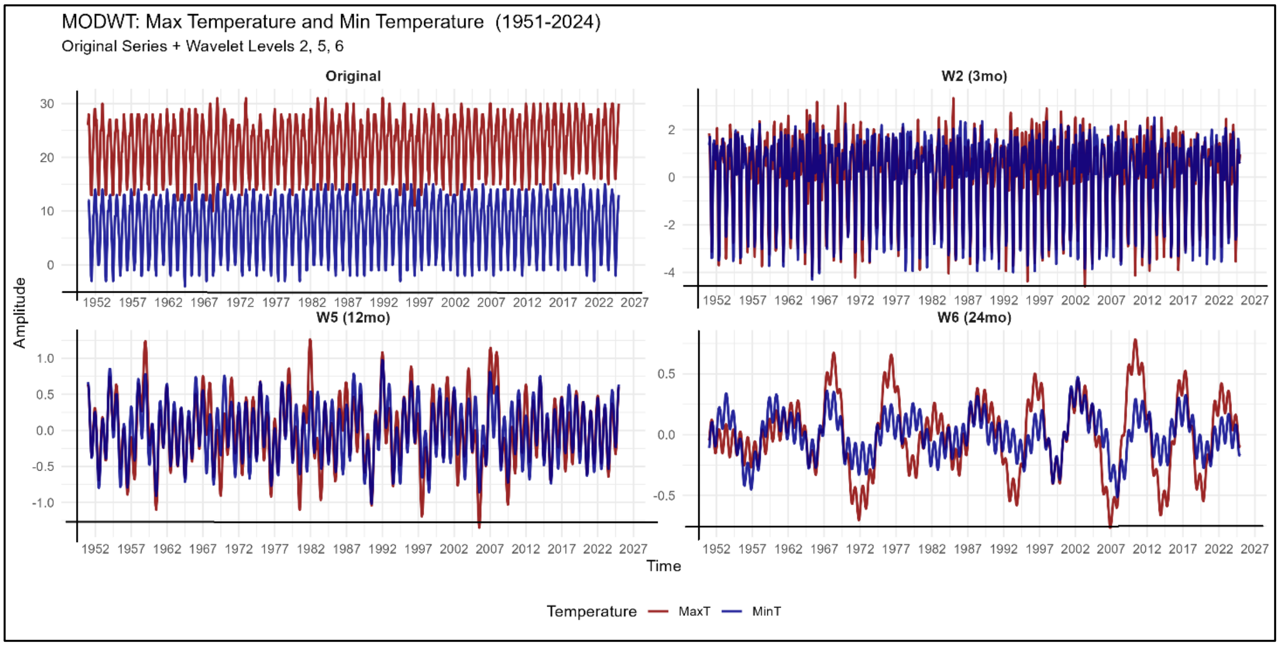

Figure 3. Monthly temperature trends (January 1951 to December 2024)

Rainfall Patterns

The rainfall within the municipality varies considerably, with the eastern section receiving between 1,000 mm and 1,400 mm annually, while the southern, western, and northern areas experience significantly less rainfall, averaging around 600 mm/year. As illustrated in Figure 4, the temporal variability of precipitation is evident, with notable peak during the summer months, especially from January to March. This variability in rainfall and its increasing trend is crucial for streamflow productivity in the Blikana Dam. Higher precipitation during the summer months correlates with increased runoff in the dam, enhancing water availability for downstream users, Conversely, the dry season from June to August typically sees reduced rainfall, which can lead to decreased streamflow and heightened pressure on water resources. Rainfall intensity is directly proportional to elevation; higher altitudes in mountainous areas tend t receive greater precipitation than lower altitudes such as valleys. The topographical influence on rainfall distribution further impacts the hydrological response of the region. The attached data indicates that significant rainfall events particularly those exceeding 50 mm, contribute significantly to the streamflow, reinforcing the importance of managing runoff during these periods.

Snowfall and Socio-Economic Impacts

Snowfall occurs sporadically, particularly in northern areas of the municipality. While it contributes to seasonal water availability, snow prevalence can also lead to socio-economic challenges, including traffic disruptions and impacts on agriculture due to livestock and crop mortality. These factors highlight the need for adaptive management strategies to mitigate the adverse effects of extreme weather events on local livelihoods.

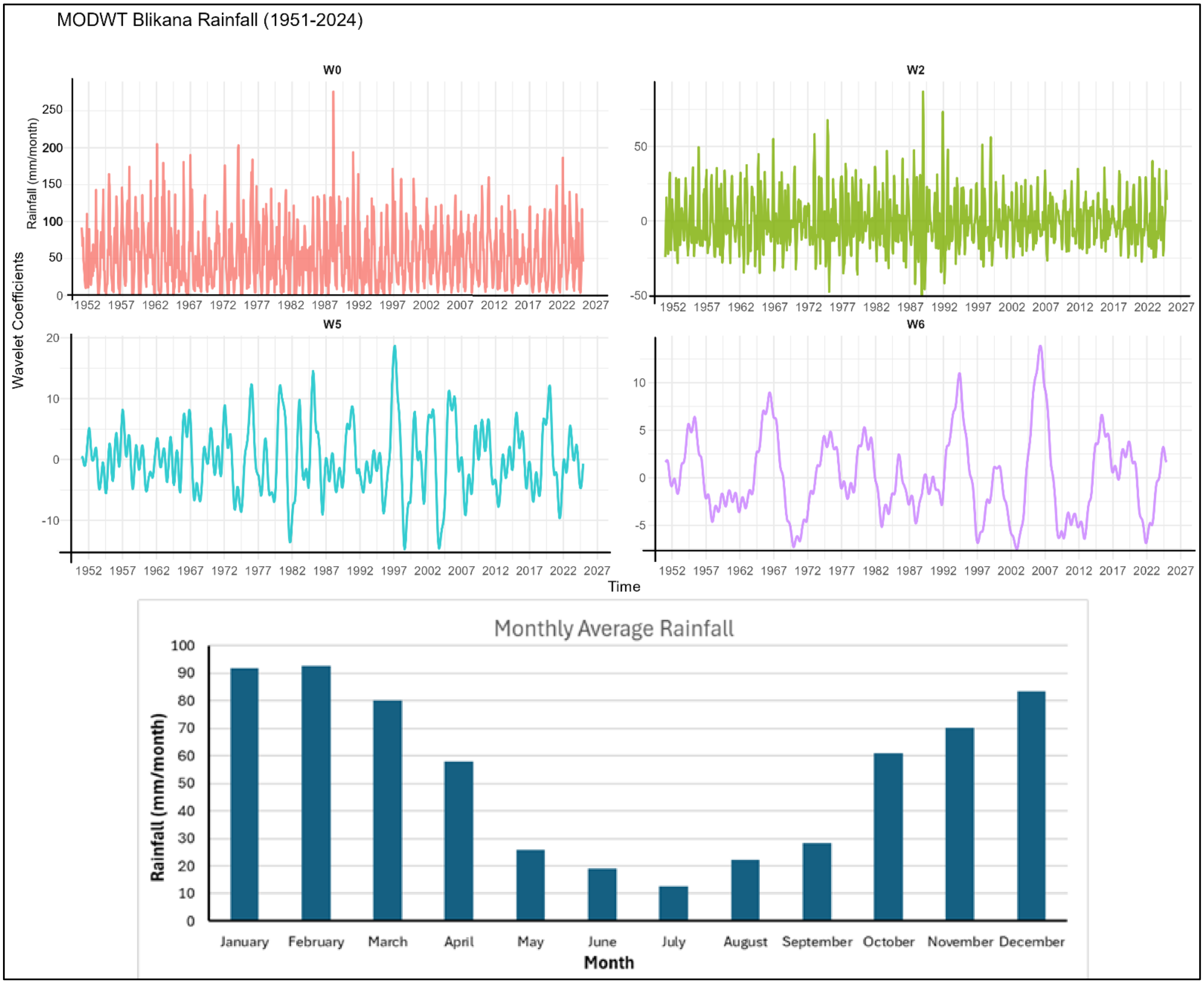

Figure 4. Monthly rianfall trends (January 1951 to December 2024)

3.2 TOPOGRAPHY AND HYDROLOGY

The municipal area is mountainous with the height above sea level increasing from the west to the east. The altitude within the project area increases in height from ~ 1 320 m amsl (metres above mean sea level) in the north (along the Orange River) to ~ 3 000 m amsl in the south (***Figure 3***). The Orange River forms the north-eastern boundary of the Study Area, with the Telle River on the eastern boundary and Kormspruit is on the western boundary. The river and streams originate in the south flowing northwards, joining the Orange River (SRK Consulting, 2023).

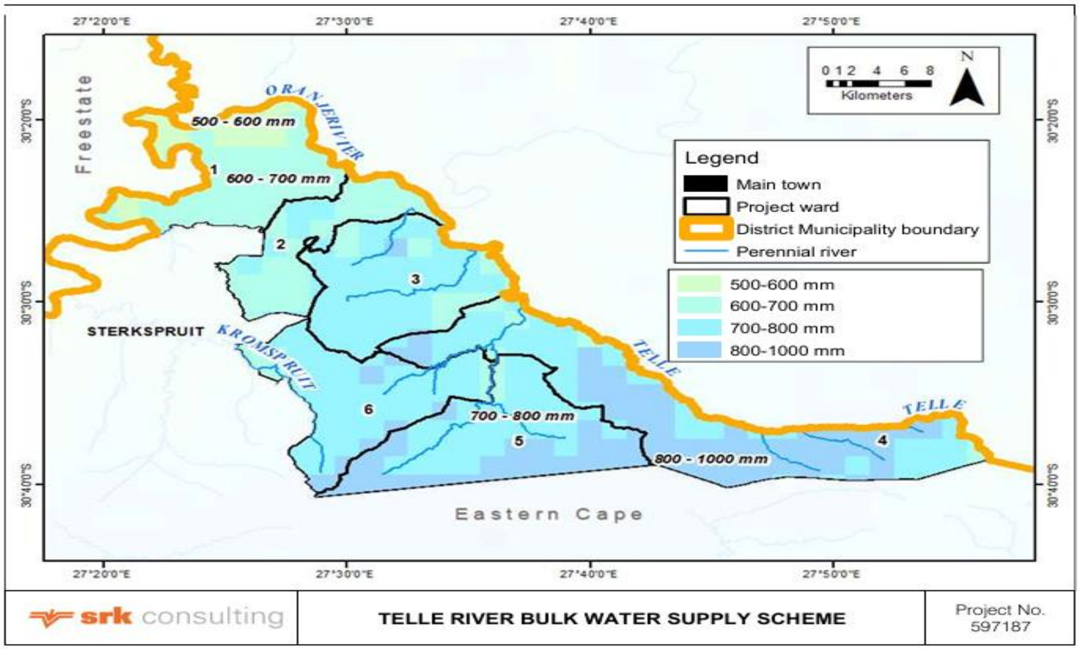

Figure 5. Mean annual Precipitation (source: SRK Consulting, 2023)

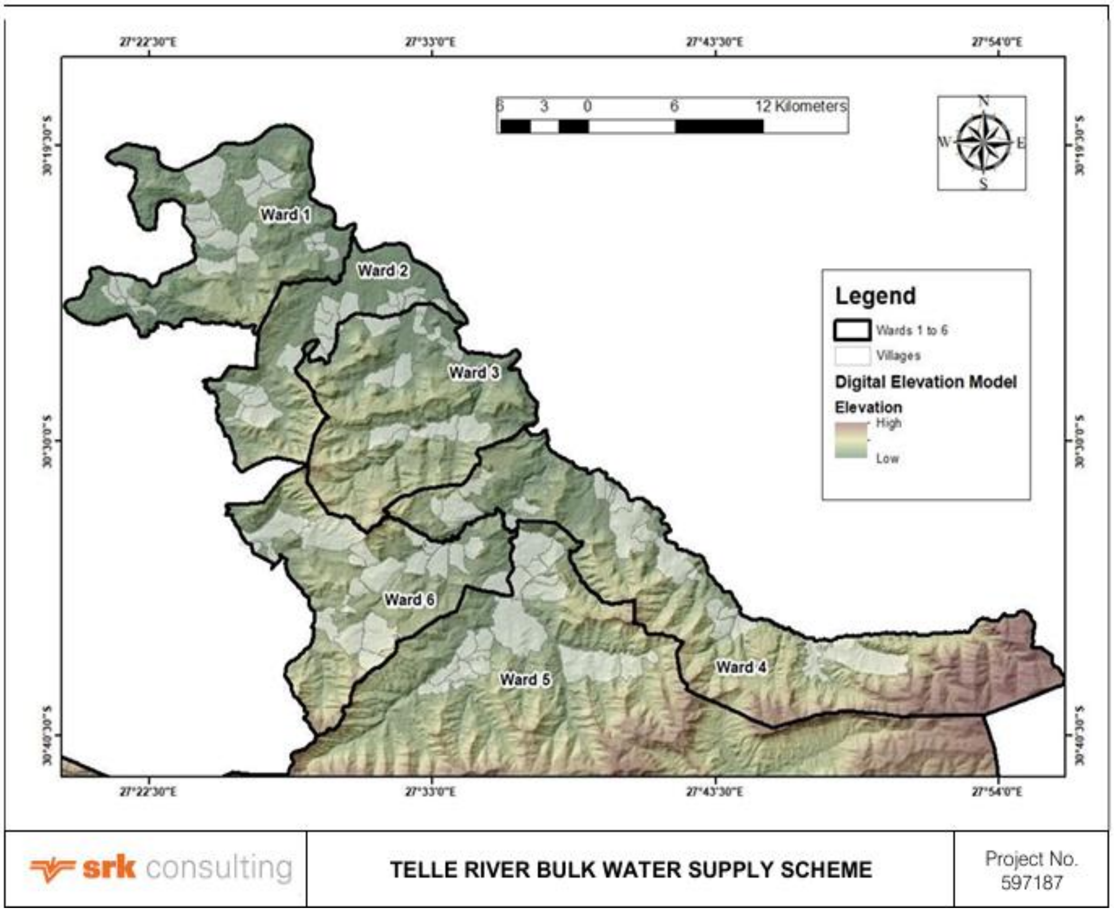

Figure 2. Digital elevation model (source: SRK Consulting, 2023)

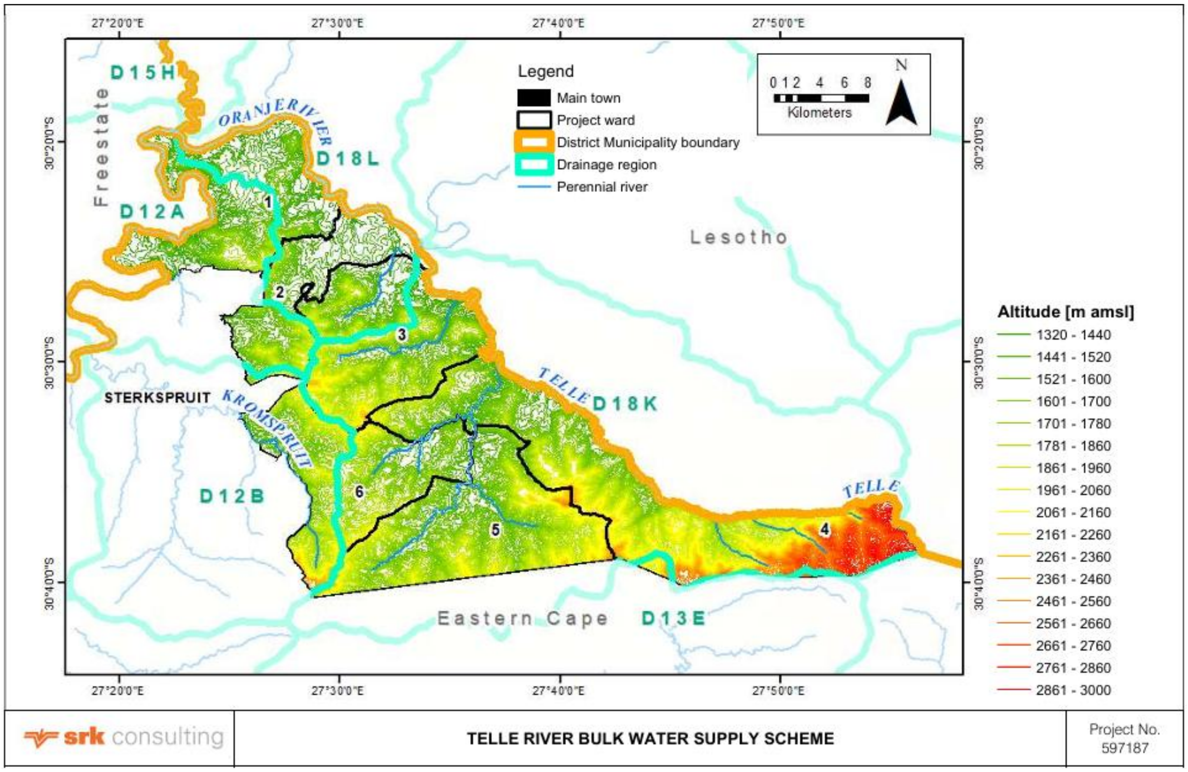

Figure 3. Topography and Quaternary regions (source: SRK Consulting, 2023)

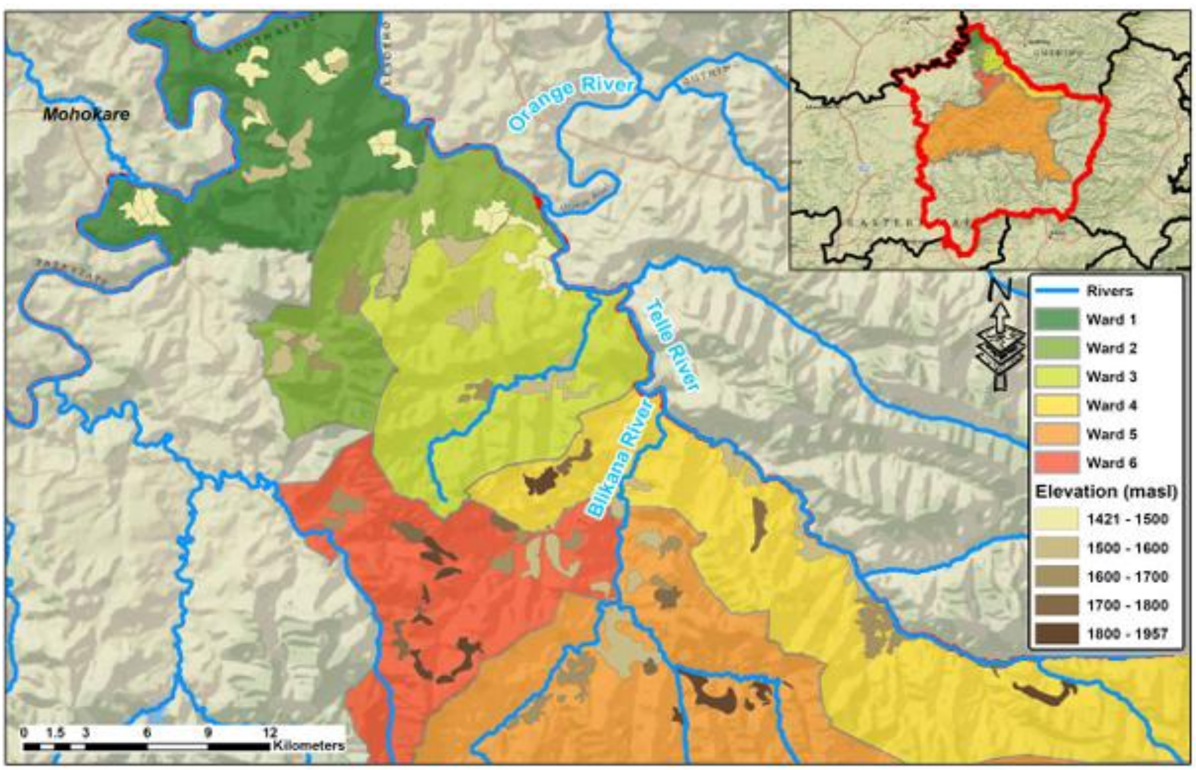

Figure 4. River systems within the project area (GIBB (Pty) Ltd, 2023)

The Telle River catchment at the outlet of interest falls under quaternary catchment (QC) D18K. It makes up for 77% of the quaternary's catchment area. This quaternary catchment constitutes the full Telle River catchment area as its outlet drains at the confluence with the Orange River.

The main physical characteristics of the delineated catchments were extracted from GIS. The main hydrological parameters extracted include the Mean Annual Precipitation (MAP), time of concentration (Tc), lag time (TL), and storm duration (SD). Tc and TL were calculated following a series of equations that link the physical parameters of the said catchment to its hydrological response time. The storm duration was varied in relation to the computed catchment response times.

A summary of the main physical and hydrological characteristics of Telle River catchment is presented in **Table 3**.

Table 3. Summary of physical and hydrological characteristics of Telle River catchment (GIBB (Pty) Ltd, 2023).

Catchment Area	L	L_c	S	C_s	MAP	MAR	Lag	T_c
Km^2	km	km	m/m	m/m	m/m	Mm^3/a	hr	hr
Telle River Catchment								
720	44.7	12.1	0.0196	0.3557	770	111	2.2	5.6

Any potential abstraction site will have a catchment area that is a subset of the quaternary catchment D18K. The D18K quaternary catchment area is 935 km2 with a Mean Annual Precipitation (MAP) of 774 mm. The D18K catchment has a Mean Annual Runoff of 144.5 million m3/annum (an average of 0.15 Mm3/a per km2)

Table 4. Summary of Rainfall-Runoff Parameters for D18K Quaternary Catchment and Telle River sub-catchment (GIBB (Pty) Ltd, 2023).

D18K Catchment			
Catchment area	**MAP**	**MAE**	**MAR**
Km^2	mm	mm	Mm^3/a
935	774	1367	144.5

D18K Catchment Mean Monthly Runoff (Mm^3 per Month)											
Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**
11.07	12.67	12.92	16.17	21.12	25.70	17.42	9.09	4.91	3.73	4.23	5.48

Telle River Catchment											
Catchment area			**MAP**			**MAE**			**MAR**		
Km^2			**mm**			**mm**			**Mm^3/a**		
720			770			1367			111.2		
Telle River Catchment Mean Monthly Runoff (Mm^3 per Month)											
Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**
8.53	9.75	9.95	12.45	16.26	19.79	13.42	7.00	3.78	2.87	3.26	4.22

Comparing the minimum target water volume of (4.4 million m3/a) to the catchment's MAR and to the long-term mean monthly runoff volumes indicates that the required abstraction volumes can be met, even when further deductions related to downstream users, environmental flow requirements, evaporation, etc. are accounted for. It also indicates that as long as the catchment area is big enough, then the type of the abstraction structure can be confined to either a weir or a dam with a maximum wall height of 10 m.

3.3 HYDROGEOLOGY

Based on the Aquifer Classification Map, the aquifer is classified as a minor aquifer region, therefore being a moderately yielding aquifer system of variable water quality. These aquifers can be fractured or fractured rocks which do not have a high permeability, or other formations with variable permeability. The aquifer extent may be limited and water quality variable. These aquifers seldom produce large quantities of water. The overall expected average groundwater exploitation potential (AGEP) in the project area is 15 000 to 25 000 m3/km2/annum (0.47 to 0.80 L/s).

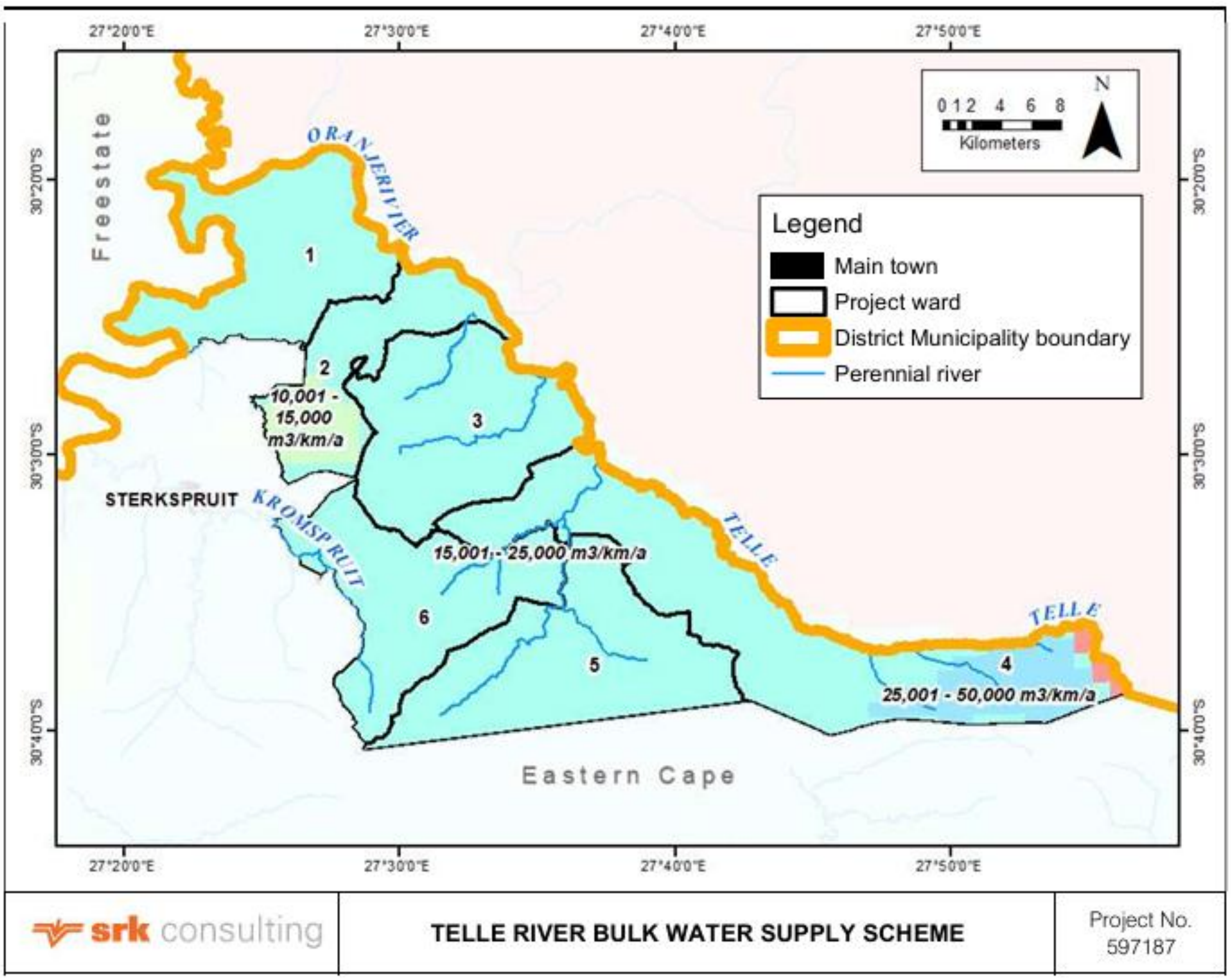

Figure 5. Average Groundwater Exploitation Potential

The quaternary catchment zones divined by DWS have been refined to delineate the groundwater recharge to proposed target zones. The larger the delineated area the higher the expected groundwater recharge volume will be.

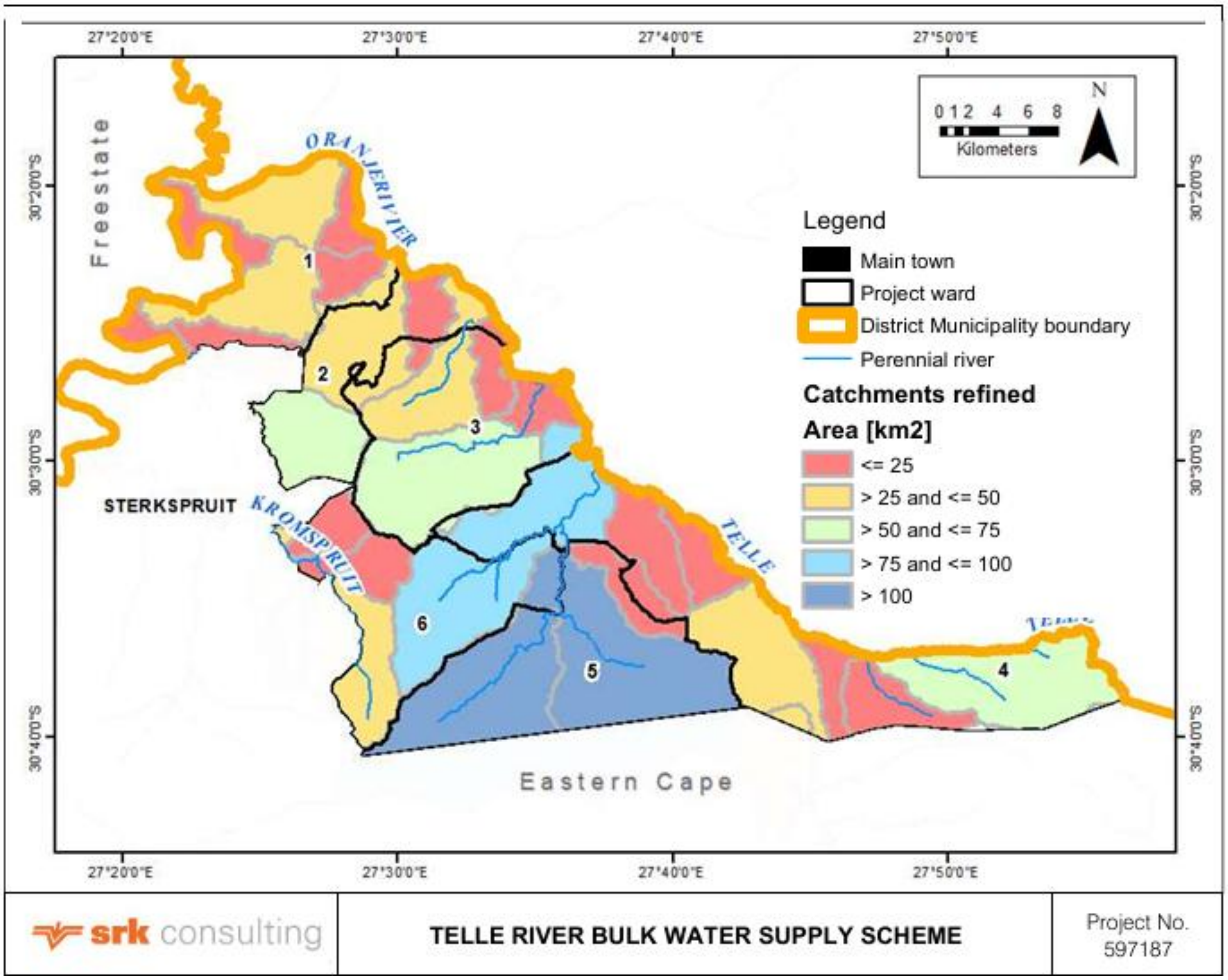

Figure 6. Refined Catchment Zones (SRK Consulting, 2023*)*

3.4 SURFACE WATER FEATURES

According to the DFFE screening tool the project area is classified as a Very High aquatic sensitivity. The project area falls within several categories, including aquatic Ecological Support Areas (ESA 1 and ESA 2) and areas classified as "Other ecosystems" (**Figure 7**). ESAs are areas that must be maintained in at least fair ecological condition (seminatural/moderately modified state) to support the ecological functioning of a CBA or protected area, or to generate or deliver ecosystem services, or to meet remaining biodiversity targets for ecosystem types or species, when it is not possible or not necessary to meet them in natural or near-natural areas (SANBI, 2017).

According to Le Maitre et al. (2018), Strategic Water Source Areas (SWSAs) are areas of land that either: (a) supply a disproportionate quantity of mean annual surface water runoff in relation to their size and are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b). Based on the DFFE screening tool, the project area falls within a Strategic Water Source Area for surface water (Eastern Cape Drakensberg).

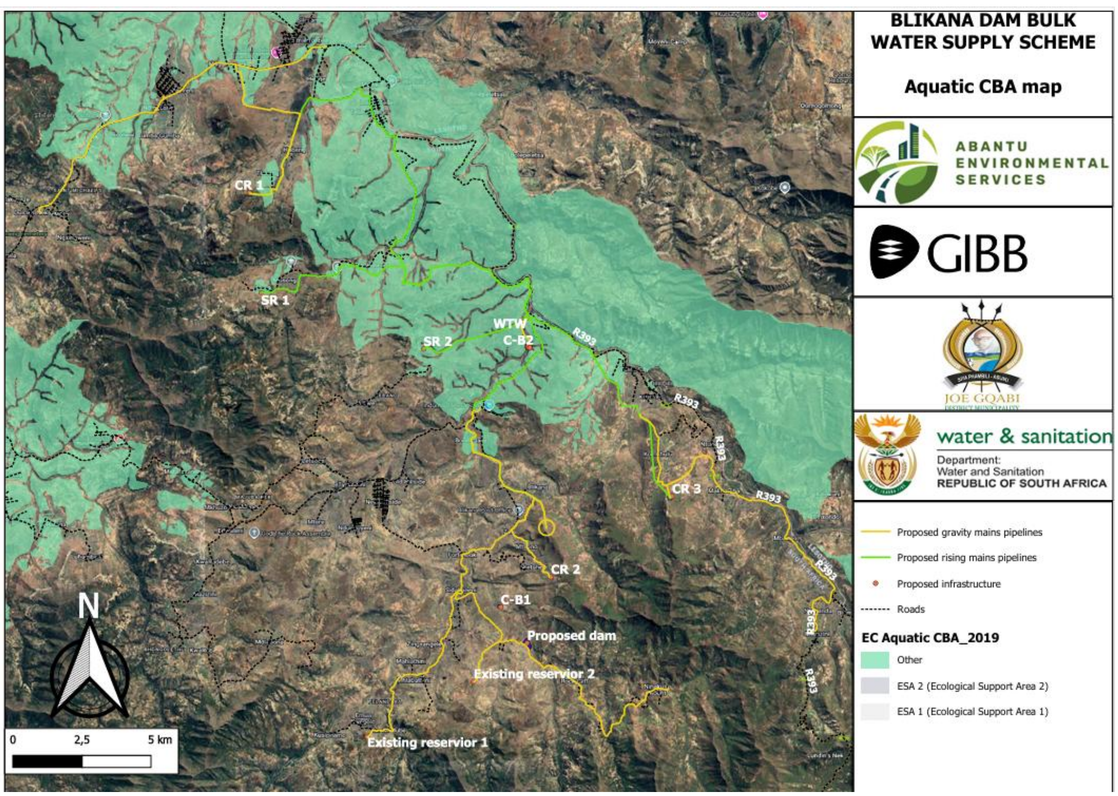

Figure 7. Aquatic CBA.

3.5 GEOLOGY AND SOILS

The greater portion of the study area is underlain by the Elliot Formation with the northern parts underlain by the Molteno Formation and the southern area and portions in the centre by the

Drakensberg Group. The Elliot Formation consists of red and greenish grey mudstone with subordinate sandstone. The Molteno Formation consists of alternating sandstone (pebbly in places) with olive mudstone and dark grey shale. The Drakensberg group comprise basaltic lava, with minor sandstone, tuff and agglomerate in the lower part of the succession in places The sedimentary rocks are intruded by multiple dolerite dykes and sills. The strike direction of the dykes varies from northwest-southeast and northeast-southwest. Patches alluvium is mapped along the Orange River and other rivers (SRK Consulting, 2023). See Figure 6 for a map showing the regional geology of study area.

The area is comprised of mudstone and sandstone of the Elliot Formation. The mudstone weathers rapidly through disintegration on exposure whilst sandstone is also erodible. Soil erosion is a problem, especially in areas with high rainfall because the steep topography increases the impact of soil erosion. The problem is further exacerbated by over-grazing which strips away vegetation, leaves the ground bare and so the rains are able to wash away the rich, top layer of soil.

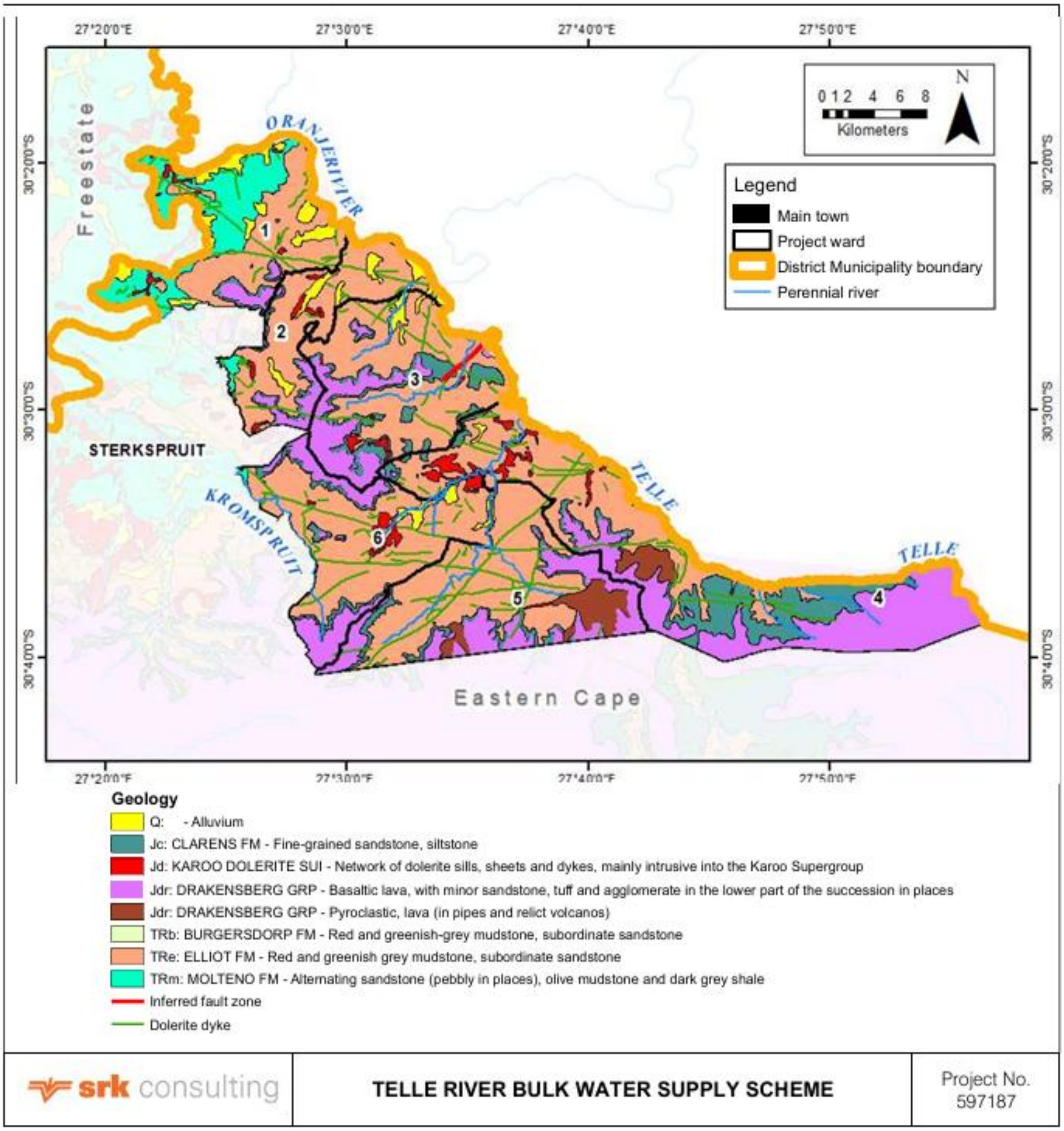

Figure 8. Geology (SRK Consulting, 2023)

3.6 CLIMATE CHANGE AND EXTREME ENVIRONMENTAL EVENTS

The municipality is increasingly experiencing the impacts of climate change, which manifest through extreme environmental events such as floods, droughts, prolonged cold spells, and veld fires. These events pose significant risks to the region's socio-economic stability, agricultural productivity, and overall environmental health. The following subsections provide a detailed account of these extreme environmental events.

3.6.1 FLOODS

Flooding has become a recurring extreme weather event in Senqu Municipality, largely driven by changes in rainfall patterns. One of the most significant flood events occurred in January 2020, when heavy rains led to widespread flooding in areas such as Sterkspruit and Lady Grey. The floods were the result of an unusual concentration of rainfall, with some areas receiving over 200 mm of rain in just 48 hours (South African Weather Service, 2020). The floods caused extensive damage to infrastructure, including roads and bridges, and displaced hundreds of residents. Agricultural fields were also submerged, leading to significant crop losses.

The increasing frequency of intense rainfall events in the region is attributed to climate change, which has altered the hydrological cycle and intensified the variability of rainfall. According to the Department of Environmental Affairs (2023), the Eastern Cape has seen a 10% increase in extreme rainfall events over the past two decades, with Senqu Municipality being one of the most affected areas.

3.6.2 DROUGHTS

Droughts are another major environmental challenge exacerbated by climate change. The region has experienced several severe droughts in recent years, with the most notable one occurring between 2015 and 2017. During this period, rainfall levels were significantly below average, with some areas receiving less than 50% of their normal annual precipitation (Statistics South Africa, 2018). The prolonged drought led to water shortages, severely impacting both urban and rural communities.

The agricultural sector, which is heavily dependent on consistent rainfall, was particularly affected very severely, Crop yields plummeted, and livestock losses were substantial, leading to economic hardship for farmers and the local economy. The drought also resulted in water restrictions and increased pressure on the municipality's water infrastructure. According to the Department of Water and Sanitation (2019), the drought contributed to a 30% decline in agricultural output in the municipality during this period.

4. ASSUMPTIONS AND LIMITATIONS

The following assumptions and potential gaps in knowledge apply:

- All information provided by the applicant to the author was correct and valid at the time it was provided
- The author does not accept any responsibility in the event that additional information comes to light at a later stage of the process
- All data from unpublished research is valid and accurate at the time this report was written.
- The scope of this investigation is limited to assessing the potential environmental impacts associated with the proposed development only

- The assessment does not account for the potential long-term effects of climate change, altered rainfall patterns or future land use changes within the catchment, which may influence hydrological regimes and sediment dynamics over time

It should be noted that findings, recommendations, and conclusions provided in this report are based on the author's best scientific and professional knowledge and experience. No part of this report may be amended or extended without prior written consent of the author. Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or refer to this report. Whenever such recommendations, statements, or conclusions form part of the main report to current investigation, this report must be included in its entirety.

5. PROPOSED DEVELOPMENT OF HYDROLOGICAL IMPACTS

This section addresses the hydrological impacts of the proposed activities for all phases of the project, thus from construction to operation, for the dam, abstraction points and the water treatment works. Key concerns include changes in river channel morphology, sediment load and transport, discharge and riverbed degradation, altered lateral and vertical erosion patterns, increased risk of channel incision downstream, modified flow regimes, and changes to floodplain morphology and sediment transport dynamics. This section presents an analysis of baseline hydrological conditions, assesses projected changes due to the proposed activities and evaluates the implications for surrounding environment. This section also outlines the linkage between the preferred alternatives and the hydrological findings.

5.1 DAM

In an undisturbed river system, river flow follows natural seasonal patterns that are characterised by periods of high and low flows because of wet and dry seasons in the area. The natural hydrological variability maintains a balanced sediment transport regime, where sediment is continuously eroded, transported and deposited along the channel and floodplain, maintaining geomorphological balance and supporting ecological diversity.The rate and capacity of sediment transport depend on stream velocity, discharge, channel gradient and sediment grain size. High flows mobilise coarse sediments, contributing to channel shaping and floodplain replenishment (Knighton, 2014), while finer particles remain in suspension and are deposited during low flows to sustain downstream ecosystem such as wetlands and estuaries (Petts & Gurnell, 2005). These processes shape the channel morphology and maintain strong longitudinal, lateral and vertical hydrological connectivity, allowing continuous interaction between surface water, groundwater and floodplains.

Rivers also have shallow groundwater reserves which play a critical role in maintaining the ecological integrity of riparian vegetation and wetlands. These groundwater reserves sustain baseflow during dry periods, ensuring a consistent supply of moisture that supports the growth and survival of hydrophilic plant species (Church, 2006). This moisture availability also stabilizes riverbanks, prevents erosion and creates microhabitats that contribute to the biodiversity of the riparian zone. Wetlands benefit from this sustained hydrological input because they are connected to shallow groundwater, this allows them to act as natural sponges that store, filter and slowly release water back into the river system. This buffering capacity regulates local hydrology, mitigates flood peaks and maintains water availability during drought conditions.

Walling and Fang (2003) state that natural nutrient cycling and sediment deposition during seasonal flood events enrich floodplain soils with organic matter and mineral sediments. This process replenishes essential nutrients such as nitrogen and phosphorus, which are vital for plant growth, soil productivity and water quality. Graf (2006) supports this by stating that water quality in an undisturbed river system remains stable due to the river’s capacity for natural infiltration and self-regulating biogeochemical processes. He states that as water flows through riparian zones and floodplains, sediment and vegetation act as filters that remove excess nutrients, suspended particles and any contaminants through processes such as sedimentation, adsorption and microbial breakdown. These natural filtration mechanisms maintain low turbidity and balanced nutrient levels

Construction of a dam instream will introduce a barrier that trap sediment within the reservoir and reduce the downstream supply of both suspended and bedload material (Kondolf et al., 2014). According to Poff et al. (1997), this trapping effect leads to sediment starvation below the dam, causing riverbed incision, bank erosion and loss of habitat complexity. Downstream ecosystems, including wetlands and estuaries, will experience reduced sediment replenishment, which diminishes nutrient availability, alters vegetation structure and increases vulnerability to erosion and salinisation.

During the construction phase, the river will be diverted to facilitate building activities, reducing downstream water availability and altering the ecological balance. Activities like excavation and clearing vegetation disturb soil, riverbank sediments and the channel bed. This increases the release of fine suspended sediments into the river, elevating turbidity levels and reduce light penetration which can affect aquatic photosynthesis. Sediment pulses may travel downstream affecting sensitive habitats such as wetlands (Kondolf et al., 2014). Excessive sedimentation in wetlands alters water retention, infiltration capacity and vegetation structure, which cumulatively leads to reduced ecological resilience (Morris & Fan, 1998)

Additionally, foundations and diversion structures often necessitate extensive dewatering to maintain a dry working environment. This process artificially lowers the local water table, which can have adverse consequences for nearby wetlands and riparian vegetation dependent on shallow groundwater (Sophocleous, 2002; Winter, 1999). These activities also modify the permeability of soil and underlying bedrock thus altering natural groundwater flow paths. These changes redirect or obstruct subsurface flows which can result in reduced spring discharges, create localised seepage zones or unintended waterlogging zones (Sophocleous, 2002; Winter, 1999).

During the operational phase, the dam wall creates a permanent upstream impoundment resulting in a backwater effect that elevates the water surface profile upstream, reduces channel slope and decreases flow velocity. This alters the hydraulic regime and influences adjacent wetlands by changing surface and groundwater interactions. Flow regulation caused by the dam wall will suppress natural flood pulses, increase baseflow and reduce seasonal variability that is essential for ecological processes such as fish migration, nutrient cycling and floodplain rejuvenation. The reduction of flow energy upstream leads to increased siltation, lateral erosion and meandering, while downstream reaches experience sediment starvation, riverbed scouring and bank destabilization. This imbalance fragments the natural sediment transport system and causes long-term morphological changes (Church, 2006).

Furthermore, the backwater effect created by the wall upstream, will reduce the natural channel slope because of reduced flow velocity that causes sediment to accumulate on the channel bed, causing vertical aggradation (…). The accumulated sediment widens the channel as flow spreads laterally, reducing channel depth and increasing the cross-sectional area of the channel. The reduced erosive power of the flow upstream also encourages meander formation and sliting in side channels and floodplain areas. This will change channel geometry into a pounded system. Downstream of the dam, the sediment starved water will have increased erosive capacity to scour the channel bed and banks. As a result, the incised channel will have a lowered base level that is disconnected from its floodplain, leading to a narrower and deeper cross section (Graf, 2006). This process will also destabilise the banks, increase the rick of channel migration and undercutting.

Graf (2006) states that hydrological connectivity is also disrupted because of the increased groundwater–surface water interactions upstream and reduced connectivity downstream. He states that this creates spatial imbalances in subsurface and surface water interactions because upstream of the dam, the impounded water raises the hydraulic head, increasing water pressure and enhancing connectivity between the surface water and the underlying aquifers. This leads to increased infiltration into the subsurface and expands the zone of groundwater recharge which potentially will elevate the local water table and promote seepage into the adjacent wetlands and floodplains. In contrast, downstream reaches of the river will experience the opposite because the dam will restrict flow and reduce hydraulic pressure. As result, there will be reduced groundwater recharge, a lowered water table and diminished baseflow contributions

(Church, 2006). Kondolf et al. (2014) state that the construction of an instream dam also alters the nutrient dynamics of the river channel because the dam traps the nutrients. This increases the risk eutrophication upstream and nutrient depletion downstream, which can cause habitat fragmentation and degrade spawning grounds and aquatic habitats, intensifying physical habitat loss and ecological stress. Additionally, prolonged upstream flooding can cause lateral seepage and waterlogging which affects soil stability and vegetation while reduced downstream overbank flooding diminishes natural sediment deposition, lowers soil fertility and agricultural productivity. This results in modified floodplain dynamics (Walling & Fang, 2003).

5.2 WEIRS (ABSTRACTION POINTS)

Under natural conditions, hillslopes act as regulators of water, sediment and nutrients inputs in the river system. These conditions function to slow down runoff which reduces flood peaks, stabilise soil to limit erosion, filter sediments and nutrients before they enter the river channel and support baseflow through groundwater contributions. The introduction of abstraction point along a river channel changes the hydrological connectivity , groundwater- surface water interactions and sediment dynamics in the surrounding landscape. River flow exerts a hydraulic pull that helps drains subsurface water from hillslopes into the channel and ensures that overland flow reaches the channel following the microtopographic features of the area. This process maintains the hillslope-river connectivity and flow continuity between the river channel and the surrounding landscape.

The construction of weirs reduces the volume of flow downstream and affects the hydraulic gradient between the channel and the adjacent hillslopes. As result, saturation increases upstream causes the water table to rise in upslope soils and reduce drainage efficiency. This leaves the soil upstream oversaturated with altered infiltration rates and overland flow patterns. Overtime, this can lead to waterlogging and soil aeration which can affect vegetation and slope stability (Poff et., 1997).

Harvey and Gooseff (2015) state that weirs also disrupt the hillslope-river connectivity because in an undisturbed river system, hillslope runoff contributes to baseflow and maintains hydrological connectivity. The introduction of weirs lowers river stage levels downstream and modifies flow variability. River stage levels refer to the height of the water surface in a river relative to a fixed point, usually called a gauge datum (Gordon et al., 2004). The lowered stage levels and modified flow variability result in weakened lateral hydrological connectivity which mean that episodic rainfall on the hillslopes may no longer effectively reach the main channel and consequently alter the soil moisture dynamics and increase subsurface flow retention because flow is instead infiltrated locally. Such changes reduce the resilience of the river system during dry seasons since there will be less upslope water contributing to baseflow recharge.

Like the dam wall, weirs also reduce downstream flow velocity and trap sediment upstream and disrupt the sediment balance of the river. Reduced downstream flow lowers the river's capacity to rework and remove deposited material, allowing sediment to build up near the abstraction point. This can lead to reduced channel incision and overbank flooding overtime, which decreases natural erosional feedback mechanisms, allowing fine sediment to accumulate upslope and alter the slope hydrology and vegetation patterns.

Vegetation patterns are influenced by soil moisture gradients which are affected by changes in flow and groundwater levels. Elevated soil moisture the weir will promote riparian vegetation encroachment and change plant community structure. Conversely, reduced downstream flow can lead to drying of lower hillslopes, resulting in a spatial shift in vegetation zones and soil desiccation, the process of moisture loss from soil, through evaporation, that causes soil to shrink, harden and crack. These shifts decrease root cohesion and increase susceptibility to erosion and mass movement.

5.3 WATER TREATMENT WORKS

Abstraction of water for treatment decreases downstream discharge and disrupts natural flow regimes and seasonal variability. These reductions in flow lowers groundwater levels within adjacent riparian zones and influences soil moisture availability and vegetation dynamics (Dlamini et al., 2020). In contrast, the return of treated effluent to the river can artificially maintain baseflows during dry periods, altering habitat conditions and the natural flow variability of the river system (Smith & van Wyk, 2021). Treated effluent also contains residual nutrients and trace metals that can alter downstream water quality and disrupt aquatic microbial communities within the river. Such conditions can lead to a shift in community structure, favouring pollution-tolerant species while reducing the abundance of sensitive taxa (Smith & van Wyk, 2021).

Thermal differences between discharged effluent and receiving water induce temperature fluctuations in the river. Elevated effluent temperatures have the potential to increase the metabolic rates and oxygen demand of aquatic organisms, while simultaneously reducing the dissolved oxygen (DO) concentration and excessive algal proliferation in the water. According to Naidoo & O'Connor (2019), this imbalance affects temperature-sensitive species such as fish and macroinvertebrates and leads to reduced growth rates and altered reproductive cycles. Warmer temperatures also favour invasive species such as algae and lead to shifts in community composition and a decline in biodiversity (Mwedzi et al., 2020).

Physiochemically, temperature variations also influence nutrient solubility and the breakdown of organic matter. Warmer effluent can accelerate microbial decomposition and nutrient transformation which potentially increases ammonia toxicity and alters the nitrification–denitrification balance within the river. In slower moving sections of the river, temperature differences between the effluent and the river water create thermal stratification and reduced vertical mixing and oxygen distribution. Thus, further intensifies the depletion of oxygen near the riverbed and impacts the nutrient cycling processes. Conversely, if the effluent is cooler than the river water, it alters the seasonal cues for processes such as spawning and migration in fish species (Smith & van Wyk, 2021).

Dlamini et al. (2020) also states that presence of water treatment works impacts the sediment dynamic in a river. Abstraction and discharge cause localized deposition and downstream erosion, which alter the channel morphology and degrade the quality of the aquatic habitats.

Table 5. Summary of hydrological impacts.

IMPACT	DESCRIPTION OF IMPACT
DAM	
CONSTRUCTION	
River flow disruption	Diversion of river flow during construction reduces downstream availability and alters natural flow regimes
Sediment mobilisation and erosion	Activities like excavation and clearing vegetation disturb soil, riverbank sediments and the channel bed. This increases the release of fine suspended sediments into the river, elevating turbidity levels and reduce light penetration which can affect aquatic photosynthesis. Sediment pulses may travel downstream affecting sensitive habitats such as wetlands. Increased sedimentation in wetlands affect water retention, infiltration capacity and plant species composition.
Lowered water table.	Dewatering operations artificially lower the water table, negatively affecting wetlands and riparian vegetation dependent on shallow groundwater.
Altered shallow groundwater flow paths	Excavation and blasting change soil and rock permeability, redirecting or obstructing natural subsurface flows, reducing spring discharges, and creating seepage or waterlogging zones.
Altered chemical composition	Potential spills of contaminants may potentially alter water chemistry and harm aquatic organisms.
Aquatic Habitat Disruption	Physical disturbance and sedimentation will cause elevated turbidity and sediment deposition which degrade aquatic habitats by altering the water quality and the natural flow rate.
OPERATION	
Backwater effect	The dam wall creates a permanent upstream impoundment which result in an elevated water surface profile upstream. This leads to reduced natural channel slope, leading to a decrease in flow velocity and alterations to the river's hydraulic regime. The increase in water level upstream raises the hydraulic head, which can change groundwater surface water interactions and influence adjacent wetlands.
Reduced flow variability	Flow regulation reduces natural seasonal fluctuations, increases baseflow, and eliminates flood pulses essential for ecological processes
Channel morphology changes	Backwater conditions induce lateral erosion, meandering and silting in upstream reaches as the river adapts to reduced flow energy and altered sediment supply, potentially changing channel patterns and meander dynamics. Sediment starvation downstream causes riverbed scouring, bank destabilisation and channel deepening
Fragmented groundwater and hydrological connectivity	Altered lateral and longitudinal connectivity. The dam wall acts as a physical and hydraulic barrier that increases upstream groundwater–surface water exchanges and connectivity with aquifers but decreases downstream exchanges, creating spatial imbalances in hydrological

	linkages. This fragments the river system and disrupts the continuous surface water and groundwater interactions along the channel.
Altered Nutrient dynamics	Reservoirs and regulated discharges trap sediments and nutrients, leading to nutrient enrichment (eutrophication) in upstream sections and nutrient depletion downstream. These imbalances alter nutrient timing, reduce floodplain fertility and affect aquatic productivity and ecological balance.
Habitat fragmentation	Dams and flow regulation disrupt the longitudinal and lateral connectivity of river systems, isolating aquatic and riparian habitats. This fragmentation restricts the migration and spawning of fish and alters seasonal habitat availability critical for biodiversity maintenance.
Sediment transport disruption	Sediment trapping causes sediment starvation downstream and increases erosive potential of downstream flow. The sediment-poor water scours the riverbed and banks, leading to channel deepening, destabilisation and loss of riparian land.
Altered floodplain dynamics	Dams modify the frequency, duration and extent of floodplain inundation by elevating upstream water levels and reducing overbank flooding downstream. These changes disrupt natural floodplain hydrology, reduce sediment and nutrient deposition, affect soil fertility and alter vegetation composition and habitat structure.
ABSTRACTION POINTS (WEIRS)	
Reduction in downstream flow	Weirs reduce the volume and velocity of water flowing downstream and disrupt sediment transport, nutrient distribution and aquatic habitats dependent on natural flow regimes.
Altered hydraulic gradients	The backwater effect from weirs flattens the river's slope upstream and increases erosion downstream which alters sediment dynamics and channel stability.
Altered lateral Hydrological connectivity	Reduced flood frequency limits the connection between the river and its floodplain and leads to decreased nutrient and sediment exchange and reducing habitat diversity
Groundwater recharge patterns	Elevated water levels upstream enhance local groundwater recharge, while reduced flow downstream lowers recharge rates and affects water availability.
Vegetation and soil moisture regime shifts	The elevated water table, changes in flow and groundwater levels upstream leads to oversaturation and waterlogging which reduces soil aeration and drainage efficiency, while downstream zones become drier, leading to shifts in vegetation types and soil moisture conditions.
WATER TREATMENT WORKS	
Altered river flow regimes	Abstraction of water for treatment decreases downstream discharge and disrupts natural flow regimes and seasonal variability. Reduced flow lowers groundwater levels in adjacent riparian zones which influences soil moisture and vegetation dynamics.
Artificial baseflow maintenance	Discharge of treated effluent into the river artificially maintains baseflows during dry periods and results in altered habitat conditions and natural flow variability.
Degraded water quality	Treated effluent contains residual nutrients, trace metals and chemicals that alter downstream water quality and disrupt aquatic microbial communities
Altered aquatic community structure	Pollutant tolerant species become dominant while sensitive species decline due to changes in water quality and nutrient levels.
Thermal alteration	Temperature differences between effluent and river water cause thermal fluctuations that increase metabolic rates and oxygen demand of aquatic organisms while reducing dissolved oxygen concentrations
Biodiversity loss	Warmer effluent favours invasive and tolerant species such as algae which leads to community shifts and reduced biodiversity.

Altered nutrient cycling	Elevated temperatures enhance microbial decomposition and nutrient transformation that result in increased ammonia toxicity and altered nitrification–denitrification processes.
Thermal stratification and oxygen depletion	In slower moving river section temperature differences cause stratification which causes reduced oxygen distribution and intensified oxygen depletion near the riverbed.
Altered sediment dynamics	Water abstraction and discharge modify sediment transport and cause upstream deposition and downstream erosion which alter channel morphology and degrade aquatic habitats.

6. EVALUATION OF IMPACTS ON THE HYDROLOGY

This section provides the methodology for assessing the significance of impacts associated with the activity. The criterion for determining impact significance has been defined in accordance with the criteria drawn from Appendix 3 of the Environmental Impact Assessment Regulations, 2014. The levels of detail described in the EIA regulations were fine-tuned by assigning specific values to each impact identified. The impact ratings are be informed by fieldwork, desktop analysis and expertise of the specialist. The significance of potential impacts that may result from the proposed development will be determined in order to assist the competent authority in making a decision.

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a ‘benefit’)
	– ve (negative – a ‘cost’)

Rating	Definition of Rating	Score
A. *Spatial extent– the area in which the impact will be experienced*		
None		0
Local	Confined to project or study area or part thereof (e.g. site)	1
Regional	The region, which may be defined in various ways, e.g. cadastral, catchment, topographic	2
(Inter) national	Nationally or beyond	3
B. *Intensity– the magnitude or size of the impact*		
None		0
Low	Natural and/or social functions and processes continue albeit in a slightly modified way	1
Medium	Natural and/or social functions and processes continue albeit in a modified way	2
High	Natural and/or social functions or processes are severely altered	3
C. *Duration– the time frame for which the impact will be experienced*		
None		0
Short-term	Up to 2 years	1

Medium-term	2 to 20 years	2
Long-term	More than 20 years	3

***Combined Score* (A+B+C)**	
Consequence Rating	
Not significant	0 – 2
Very low	3 – 4
Low	5
Medium	6
High	7
Very high	8 – 9

Probability– the likelihood of the impact occurring		
Improbable	< 40% chance of occurring	0
Possible	40% - 70% chance of occurring	1
Probable	> 70% - 90% chance of occurring	2
Definite	> 90% chance of occurring	3

Significance Rating	***Possible Impact Combinations***	
	Consequence	***Probability***
Insignificant	Very Low	Improbable
	Very Low	Possible
Very Low	Very Low	Probable
	Very Low	Definite
	Low	Improbable
	Low	Possible
Low	Low	Probable
	Low	Definite
	Medium	Improbable
	Medium	Possible
Medium	Medium	Probable
	Medium	Definite
	High	Improbable
	High	Possible
High	High	Probable
	High	Definite
	Very High	Improbable
	Very High	Possible
Very High	Very High	Probable
	Very High	Definite

Confidence of assessment	**Rating**
The degree of confidence in predictions based on available information, Specialists' judgment and/or specialist knowledge.	Low
	Medium
	High

6.1 IMPACT ASSESSEMENT

All identified impacts for the proposed development are assessed, and findings are entailed in this sub-section.

Table 6. Impact Assessment results.

	Impact	Mitigation	Extent	Intensity	Duration	Consequence	Consequence	Probability	Probability	Significance	Status	Confidence
						DAM						
Construction	**River flow disruption**	Without	2	3	2	7	High	1	Possible	**Medium**	- ve	High
		With	1	1	1	3	Very low	0	Improbable	**Insignificant**	-ve	High
	Sediment mobilisation and erosion	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
	Groundwater disturbances	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
	Altered chemical composition	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
	Aquatic habitat disruption	Without	2	3	2	7	High	2	Probable	**High**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	-ve	High
Operations	**Backwater Effect**	Without	2	3	2	7	High	3	Definite	**High**	-ve	High
		With	1	1	1	3	Very low	2	Probable	**Very Low**	-ve	High
	Reduced flow variability	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
		With	1	1	2	4	Very low	2	Probable	**Very Low**	- ve	High
	Channel morphology changes	With	2	2	2	6	Medium	2	Probable	**Medium**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
	Fragmented groundwater and	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
		With	1	2	1	4	Very low	2	Probable	**Very Low**	-ve	High

Impact	Mitigation	Extent	Intensity	Duration	Consequence	Consequence	Probability	Probability	Significance	Status	Confidence
hydrological connectivity											
Altered nutrient dynamics	Without	2	1	2	5	Low	3	Definite	**Low**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Habitat fragmentation	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	-ve	High
Sediment transport disruption	With	2	2	2	6	Medium	3	Definite	**Medium**	-ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	-ve	High
Altered floodplain dynamic	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	1	Possible	**Insignificant**	-ve	High
Reduced floodplain connectivity	Without	2	3	2	7	High	1	Possible	**Medium**	-ve	High
	With	1	1	1	3	Very low	0	Improbable	**Insignificant**	-ve	High
ABSTRACTION POINTS (WEIRS)											
Reduction in downstream flow	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Altered hydraulic gradients	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Altered lateral Hydrological connectivity	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Groundwater recharge patterns	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	2	1	4	Very low	1	Possible	**Insignificant**	- ve	High
Vegetation and soil	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	2	1	4	Very low	2	Probable	**Very Low**	- ve	High

Impact	Mitigation	Extent	Intensity	Duration	Consequence	Consequence	Probability	Probability	Significance	Status	Confidence
moisture regime shifts											
WATER TREATMENT WORKS											
Altered river flow regimes	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
Artificial baseflow maintainance		2	3	2	7	High	3	Definite	**High**	- ve	High
		1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
Degraded water quality		2	2	2	6	Medium	2	Probable	**Medium**	- ve	High
		1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High
Altered aquatic community structure	Without	2	3	2	7	High	3	Definite	**High**	+ ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Thermal alteration	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Biodiversity loss	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Altered nutrient cycling	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Thermal stratification and oxygen depletion	Without	2	2	2	6	Medium	3	Definite	**Medium**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High
Altered sediment dynamic	Without	2	3	2	7	High	3	Definite	**High**	- ve	High
	With	1	1	1	3	Very low	2	Probable	**Very Low**	- ve	High

	Impact	Mitigation	Extent	Intensity	Duration	Consequence	Consequence	Probability	Probability	Significance	Status	Confidence
	Disruption of biological cycles	Without	2	2	2	6	Medium	2	Probable	**Medium**	- ve	High
		With	1	1	1	3	Very low	1	Possible	**Insignificant**	- ve	High

7. IMPACTS AND MITIGATIONS OF THE PROPOSED DEVELOPMENT

This section outlines and explains mitigations emanating from this report.

Table 7. Mitigations of the identified impacts.

ASPECT	IMPACT	MITIGATIONS MEASURES
DAM		
CONSTRUCTION PHASE		
Direct Impacts		
River flow disruption	Diversion of river flow during construction reduces downstream availability and alters natural flow regimes	• Implement temporary diversion channels or coffer dams designed to maintain minimum ecological flows downstream. • Schedule in-stream work during low-flow periods to reduce the impact on downstream water availability. • Continuous monitoring of flow levels downstream to ensure ecological flow requirements are met. • Minimise construction works within and along the watercourse, where the development is proposed
Sediment mobilisation and erosion	Activities like excavation and clearing vegetation disturb soil, riverbank sediments and the channel bed. This increases the release of fine suspended sediments into the river, elevating turbidity levels and reduce light penetration which can affect aquatic photosynthesis. Sediment pulses may travel downstream affecting sensitive habitats such as wetlands.	• Stabilize exposed soils using silt fences and sediment traps to prevent sediment runoff into the river. • Implement progressive clearing and excavation to minimize large, exposed areas at once • Limit the extent of vegetation clearance and soil disturbance to only essential construction areas.

	Increased sedimentation in wetlands affect water retention, infiltration capacity and plant species composition.	• The implementation of the development should be during the dry season to minimise sediment load contributions • Revegetate disturbed areas immediately after construction to stabilize banks and reduce erosion. • Limit machinery operation near riverbanks and wetlands to reduce disturbance. • Install sedimentation ponds or detention basins to capture sediments before water enters the river. •
Groundwater disturbances	Lowered water table. Dewatering operations artificially lower the water table, negatively affecting wetlands and riparian vegetation dependent on shallow groundwater. Altered shallow groundwater flow paths. Excavation and blasting change soil and rock permeability, redirecting or obstructing natural subsurface flows, reducing spring discharges, and creating seepage or waterlogging zones.	• Implement gradual dewatering schedules to prevent abrupt water table declines. • Monitor groundwater levels and the condition of wetlands and riparian vegetation throughout construction • Avoid excavation and blasting near sensitive areas such as springs or seepage zones. • Use permeable backfill materials to facilitate natural groundwater recharge.
Altered chemical composition	Potential spills of contaminants may potentially alter water chemistry and harm aquatic organisms.	• No handling of hazardous material / potentially contaminants near and within the watercourse • Where the handling is necessary, it should be handled in safe manner to prevent spillage and subsequent contamination • Spill kit should be available on site to handle spills • Prevent direct discharge of contaminated water into the river by diverting it to designated treatment areas.
Aquatic Habitat Disruption	Physical disturbance and sedimentation will cause elevated turbidity and sediment deposition which degrade aquatic habitats by altering the water quality and the natural flow rate.	• Confine in-stream works to the development footprint to reduce habitat disturbance • Remove construction debris and sediment barriers once works are completed and rehabilitate disturbed areas
OPERATION		
Direct Impacts		

Backwater effect	The dam wall creates a permanent upstream impoundment which result in an elevated water surface profile upstream. This leads to reduced natural channel slope, leading to a decrease in flow velocity and alterations to the river's hydraulic regime. The increase in water level upstream raises the hydraulic head, which can change groundwater surface water interactions and influence adjacent wetlands.	• Regulate dam outflows to mimic natural flow variability and minimize prolonged backwater conditions • Adjust reservoir operation schedules during high-flow seasons to prevent excessive upstream inundation. • Implement periodic sediment flushing to prevent silt accumulation that amplifies backwater elevation Establish riparian vegetation zones to stabilize banks and reduce erosion from prolonged inundation. • Where feasible, design secondary channels or bypass structures to maintain upstream drainage and ecological connectivity.
Reduced flow variability	Flow regulation reduces natural seasonal fluctuations, increases baseflow, and eliminates flood pulses essential for ecological processes	• Implement flow releases that replicate seasonal variability, including high-flow pulses • Maintain flow schedules that support ecological processes such as fish migration and floodplain inundation.
Channel morphology changes	Backwater conditions induce lateral erosion, meandering and silting in upstream reaches as the river adapts to reduced flow energy and altered sediment supply, potentially changing channel patterns and meander dynamics. Sediment starvation downstream causes riverbed scouring, bank destabilisation, and channel deepening	• Use indigenous riparian vegetation along banks and floodplains to stabilise soils, dissipate flow energy and support groundwater recharge. • Manage riparian vegetation along downstream banks to enhance bank strength and reduce erosion susceptibility. • Conduct regular monitoring of sediment deposition and erosion patterns upstream and downstream • Implement regular monitoring of sedimentation and erosion after every heavy rainfall event • Regular monitoring in invasive species that induce soil loss • Regular removal of accumulated sediment and infilling and stabilization of gullies and rills • Where feasible, design secondary channels or bypass structures to maintain upstream drainage and ecological connectivity.

Fragmented groundwater and hydrological connectivity	Altered lateral and longitudinal connectivity. The dam wall acts as a physical and hydraulic barrier that increases upstream groundwater–surface water exchanges and connectivity with aquifers but decreases downstream exchanges, creating spatial imbalances in hydrological linkages. This fragments the river system and disrupts the continuous surface water and groundwater interactions along the channel.	• Implement controlled releases that simulate natural flow variability to sustain downstream groundwater recharge and maintain hydrological linkages • Rehabilitate riparian vegetation and wetlands downstream to enhance infiltration and maintain local groundwater levels. • Install observation boreholes upstream and downstream of the dam to monitor water table fluctuations and detect connectivity losses over time • Where feasible, design secondary channels or bypass structures to maintain upstream drainage and ecological connectivity.
Altered Nutrient dynamics	Reservoirs and regulated discharges trap sediments and nutrients, leading to nutrient enrichment (eutrophication) in upstream sections and nutrient depletion downstream. These imbalances alter nutrient timing, reduce floodplain fertility and affect aquatic productivity and ecological balance.	• Implement catchment based nutrient control measures such as buffer strips and sediment traps to limit nutrient inflow into the reservoir • Periodically release nutrient-rich water during high-flow seasons to restore downstream nutrient balance and support floodplain fertility • Re-establish natural vegetation buffers along riverbanks to enhance nutrient uptake and filtration before nutrients enter watercourses. • Conduct regular monitoring of nitrogen, phosphorus and chlorophyll-a levels to detect early signs of eutrophication and adapt management actions accordingly.
Habitat fragmentation	Dams and flow regulation disrupt the longitudinal and lateral connectivity of river systems, isolating aquatic and riparian habitats. This fragmentation restricts the migration and spawning of fish and alters seasonal habitat availability critical for biodiversity maintenance.	• Release flows that mimic natural seasonal patterns to support habitat connectivity and species life cycles • Rehabilitate and protect riparian vegetation to provide continuous habitat corridors along the riverbanks and floodplains • Maintain natural sediment transport through controlled flushing or sediment bypass systems to preserve downstream habitats and spawning grounds
Sediment transport disruption	Sediment trapping causes sediment starvation downstream and increases erosive potential of downstream flow. The	• Regular removal of accumulated sediment and infilling and stabilization of gullies and rills

	sediment-poor water scours the riverbed and banks, leading to channel deepening, destabilisation and loss of riparian land.	• Maintain natural sediment transport through controlled flushing or sediment bypass systems to preserve downstream habitats and spawning grounds • Release controlled high-flow pulses that simulate natural flood events, enhancing sediment transport and channel reshaping processes • Implement soil conservation practices upstream such as reforestation and riverbank stabilization to reduce excessive erosion and siltation • Continuously monitor sediment load, grain size distribution, and channel morphology to guide sediment management and evaluate long-term effectiveness.
Altered floodplain dynamics	Dams modify the frequency, duration and extent of floodplain inundation by elevating upstream water levels and reducing overbank flooding downstream. These changes disrupt natural floodplain hydrology, reduce sediment and nutrient deposition, affect soil fertility and alter vegetation composition and habitat structure.	• Implement flow releases that mimic natural flood pulses to sustain seasonal overbank flooding and floodplain recharge • Rehabilitate flood channels and spillways that allow managed inundation of disconnected floodplain areas • Facilitate controlled sediment flushing to restore downstream floodplain fertility and maintain soil productivity. • Re-establish native vegetation along floodplains to enhance bank stability, soil infiltration, and habitat diversity • Protect existing wetlands and create artificial wetlands in affected areas to retain water, trap sediments, and support biodiversity. • Conduct regular hydrological monitoring to assess floodplain response to flow releases and adjust dam operation accordingly.
ABSTRACTION POINTS (WEIRS)		
OPERATIONS		
Direct Impacts		
Reduction in downstream flow	Weirs reduce the volume and velocity of water flowing downstream and disrupt sediment transport, nutrient	• Install a water measuring device to monitor the abstraction of downstream release volumes of the

	distribution and aquatic habitats dependent on natural flow regimes.	weir at monthly intervals as per regulations of The National Water Act 36 of 1998.
Altered hydraulic gradients	The backwater effect from weirs flattens the river's slope upstream and increases erosion downstream which alters sediment dynamics and channel stability.	• Implement periodic sediment flushing or dredging to prevent excessive upstream sediment accumulation and maintain channel slope stability. • Stabilize downstream banks using bioengineering strategies such as vegetative buffers and structural measures to reduce scouring. • Design weir operations to include controlled flow releases that sustain natural hydraulic gradients and prevent prolonged backwater effects. • Conduct regular assessments of slope, flow velocity, and sediment load to guide adaptive management.
Altered lateral Hydrological connectivity	Reduced flood frequency limits the connection between the river and its floodplain and leads to decreased nutrient and sediment exchange and reducing habitat diversity	• Release seasonal high flows that mimic natural flood events to reconnect floodplains and promote nutrient exchange. • Rehabilitate riparian zones to facilitate natural overbank flow and improve nutrient filtration.
Groundwater recharge patterns	Elevated water levels upstream enhance local groundwater recharge, while reduced flow downstream lowers recharge rates and affects water availability.	• Install observation boreholes upstream and downstream to monitor recharge patterns and detect declines. • Enhance infiltration through vegetative buffers • Coordinate abstraction and discharge operations with groundwater management plans to balance recharge and extraction rates.
Vegetation and soil moisture regime shifts	The elevated water table, changes in flow and groundwater levels upstream leads to oversaturation and waterlogging which reduces soil aeration and drainage efficiency, while downstream zones become drier, leading to shifts in vegetation types and soil moisture conditions.	• Implement variable flow releases to balance moisture regimes along the riparian corridor. • Restore natural vegetation gradients to stabilize soils and support appropriate habitat structure.
WATER TREATMENT WORKS		
OPERATIONS		
Direct Impacts		

Altered river flow regimes	Abstraction of water for treatment decreases downstream discharge and disrupts natural flow regimes and seasonal variability. Reduced flow lowers groundwater levels in adjacent riparian zones which influences soil moisture and vegetation dynamics.	• Limit water abstraction during low-flow periods to maintain ecological flow requirements. • Install flow gauges to continuously monitor downstream discharge and adapt abstraction rates.
Artificial baseflow maintenance	Discharge of treated effluent into the river artificially maintains baseflows during dry periods and results in altered habitat conditions and natural flow variability.	• Regulate discharge timing and volume to mimic natural flow variations. Monitor upstream and downstream flow conditions to prevent unnatural flooding or stagnation. • Adjust discharge timing to align with natural reproductive cycles of aquatic species.
Degraded water quality	Treated effluent contains residual nutrients, trace metals and chemicals that alter downstream water quality and disrupt aquatic microbial communities	• Conduct regular effluent quality testing • Establish buffer zones and vegetative filters along discharge points.
Altered aquatic community structure	Pollutant tolerant species become dominant while sensitive species decline due to changes in water quality and nutrient levels.	• Maintain natural flow and temperature conditions. • Implement regular monitoring to track species diversity and the success of vegetation establishment in disturbed areas • Implement regular removal of alien invasive plants after construction is complete • Revegetate disturbed areas with native species
Thermal alteration	Temperature differences between effluent and river water cause thermal fluctuations that increase metabolic rates and oxygen demand of aquatic organisms while reducing dissolved oxygen concentrations	• Use temperature cooling systems such as cooling ponds before effluent discharge • Conduct regular monitoring of the temperature and dissolved oxygen concentration
Biodiversity loss	Warmer effluent favours invasive and tolerant species such as algae which leads to community shifts and reduced biodiversity.	• Use temperature cooling systems such as cooling ponds before effluent discharge • Conduct biodiversity assessments to guide adaptive management • Implement active monitoring and removal programs for thermally tolerant or invasive species • Conduct regular assessments of aquatic macroinvertebrates and fish communities to detect and respond to ecological changes.

Altered nutrient cycling	Elevated temperatures enhance microbial decomposition and nutrient transformation that result in increased ammonia toxicity and altered nitrification–denitrification processes.	• Use cooling ponds before effluent discharge to regulate temperature • Establish vegetated buffer zones to absorb excess nutrients and stabilize banks. • Implement regular monitoring of temperature, dissolved oxygen and nutrient levels to guide adaptive effluent management.
Thermal stratification and oxygen depletion	In slower moving river section temperature differences cause stratification which causes reduced oxygen distribution and intensified oxygen depletion near the riverbed.	• Conduct regular monitoring of the temperature and dissolved oxygen concentration • Use temperature cooling systems such as cooling ponds before effluent discharge
Altered sediment dynamics	Water abstraction and discharge modify sediment transport and cause upstream deposition and downstream erosion which alter channel morphology and degrade aquatic habitats.	• Monitor sediment transport and deposition patterns upstream and downstream • Implement sediment management strategies such as controlled sediment flushing. • Stabilize riverbanks using bioengineering methods
Disruption of biological cycles	Cooler effluent alters thermal cues essential for fish spawning and migration, disrupting reproductive and behavioural processes.	• Adjust discharge timing to align with natural reproductive cycles of aquatic species. • Reduce effluent volumes during critical reproductive or migratory periods. • Maintain minimum flows to buffer temperature fluctuations and preserve habitat stability.

8. DISCUSSION OF THE DESIGN IMPACT ASSESSMENT FINDINGS

The construction of the in-stream dam is expected to exert considerable hydrological impacts on the surrounding area. Impacts include the alteration of natural flow regimes by reducing downstream discharge and diminishing seasonal variability, disrupting groundwater recharge, lateral hydrological connectivity and floodplain inundation. Upstream backwater effects will reduce flow velocities and cause sediment deposition, while downstream reaches will experience increased erosion and sediment starvation, adversely affecting channel morphology and habitat integrity. The discharge of treated effluent from the water treatment works will modify water temperature and nutrient concentrations, potentially disrupting aquatic communities, promoting invasive species and interfering with biological cycles such as fish spawning and migration.

Given the overlap of the proposed development with an ESA 1, ESA 2 and the vulnerability of the minor aquifer, construction activities will need to be carefully planned and implemented avoid unnecessary disturbance to riparian zones and wetlands, with clear demarcation of sensitive areas and restricted access. It should also be scheduled to avoid critical periods for aquatic species such as spawning and migration seasons. It is essential that development footprints be minimised and no-go buffers zones be demarcated and maintained around high sensitivity zones such as intact wetland and riparian vegetation patches during construction phase. The site should be accessed through existing routes, R393 and the gravel road via the main road from Sterkspruit to avoid the creation of new disturbance within the ESAs. Should the need for new access routes arise, temporary access roads must be stabilised to reduce erosion and construction equipment should be constricted to clearly marked corridors. No access should be allowed through the wetland areas or undisturbed riparian corridors. Furthermore, Erosion and sediment control measures, such as silt fences, sediment traps and temporary drainage channels must be installed to prevent sediment mobilisation into the river and downstream habitats. Excavation and dewatering activities must be managed to limit alterations to groundwater flow and maintain the natural water table as much as possible.

Operationally, flow releases must be maintained to mimic natural hydrological variability, effluent temperature and nutrient concentrations must be regulated, sediment transport must be managed through flushing or bypass mechanisms, and riparian habitats must be restored. Continuous monitoring of surface water flows, groundwater levels, water quality and biodiversity must be conducted to inform adaptive management to ensure that these measures are effective and that the ecological integrity of ESA1 and ESA2, as well as the minor aquifer, is maintained. Rehabilitation of disturbed ESA margins should follow immediately after construction using indigenous vegetation to restore the ecological integrity of the zones.

Influence of climate change and extreme environmental events

The recurring floods within the municipality has important implications for the proposed dam, weirs, and water treatment infrastructure. Flooding can overwhelm water control structures, including weirs and dam spillways, if they are not designed to accommodate extreme flow volumes (Poff et al., 1997). During high-intensity rainfall, inflows to the proposed dam may exceed storage capacity and require spillway releases that could damage downstream infrastructure, erode riverbanks and increase sediment loads. High flood flows can also mobilize large quantities of sediment and debris, which may accumulate upstream of weirs and in the reservoir reducing storage capacity, damaging intake structures and impacting water treatment works by increasing turbidity and contaminant loads. The increasing frequency and intensity of floods attributed to climate change, implies that the dam and associated abstraction points must be designed with resilience to extreme hydrological events. Additionally, water treatment works will need to account for rapidly fluctuating water quality during flood events, as elevated suspended sediments, nutrient loads and potential pollutants can exceed normal treatment capacity, compromising water quality and supply.

Conversely, the drought conditions experienced in the area highlight the opposite challenge where prolonged low-flow periods reduce water availability for both abstraction at weirs and dam storage. During droughts, river discharge may be insufficient to maintain environmental flows and support downstream ecosystems. Poff et al. (1997) states that this increases reliance on the proposed dam as a storage buffer and places greater operational pressure on the reservoir. Reduced inflows can also concentrate pollutants and nutrients in the water, complicating water treatment processes and potentially affecting water quality for human consumption. In extreme cases, low reservoir levels can limit abstraction capacity at weirs and disrupt supply for municipal use.

9. CONCLUSION

This Hydrology Impact Assessment report considers and reports on the hydro-geomorphological impacts that the proposed infrastructure has on the hydrology of the proposed site. The development imposes both short and long-term disturbance to the hydrological and geomorphic environment of the site. Key impacts include altered lateral and vertical erosion patterns, increased risk of channel incision downstream, modified flow regimes, and changes to floodplain morphology and sediment transport dynamics. Considering fluvial systems are an integrated unit, the proposed development along the river corridor, its impacts are deemed manageable, provided that appropriate mitigation measures are implemented and adhered to throughout the construction and operational phases. It is the opinion of the specialist that the development be considered for positive environmental authorizations in terms of NEMA and the National Water Act, provided mitigation measures in line with this report are adhered to.

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