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THE PROPOSED CONSTRUCTION AND UPGRADING OF ROADS D5010 AND D5021, INCLUDING ASSOCIATED INFRASTRUCTURES, WITHIN THE LEPELLE-NKUMPI AND FETAKGOMO TUBATSE LOCAL MUNICIPALITIES, CAPRICORN AND SEKHUKHUNE DISTRICTS, LIMPOPO PROVINCE

Prepared for

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16 October 2026

DECLARATION BY THE AUTHORS

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Independence

I, **Dr. Humbulani Edward Munzhelele,** declares that this report has been prepared independently of any external influence from any individual or organization or institution. I act as an independent specialist in this application. I conduct the work related to this application in an objective manner, even if some parts of results or findings may not be favourable to the applicant. I declare that there are no circumstances that may compromise my objectivity in performing such work. I commit to complying with all relevant legislation, Acts, Regulation and applicable policies, norms and standards. In addition, Pragmatic Scientific Services (Pty) Ltd, which is the entity I represent in this application, is an independent service provider and has no financial interest or vested interest in the proposed project.



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Independence

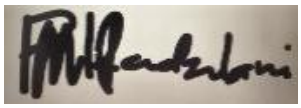
I, **Mr. Michael Radzilani**, declare that I am independent and unbiased. The information in this report was prepared independently, without influence from any person, organisation, or institution. I confirm that I have carried out my work fairly and objectively, even if some of my findings may not be in favour of the applicant. I also declare that there is nothing that may affect my independence or ability to do this work fairly. I commit to following all relevant laws, regulations, policies, rules, and standards that apply to this work. I confirm that the information in this declaration is true to the best of my knowledge.

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EXECUTIVE SUMMARY

Introduction

Pragmatic Scientific Services (Pty) Ltd (PSS) was appointed by Qems Management and Business Solutions CC (QEMS) on behalf of the Applicant, Roads Agency Limpopo (RAL) to undertake a comprehensive Hydrology Impact Assessment study. PSS was tasked to conduct a study pertaining the proposed upgrading of access Roads D5021 and D5010 and bridge construction across the Olifants River between Apel and Nkotokwane villages, in Limpopo Province, South Africa.

The proposed project is being undertaken by RAL. The Environmental Screening Report dated 28 April 2026 identifies rivers and aquatic biodiversity as very-high-sensitivity environmental features. A site-specific hydrology specialist study is therefore required to inform and confirm the bridge design, assess potential hydrological and hydraulic impacts, support the Aquatic Biodiversity Impact Assessment, and provide information for the Environmental Assessment Report (EAR) and Environmental Management Programme (EMPr).

This report has been structured in accordance with the supplied Terms of Reference (ToR). It incorporates the available project information and field observations from the inspection and ground-truthing conducted on the 03rd of October 2026.

Methodology

When PSS staff members visited the area for ground-truthing assessment on the 3rd of October 2026 and at the time of the site visit, no activity associated with the project had commenced. However, during the survey period it was discovered that the area had been delineated and markings were set in some areas for demarcation purposes in relation to the proposed bridge construction activities and access roads pertaining to the Apel-Nkotokwane villages and upgrading of the Road D5021 and D5010 in the Olifants River.

The objective of the assessment was to determine the ecological sensitivity of the project area, identify hydrological features and habitats potentially affected by the

proposed bridge construction and road upgrading activities in Olifants River, and evaluate anticipated impacts, and recommend appropriate mitigation measures.

Field Assessment

A detailed hydrological survey was undertaken on the 03rd of October 2026 during the early summer period.

Project location and existing conditions

The proposed bridge crossing is associated with Roads D5021 and D5010 between the Apel–Nkotokwane villages, across the Olifants River, near the farms Olifantspoort 479, Mooiplaats 516, and Eerste Recht 502. The supplied coordinates are latitude 24.415006° S and longitude 29.737367° E.

The field inspection identified a defined river channel, active flowing water, pools, riffles, wetland and seepage features, and a tributary entering the study area. Evidence of previous elevated flows included flood deposits, flood debris and vegetation damage. Erosion, channel incision, sediment deposition, bank instability and localised scour were also observed, particularly along the right bank facing downstream. The surrounding land uses include wetlands, agriculture, livestock farming and human settlements. Solid waste, including disposable nappies, clothing and glass bottles, were observed in the river environment.

Hydrological and environmental risks

The principal issues requiring assessment were:

- Flooding and potential overtopping of the proposed bridge and approach roads.
- Changes in flood levels and floodplain conveyance due to bridge construction and road upgrading.
- Localised scour in and around proposed bridge piers, abutments and foundations.
- Riverbank erosion, channel instability and sediment mobilisation.
- Potential obstruction of flow by bridge components or flood debris.
- Temporary construction works and possible river diversions.
- Pollution and sediment release during construction.

- Potential alteration of longitudinal and lateral river connectivity, with implications for aquatic biodiversity and the River Continuum Concept (RCC).
- Potential changes in extreme rainfall and flood behaviour under future climate conditions.

Conclusion and Specialist Opinion

From a hydrological perspective, the project can proceed with the construction of the bridge and access roads, provided that the engineers and contractors consider the potential for the river channel to shift towards the right bank due to channel instability. They must also consider the soil types, river flow, flooding, erosion, and scouring around the bridge foundations. The engineers and geotechnical specialists must ensure that these factors are adequately addressed in the existing design to maintain the safety and stability of the bridge and access roads. The bridge design must also confirm the required flood levels, bridge opening sizes, and foundation protection measures. Therefore, the hydrologist gives the go-ahead for the project to proceed, subject to these considerations being addressed by the relevant engineers and specialists and all applicable regulatory requirements being met.

APPENDIX 6 OF THE EIA REGULATION – CHECKLIST AND REFERENCE FOR THE REPORT

Table 1.1: Requirements from Appendix 6 of GN326 EIA Regulation 2017

Requirements from Appendix 6 of GN326 EIA Regulation 2017	Chapter
(a) Details of (i) The specialist who prepares the reports, and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae (b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Section 1 and Appendices (And B)
(c) Indication of the scope of and purpose for which the report was prepared	Section 1
(c(i)) Indication of the quality and age of base data used for the specialist report	Section 2
(c(ii)) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 7
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 2
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process including equipment and modelling used	Section 2
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate`s structures and infrastructure, inclusive of a site plan identifying alternative	Section 3
(g) Identification of any areas to be avoided, including buffers	Section 5
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Sections 5 and 9
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Sections 4 and 6
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Section 4

(k) Mitigation measures for inclusion in the EMPr	Sections 8 and 9 (9.3)
(l) Conditions for inclusion in the environmental authorisation	Section9
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Sections 8 and 9
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised, regarding the acceptability of the proposed activity or activities, and (ii) if the opinion is that the proposed activity, activities, or portions thereof should be authorised, and avoidance, management, and mitigation measures should be included in the EMPr, and where applicable, the closure plan	Section 9

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List of Abbreviations

Acronyms	Description
CBA	Critical Biodiversity Areas
DFFE	Department of Forestry, Fisheries and Environment
EA	Environmental Authorization
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
LEDET	Limpopo Department of Economic Development, Environment and Tourism
NEMA	National Environmental Management Act No. 107 of 1998
NEM:BA	National Environmental Management: Biodiversity Act
PSS	Pragmatic Scientific Services (Pty) Ltd
RAL	Roads Agency Limpopo (SOC) Ltd
SEI	Site Ecological Importance
S&EIA	Scoping and Environmental Impact Assessment
QEMS	Qems Management and Business Solutions CC

CHAPTER 1. INTRODUCTION

1.1. Background Information and Project Description

Pragmatic Scientific Services (Pty) Ltd (PSS) was appointed by Qems Management and Business Solutions CC (QEMS) to undertake a Hydrology Impact Assessment study on behalf of Roads Agency Limpopo (SOC) Ltd (RAL) for a proposed bridge and upgrading of Road D5021 and D5010 from Apel to Nkotokwane. Road Agency Limpopo (RAL) proposes the upgrading of Roads D5021 and D5010 from Apel to Nkotokwane, including construction of a bridge across a river near Farms Olifantspoort 479, Mooiplaats 516 and Eerste Recht 502, Limpopo Province. The locality map is given in Figure 1.1. The Environmental Screening Report dated 28 April 2026 identifies aquatic biodiversity and rivers as very-high-sensitivity environmental features. A Hydrology Specialist Study is therefore required to complement the Aquatic Biodiversity Impact Assessment and provide the hydrological and flood-related information necessary to inform the bridge design and Environmental Authorisation process.

The study characterizes the river and contributing catchment, determines appropriate design flood characteristics, assesses flood, hydraulic, erosion and scour risks, and recommends measures to avoid or minimise impacts associated with the proposed bridge and roadworks to the watercourse and receiving water. The planned bridge over the Olifants River connecting Apel and Nkotokwane villages (via D5021 and D5010) was officially prioritized by the Limpopo Department of Public Works and Roads Agency Limpopo in 2026/27 budget speech. This project was approved to resolve long-standing community safety issues where residents and learners were forced to cross the river during heavy rainfall. The hydrological map presented as Figure 1.2 illustrates the hydrological features within the proposed development area, including the Olifants River, the proposed bridge crossing, and the proposed access roads D5010 and D5021 linking Apel and Nkotokwane villages.

The proposed new Road D5021 is located on Portion 0 of Farm Olifantspoort 479 KS, Portions 0 and 2 of Farm Mooiplaats 516 KS, and Portion 0 of Farm Eerste Recht 502 KS in Apel and Nkotokwane villages. The road traverses both the Fetakgomo Tubatse Local Municipality, Sekhukhune District Municipality, and the Lepelle-Nkumpi Local Municipality, Capricorn District Municipality.

The proposed bridge over the Olifants River will be located on Portion 0 of Farm Olifantspoort 479 KS, Portions 0 and 2 of Farm Mooiplaats 516 KS, and Portion 0 of Farm Eerste Recht 502 KS. The bridge site spans the boundary between the Fetakgomo Tubatse Local Municipality within the Sekhukhune District Municipality and the Lepelle-Nkumpi Local Municipality within the Capricorn District Municipality. Road D5010 is located on Portion 0 of Farm Olifantspoort 479 KS in Nkotokwane Village, within the Lepelle-Nkumpi Local Municipality, Capricorn District Municipality, Limpopo Province.

The proposed project entails the upgrading of Road D5010 in Nkotokwane and the installation of culverts and the construction of a new section of Road D5021 between Nkotokwane and Apel villages. Both roads are envisaged for upgrade from gravel to a bituminous surface standard. The proposed development also includes the construction of a new 1.687 m2 bridge which is 140 m long over the Olifants River. The total length of the proposed road works is approximately 3.6 km, comprising 2.2 km for the upgrading of Road D5010 and 1.4 km for the construction of the new Road D5021. In addition, the project includes applications for the excavations of five borrow pits to provide construction materials for the road and bridge works.

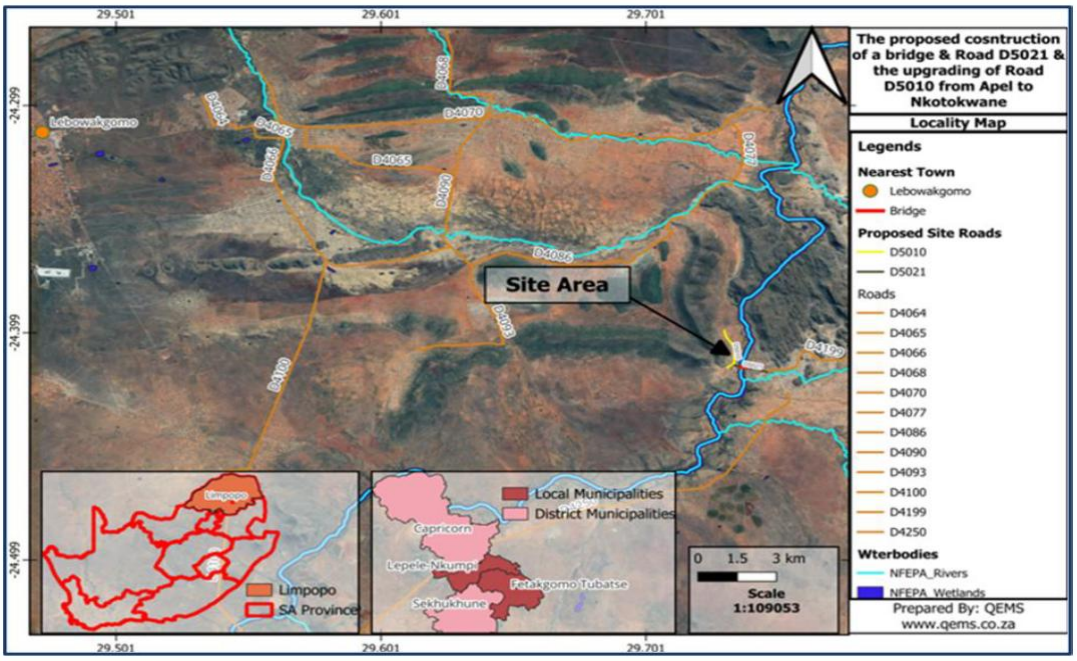


Figure 1.1: Project Locality Map

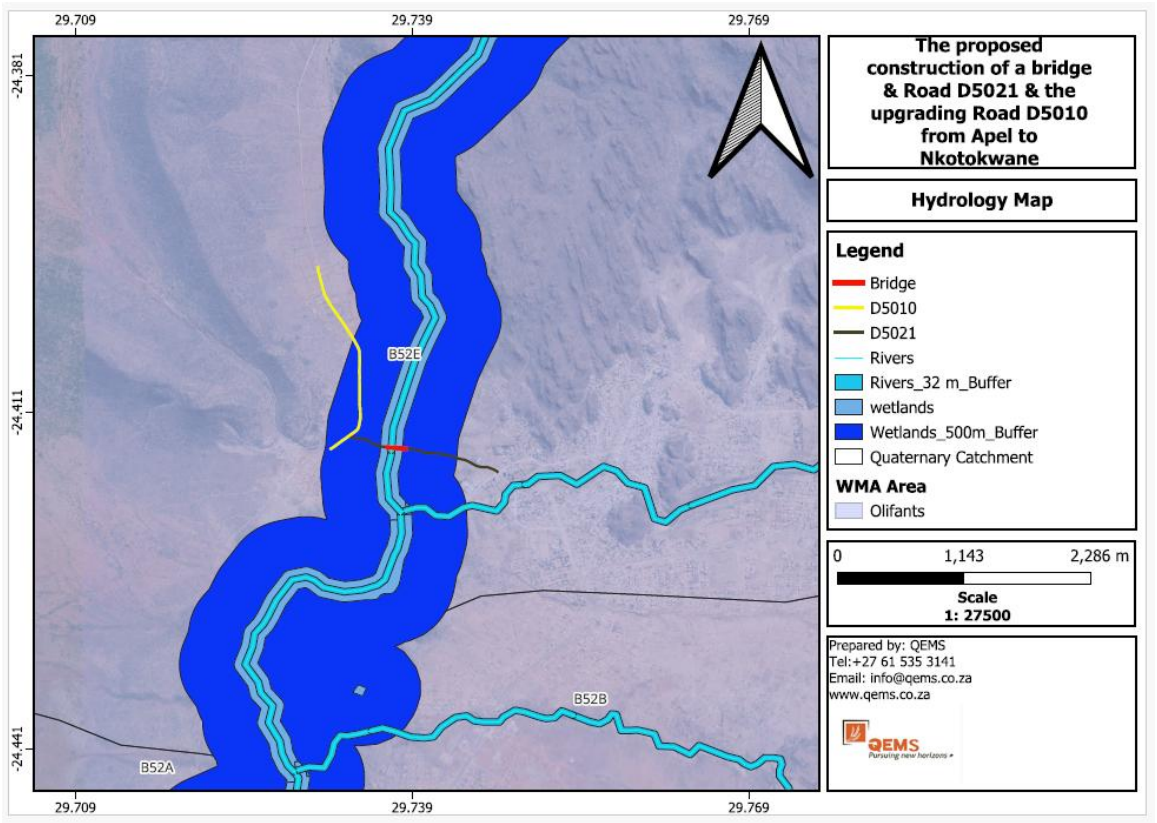


Figure 2.2: Hydrology Map of the project area in relation to the proposed bridge and access roads in the Olifants River.

1.2. Legislation and Reporting Requirements

In terms of the Protocol for the Specialist Assessment and Minimum Reporting Content Requirements for Environmental Impacts, prior to the commencement of a specialist assessment, the current use of the land and the potential environmental sensitivity of the site under consideration as identified by the screening tool, are confirmed by undertaking a site sensitivity verification. The results of the screening tool, together with the site sensitivity verification, ultimately determine the minimum report content requirements. Where the information gathered from the site sensitivity verification differs from the screening tool designation of 'very high' or 'high' and is found to be of a 'low' sensitivity, then a Compliance Statement must be submitted. However, if the site sensitivity verification confirms the findings of the Screening Report generated for this site, then a full Environmental Impact Assessment must be submitted as part of the Application for Environmental Authorisation (EA). According to the Site Sensitivity Verification Report undertaken for this project, the Hydrology and Freshwater Assessment was found to be Very High.

For the proposed bridge crossing and access roads D5021 and D5010 between Apel and Nkotokwane in the Olifants River, Limpopo Province, and the legislation should address three main matters: environmental authorisation, protection and use of water resources, and the conservation of aquatic ecosystems. Since the Site Sensitivity Verification Report classifies the Hydrology and Freshwater Assessment as **Very High sensitivity**, the specialist assessment and reporting requirements was determined using the applicable environmental assessment protocols. The high-sensitivity classification does not, by itself, establish which water-use authorisations are required; those depend on the proposed activities and their location.

Based on the above-mentioned statement, the following legislations are applicable and are defined as follow:

1.2.1. National Environmental Management Act, 1998 (Act No. 107 of 1998) — NEMA

NEMA is the main law that guides environmental protection and environmental approval in South Africa.

Relevance of the Act to the study:

- **Section 2:** Sets out the principles for protecting the environment and preventing or reducing environmental damage.
- **Section 24:** Explains the requirements for environmental approval of activities that may harm the environment.
- **Section 24(5):** Provides for rules and regulations on Environmental Impact Assessments (EIAs).
- **Section 28:** Requires people to take steps to prevent, reduce and repair environmental damage.

Application to the study:

The hydrology specialist must identify possible flooding, riverbank erosion, scouring, sediment build-up and other impacts on the river. The specialist must also recommend ways to reduce these impacts. These measures must be included in the Environmental Impact Assessment (EIA) and the Environmental Management Programme (EMPr).

1.2.2. Environmental Impact Assessment Regulations, 2014, as amended

These regulations fall under NEMA and explain how the effects of a project on the environment must be checked before certain activities can be approved.

Relevance of the regulations to the study:

- They help determine whether the proposed bridge and roadworks need Environmental Authorisation (EA).
- They determine whether the project needs a Basic Assessment or a more detailed environmental study.
- They require specialists to identify possible environmental impacts and suggest ways to reduce them.
- They explain how to check the environmental sensitivity of the site and prepare specialist reports.

Application to the study:

The Environmental Assessment Practitioner (EAP) must identify which activities related to the bridge, river crossing, access roads, vegetation clearing and other construction work need environmental approval. This helps determine which environmental studies and approvals are required before construction begins.

1.2.3. National Water Act, 1998 (Act No. 36 of 1998) — NWA

The National Water Act protects rivers and other water resources in South Africa. It controls activities that may affect water flow, water quality, riverbanks and riverbeds. This Act is important for the proposed bridge because construction may affect the river and its surroundings.

Relevant sections of the Act:

- **Section 19:** Requires steps to prevent and clean up water pollution.
- **Section 21(c):** Covers activities that block or change the flow of water in a river. This is explained in Table 1.2.
- **Section 21(i):** Covers changes to the riverbed, riverbanks or the course of the river. This is explained in Table 1.2.
- **Section 22:** Explains when water use is allowed and what approvals are needed.

Application to the study:

Bridge foundations, abutments, temporary river diversions and construction work inside the river may affect the riverbed, riverbanks or water flow. These activities may need approval from the Department of Water and Sanitation (DWS).

The project team must check whether the proposed bridge needs a Water Use Licence (WUL), a General Authorisation or another form of approval. This depends on the final bridge design and the planned construction work.

Table 1.2: Potentially Applicable Water Uses under Section 21 of the National Water Act

Water use	Project activity and reported information	Hydrological relevance and action required
Section 21(a): Taking water from a water resource	The supplied project information indicates that approximately 9,840 m^3/year will be abstracted from the Olifants River for the proposed development.	Confirm the purpose, abstraction point, method, volume, duration and authorisation route. Assess any relevant implications for river flows and downstream users.
Section 21(c): Impeding or diverting the flow of water in a watercourse	Bridge construction, in-channel works, culverts and possible temporary or permanent changes to flow paths are identified.	Confirm the nature and duration of flow interference. Assess flood conveyance, upstream water levels, flow velocities and downstream effects, and determine the applicable authorisation requirements.
Section 21(i): Altering the bed, banks, course or characteristics of a watercourse	Bridge foundations and supports, excavation, fill placement, bank protection, culvert installation and associated works may alter the watercourse.	Confirm the locations and extent of disturbance. Assess channel stability, scour, sediment transport, bank erosion and potential changes to aquatic habitat.

1.2.4. Catchment Management Agencies

Catchment Management Agencies (CMAs) help manage and protect water resources in their areas. They work with government departments, organisations and water users to ensure that water is used and managed responsibly (DWS, 2012). Their main role is to protect, use, develop and conserve water resources and ensure that they are managed properly. Each CMA uses a Catchment Management Strategy to guide water management in its area in line with national laws and policies.

Application to the study:

The proposed bridge construction and the upgrading of Roads D5021 and D5010 are located within the Olifants Water Management Area (WMA 2), specifically in Quaternary

Catchment B52A. The relevant water management authority should be consulted to confirm any water-related requirements for the proposed project.

1.2.5. National Water Resources Strategy

The National Water Resources Strategy (NWRS 2) was developed to help implement the National Water Act and guide the management of water resources in South Africa (DWS, 2013). The strategy provides guidelines and plans for protecting, using, developing and managing water resources. It also helps ensure that water is used responsibly and supports the country's development goals (DWS, 2013).

Application to the study:

The proposed bridge construction and road upgrades must consider the protection of the river and its surrounding environment. Measures should be taken to prevent water pollution, reduce erosion and sediment entering the river, and avoid unnecessary changes to the natural flow of water during construction.

1.2.6. National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) — NEMBA

This Act aims to protect South Africa's plants, animals and natural ecosystems.

Relevance of the Act to the study:

- It helps assess how the proposed bridge may affect river life and the natural environment.
- It considers how changes in river flow, sediment movement and water conditions may affect aquatic habitats.
- It helps manage listed invasive species that may be affected by construction or rehabilitation work.

Application to the study:

The hydrology assessment should help the aquatic biodiversity specialist understand how the bridge construction may affect the river ecosystem. This includes changes in river flow, the movement of sediment and the connection between different habitats.

These factors are important because plants and animals depend on suitable river conditions to survive and move through the ecosystem.

1.3. Scope, Purpose and Objectives

The purpose of this report is to assess the hydrology and freshwater features of the project area, determine the Site Ecological Importance (SEI), and assess how the proposed development may affect river flow and other water-related features. Where possible, the report will also recommend measures to reduce these impacts and identify areas where development should not take place (no-go areas). Based on this purpose, the objectives and Terms of Reference or Scope of Work for the Hydrology Impact Assessment are as follows:

The Hydrology Specialist carried out the following activities:

1.3.1. Desktop Assessment

Reviewed available maps and information on the catchment, rainfall, river flow, drainage, land use, soil, climate, flood studies and existing infrastructure. The proposed bridge and access road designs were reviewed.

1.3.2. Site Investigation

A site visits was initiated to check the river channel, drainage, signs of flooding, erosion, scour, sediment build-up, bank stability, blockages and existing drainage structures.

1.3.3. Catchment Assessment

Identify and describe the area that drains into the river at the proposed bridge site. This includes the catchment size, land shape, drainage, land use, soil and rainfall.

1.3.4. Design Flood Assessment

Estimate the expected flood flows for different return periods using available rainfall and river-flow data, site observations and field measurements. Any assumptions, limitations and uncertainties were recorded.

1.3.5. Flood and Hydraulic Assessment

Assess flood levels, water depths, flow speeds, floodplain capacity and the required bridge opening. Possible effects on areas upstream and downstream of the bridge were considered.

1.3.6. Scour and Erosion Assessment

Assess the risk of erosion around bridge piers and abutments, riverbank erosion, sediment build-up and changes in flow speed. Suitable protection measures are recommended where needed.

1.3.7. Climate Change Assessment

Consider how climate change may affect heavy rainfall and flooding. Where necessary, different rainfall and flood conditions were reviewed to understand the possible risks.

1.3.8. Construction and Operational Assessment

Identify possible risks during construction and after the bridge is completed. These include temporary river diversions, flooding, pollution, and sediment entering the river, blocked flow, changes in flood levels, erosion and scour.

1.3.9. Impact Assessment and Mitigation

Assess how the proposed development may affect river flow, drainage and freshwater features. Recommend measures to avoid or reduce impacts and, where necessary, restore affected areas or provide other suitable measures.

The Hydrology Specialist also:

- Recommended measures to reduce the impacts of the proposed development on the river and freshwater features in the project area.
- Provided a specialist opinion on whether the proposed development is acceptable from a hydrology and freshwater perspective, considering the identified impacts and recommended mitigation measures.

1.4. Limitations and Assumptions

This report is based on the information currently available. The following limitations and assumptions should be considered:

- The site visits on 3 October 2026 took place in early spring in Limpopo. The visit provided an opportunity to observe the river channel, bank stability and signs of past flooding. However, one site visit cannot show all seasonal river conditions or how the river behaves during extreme floods.
- A bridge may meet the hydraulic design requirements but still affect river life and the natural environment. The hydrology findings should therefore be linked to the aquatic ecology assessment to identify possible impacts and suitable ways to reduce them. It is assumed that continuous monitoring of the aquatic biodiversity prior, during and post proposed bridge and access roads

construction will always be conducted by designated aquatic specialist as per instruction from the project management team.

- Construction may increase flood risks, cause soil erosion and allow sediment and pollutants to enter the river, even if the completed bridge is designed to handle floods safely.
- Assessing the bridge on its own may not show its full effect on the wider river catchment. The assessment should also consider how the project may contribute to flooding, erosion and changes in the natural flow of the river.

1.5. Some General Overview and further Description of the study area

1.5.1. Land Use

The proposed bridge across the Olifants (Lepelle) River, between Apel and Nkotokwane villages in Limpopo Province, is in a mainly rural area. The surrounding land is used for homes, small-scale farming, livestock grazing and local roads. Natural vegetation is also found along the riverbanks. Farming and livestock grazing are important for the local communities, while the river and its surrounding vegetation are important for the natural environment. The proposed bridge aims to improve travel between the two villages and provide easier access to schools, healthcare facilities and other important services, especially during heavy rainfall when river levels may rise.

Possible impacts of the project include temporary disturbance of farming and grazing land, disruption of existing roads and access routes, and the need for land for the bridge and construction areas, and damage to vegetation along the riverbanks. These impacts should be reduced through proper planning and construction management. A detailed site assessment is needed to confirm how the land is currently used within and around the proposed bridge site. This should include reviewing recent aerial images, visiting the site and consulting affected landowners and traditional authorities.

1.5.2. Landscape and vegetation cover

The proposed bridge between Apel and Nkotokwane villages crosses the Olifants (Lepelle) River in a mainly rural area of Limpopo Province, South Africa. The surrounding area includes villages, farmland, grazing land, unpaved roads and natural vegetation. The land is generally gently sloping, with changes in height near the river,

riverbanks and drainage areas. The vegetation in the area may include natural grassland, bushveld, plants around settlements and cultivated fields. Along the Olifants River, grasses, shrubs and trees may provide shelter for wildlife, help hold the riverbanks together and support the river ecosystem. The type and amount of vegetation may vary depending on the soil, water availability, land use and seasonal rainfall.

Human activities such as housing, livestock grazing, farming and road construction have changed the natural vegetation in some areas. Vegetation near villages and cultivated fields may be disturbed or broken into smaller areas, while some parts of the riverbanks may still have natural vegetation. Building the bridge and its approach roads may require the removal of vegetation and disturbance of the soil. This could cause riverbank erosion and allow soil to wash into the river. Construction may also damage plants and habitats along the riverbanks.

To reduce these impacts, vegetation clearing should be limited to the approved construction area, sensitive riverbank vegetation should be protected where possible, and disturbed areas should be restored after construction.

CHAPTER 2. METHODOLOGY

2.1. General Introduction

This chapter describes the methodology adopted to undertake the hydrological and hydraulic assessment for the proposed bridge across the Lepelle (Olifants) River between Apel and Nkotokwane villages in Limpopo Province, South Africa. The study aims to characterise the hydrological conditions of the river and its contributing catchment, determine the influence of tributary inflows on river discharge and flow velocities, and assess the potential flood risks and hydraulic constraints associated with the proposed bridge infrastructure.

Attention is given to the Lepellane and Nkumpi tributaries, which contribute to the flow quantity and velocities within the drainage network leading towards the proposed bridge crossing in the Olifants River. Their contribution is important in understanding the cumulative runoff response of the catchment, particularly during periods of intense rainfall and elevated river flows. The assessment therefore considered the catchment characteristics, rainfall patterns, drainage connectivity and flow contributions associated with these tributaries to establish their potential influence on peak discharge, water levels and flow velocities at the proposed bridge site and access roads between Apel and Nkotokwane villages in the Olifants River.

The study included a review of available maps, aerial images, rainfall records, catchment information, river networks and other water-related data. The catchment areas draining into the Olifants River and the Lepellane and Nkumpi rivers were identified. Available data were used to estimate possible flood flows, including water coming from the tributaries. The study also considered the river channel, water speed, flood levels, possible flooding of surrounding land, sediment movement and erosion around the bridge foundations and approach roads.

The study also looked at how the bridge could change natural drainage and identified possible risks, such as faster water flow, riverbank erosion, sediment build-up and blocked floodwater. These factors were considered when assessing the bridge opening, bridge deck height, foundation protection and drainage structures, based on the available hydrological and hydraulic information.

The assessment was based on available information, hydrological data, site visits, field observations and relevant calculations where possible. Relevant laws were also considered, including the National Water Act, 1998 (Act No. 36 of 1998), the National Environmental Management Act, 1998 (Act No. 107 of 1998), and the requirements for activities that may affect rivers and other water resources.

The findings help explain how the Olifants River catchment and its tributaries may affect water flow at the proposed bridge site. They also help identify flood risks, assess possible impacts on the river and recommend ways to support the safe design and construction of the bridge while protecting the environment. The study also included a review of available information, field surveys, assessments of habitats and ecological conditions, checks of environmentally sensitive areas, and an assessment of possible impacts. This helped consider both the wider natural environment and the conditions at the project site when assessing the possible effects of the proposed road and bridge construction.

The study also included a review of available information, field surveys, assessments of habitats and ecological conditions, checks of environmentally sensitive areas, and an assessment of possible impacts. This helped consider both the wider natural environment and the conditions at the project site when assessing the possible effects of the proposed road and bridge construction.

2.2. DFFE Environmental Screening Report

Before the specialist study began, the Department of Forestry, Fisheries and the Environment (DFFE) Environmental Screening Tool was used, as required by the Environmental Impact Assessment Regulations. The tool helps identify environmentally sensitive areas using information from government departments, water management authorities, the South African National Biodiversity Institute (SANBI) and other environmental organizations. For the proposed bridge and access roads across the Olifants River between Apel and Nkotokwane villages, the screening helped identify areas that may be sensitive to construction. These include rivers and tributaries, wetlands, drainage lines, areas that may flood and aquatic habitats within and around the proposed construction area.

The screening results help identify possible water-related risks and show where further site investigations may be needed. These investigations may include identifying the area that drains into the river, assessing flood risks, checking the river channel and determining how the project may affect surface water resources.

The Environmental Screening Tool identified the following environmental sensitivities in the project area, as shown in Table 2.1:

Table 2.1. DFFE Screening Environmental Sensitivities Tool

Environmental Sensitivity Theme	Screening Tool
Hydrology and Freshwater Assessment Theme	Very High Sensitivity

The Very High Hydrology and Freshwater Assessment Sensitivity was primarily attributed to the occurrence of:

- Critical Biodiversity Areas (CBA 1)
- Ecological Support Areas (ESA 1 and ESA 2)
- National Protected Area Expansion Strategy (NPAES) priority areas

2.3. Field Survey

2.3.1. Survey Date

The hydrological field survey was undertaken on 03 October 2026. The survey coincided with the early spring season, during which vegetation remained sufficiently identifiable and animal activity was representative of seasonal conditions. Weather conditions during the survey were favourable, with clear skies, moderate temperatures and low wind speeds, allowing effective observation of river geomorphology, flora and fauna.

2.4. Description of Impact Assessment Methodology

Potential impacts associated with the proposed bridge construction activities were assessed using a standard Environmental Impact Assessment significance rating methodology widely adopted in South African specialist studies.

2.5. Limitations and Assumptions

The assessment is subject to the following limitations:

- The field survey was conducted during a single sampling event (3 October 2026), representing late spring conditions.

Despite these limitations, the combination of desktop analysis, field verification and specialist interpretation provides a robust and reliable assessment of the hydrological assessment associated with the proposed bridge and access roads construction between Apel and Nkotokwane villages in the Olifants River.

2.6. Quality Assurance

To ensure scientific credibility and regulatory compliance, the assessment:

- Followed DFFE Specialist Assessment Protocols.
- Incorporated both desktop and field-based data.
- Applied recognized ecological assessment methodologies.
- Was undertaken by an appropriately qualified and independent specialist.

2.7. Hydrological risk assessment

Due to the assessment forming part of a larger risk assessment for the study area, the potential impacts and the determination of impact significance were assessed. The process of assessing the potential impacts of the project encompasses the following four activities as indicated in Table 2.2.

1. Identification and assessment of potential impacts
2. Prediction of nature, magnitude, extent, and duration of potentially significant impacts
3. Identification of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the activity, and
4. Evaluation of the significance of the impact after the mitigation measures have been implemented, i.e., the significance of the residual impact.

Detailed explanations of the terms describing the potential impacts are depicted in Table 2.3.

As per GNR 982 of the EIA Regulations (2014), the significance of potential impacts was assessed in terms of the following criteria:

a. Cumulative impacts

b. Nature of the impact

c. The extent of the impact

d. Probability of the impact

e. The degree to which the impact can be reversed

f. The degree to which the impact may cause irreplaceable loss of resources, and

g. The degree to which the impact can be monitored.

Table 2.2. Proposed criteria and rating scales applied in the assessment of potential impacts

Criteria	Rating scales	Comments
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development
	Negative (-)	
Extent	Footprint	The impact only affects the area in which the proposed activity will occur
	Site	The impact will affect only the development area
	Local	The impact affects the development area and adjacent properties
	Regional	The effect of the impact extends beyond municipal boundaries
	National	The effect of the impact extends beyond more than 2 regional/ provincial boundaries
	International	The effect of the impact extends beyond country borders
Duration	Temporary	The duration of the activity associated with the impact will last 0-6 months
	Short-term	The duration of the activity associated with the impact will last 6-18 months
	Medium-term	The duration of the activity associated with the impact will last 18 months – 5 years
	Long-term	The duration of the activity associated with the impact will last more than 5 years
Severity	Low	Where the impact affects the environment in such a way that natural, cultural, and social functions and processes are minimally affected
	Moderate	Where the affected environment is altered but natural, cultural, and social functions and processes continue albeit in a modified way, and the valued, important, sensitive, or vulnerable systems, or communities are negatively affected
	High	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease, and valued, important, sensitive, or vulnerable system or communities are substantially affected

Potential for impact on irreplaceable resources	No	No irreplaceable resources will be impacted
	Yes	Irreplaceable resources will be impacted
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable	It is highly unlikely or less that 50% likely that an impact will occur
	Probable	It is between 50 and 70% certain that the impact will occur
	Definite	It is more than 75% certain that the impact will occur, or the impact will occur
Significance	Very high – negative (-49 to -66)	A function of Consequence and Probability
	High-negative (-37 to -48)	
	Moderate-negative (-25 to -36)	
	Low-negative (-13 to -24)	
	Neutral- very low (0 to -12)	
	Low-positive (0 to 12)	
	Moderate-positive (13 to 24)	
	High-positive (24 to 48)	
	Very high -positive (49 to 66)	

Table 2.3. Explanation of the Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact of change on the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of the scale refers to the actual physical footprint of the impact, not the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are very high importance, e.g., impacts on species of a very restricted range. To avoid double counting specialists have been requested to indicate spatial significance under intensity or impact on irreplaceable resources but not under extent as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long-term
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, after its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could be replaced by natural processes (e.g., by natural colonization from surrounding areas), through artificial means (e.g., by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g., by constructing new social facilities for those who are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable, e.g., red data species that are restricted to a particular site or habitat to a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of impact occurring and the probability that the activity of the impact occurring, not as the probability of the activities that may result in the impact
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high. Then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making
Degree of confidence in predictions	Specialists and the EIR team are required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact based on the available information and their level of knowledge and expertise. The degree of confidence is not considered in the determination of consequence of probability
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation

CHAPTER 3. HYDROLOGICAL ASSESSMENT

3.1. General Hydrological Conditions

The field observations indicate that the proposed crossings are located within an active drainage system with flowing water, tributary inflow, wetlands, and evidence of previous high-flow events (Figure 3.1). Flood deposits, accumulated debris, vegetation damage, and sediment deposition provide qualitative evidence of elevated flows (Figure 3.1). However, these indicators cannot independently establish flood discharge, return period, or flood level. The design flood assessment should therefore be based on catchment characteristics, rainfall and streamflow records, and appropriate hydrological methods.



Figure 3.1: Flood deposits, accumulated debris and evidence of high flow events on the left bank in the Olifants River adjacent to the proposed bridge and road crossing.



Figure 3.2: Scouring and incision in the right bank of the Olifants River Proposed Bridge Crossing



Figure 3.3: Sediment deposits in the left bank facing downstream indicating inactive stream channel in the Olifants River.



Figure 3.4: The indication of the high-erosive energy on the right bank in the Olifants River

3.2. Catchment Delineation

The contributing catchment area for each proposed crossing has been quantified in the available information. Catchment delineation was undertaken using a suitable verified topographical information. The assessment identified the:

- Catchment area and boundaries.
- Main river channel and tributaries.
- Drainage paths and catchment slopes.
- Land use and soil characteristics.
- Relevant upstream dams and hydraulic controls (gauging station).
- Potential differences in contributing drainage areas between the crossing locations.

3.3. Rainfall and Streamflow Data

Available rainfall and river-flow records were obtained from relevant sources, including the South African Weather Service and the Department of Water and Sanitation, where suitable records are available. The analysis examined data completeness, record length,

spatial relevance, and the potential influence of upstream regulation. Historical flood reports, high-water marks, aerial imagery, and observations from surrounding communities that may provide supplementary information for interpreting flood behaviour were searched through literature review.

CHAPTER 4. HYDROLOGICAL ASSESSMENT FINDINGS

The project area falls within the quaternary catchment B52A of the Limpopo Water Management Area (WMA) (DWS, 2016). Elevations for the site area range from 749 – 751 meters above mean sea level (m.a.m.s.l), based on the recorded data during the once-off fieldwork or survey on the 3rd of October 2026.

4.1. Sub-catchments / Hydrological Response Units (HRUS)

The villages of Apel and Nkotokwane are in Limpopo Province, within the broader Olifants River catchment. Hydrologically, the surrounding area is associated with the Middle Olifants sub-catchment and the B5 drainage region, which includes quaternary catchments such as B51G, B52B and B52J. The Olifants River and its tributaries, including the Nkumpi and Lepellane rivers, form part of this regional drainage system (DWS, 2011 & 2018). The HRUS surrounding the Apel and Nkotokwane villages are based on the following local parameters:

4.1.1. Land use / Land Cover (LULC)

This zone consists largely of degraded or overgrazed rangelands (savanna / mixed bushveld), rural residential developments (expanding village footprints), and scattered subsistence or small-scale community agricultural plots.

4.1.2. Soil characteristics

HRUS here are defined by shallow, sandy, and rocky soils underlain by granites, quartzites, and conglomerates of the Bushveld Igneous Complex. These soils are highly erodible, which contributes significant red-brown suspended sediment to the river system during heavy flows (DWS, 2018).

4.1.3. Topography

The terrain transitions sharply from the flat, low-lying alluvial plains along the main mainstem of the Olifants River up to the steep, rocky slopes of the surrounding mountain ranges and hills. There is a flow gauging station within the Olifants River upstream of the Apel and Nkotokwane villages study area, which is the Zeekoegat Gauging Station and officially designated as Station B5H002 by the South African Department of Water and Sanitation (DWS). The flow hydrograph and water level for

the gauging station B5H002 is shown in Figures 4.1 and 4.2, respectively. The data available for the station is from 1948 to 1979 (Kibii and Du Plessis, 2026).

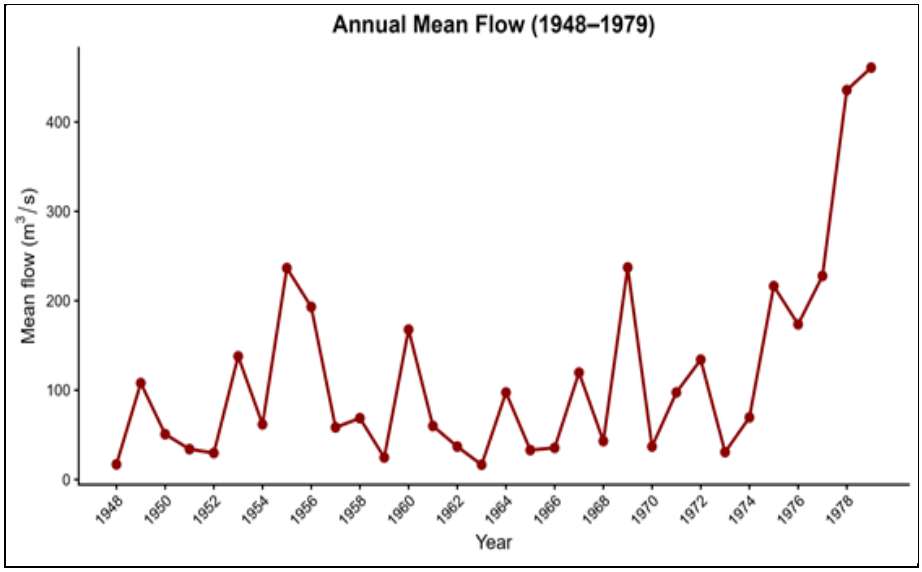


Figure 4.1: DWS flow gauging station (B5H002, mean flow) in the upstream of Apel and Nkotokwane villages and proposed bridge and roads upgrading site in the Olifants River (1948 to 1979).

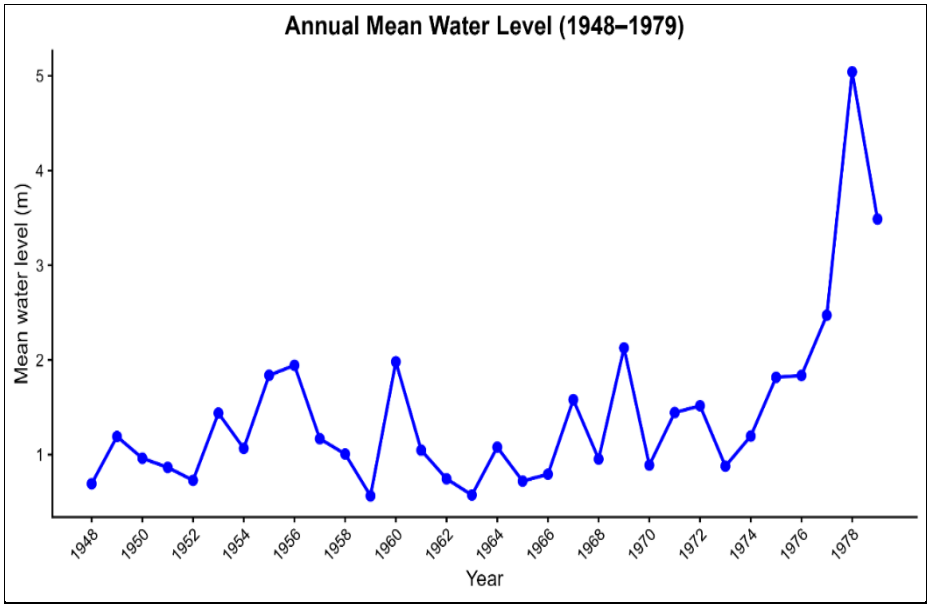


Figure 4.2: DWS flow gauging station (B5H002, mean water level) in the upstream of Apel and Nkotokwane villages and proposed bridge and roads upgrading site in the Olifants River (1948 to 1979).

4.1.4. Climate

Climate, amongst other factors, influences soil-water processes, runoff, and peak flows. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand, and runoff were considered in this study to indicate rainfall partitioning within the project proposed development area.

4.1.4.1. Temperature and Rainfall

The average yearly temperature for the project proposed development area ranges from 4 to 17˚C (low) and 20 to 28˚C (high) (Figure 4.3). The average yearly rainfall related to the project proposed development area ranges from 2.6 to 85.8 mm (Figure 4.4).

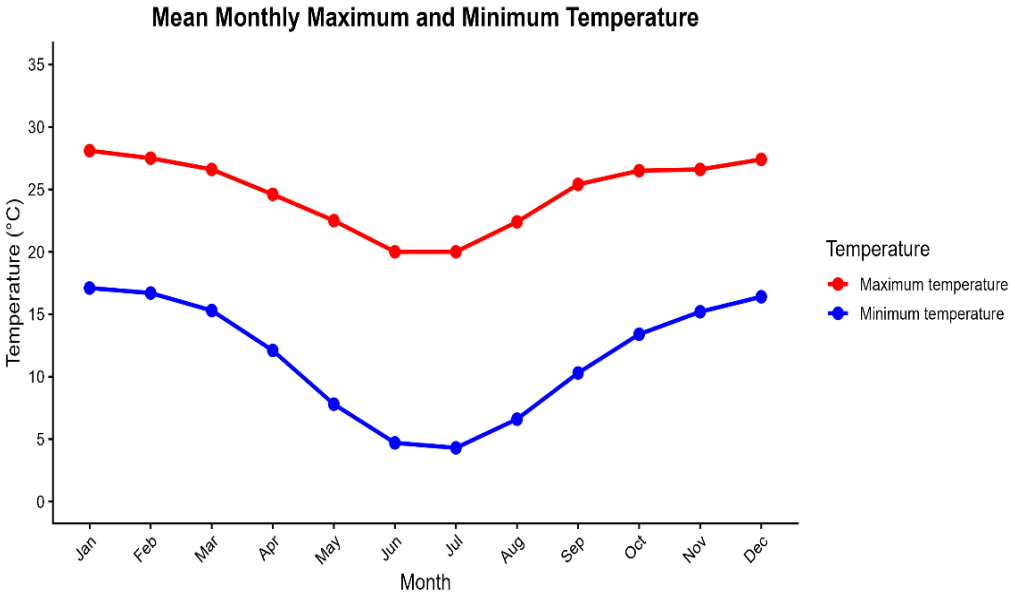


Figure 4.3: Average annual temperatures (minimum and maximum) recorded at Polokwane Monitoring Station, used for the proposed Olifants River development area.

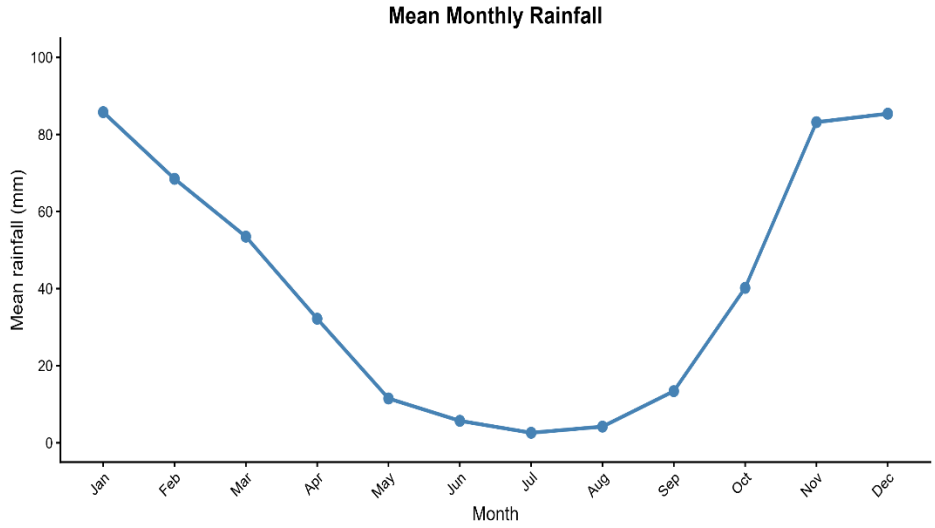


Figure 4.4: Average annual rainfall recorded at Polokwane Monitoring Station for the proposed development area along the Olifants River.

4.2. Desktop wetland and ecological areas

Based on the available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) evaluated on a desktop level, and during field survey, a floodplain wetland was identified and confirmed to be present on the Apel Village side, along the right bank of the Olifants River in relation to the project proposed development area (**Figure 4.5**). A minor road crosses the floodplain wetland on the Apel Village side, along the right bank of the Olifants River. The wetland is experiencing erosion and channel incision, like the riverbank, making it vulnerable to further erosion and possible collapse.



Figure 4.5: Floodplain wetland and erosion on the Apel Village side of the Olifants River.

4.3. Present Ecological State (PES), Target Ecological Category (TEC), and Environmental Sensitivity and Ecological Importance (EIS).

Table 4.1 provides a summary of the PES, TEC and EIS for the quaternary catchment associated with the project proposed development area. The resource management objectives (RMO) for the wetland need to main the current PES and EIS post-development.

Table 4.1. PES, REC, and TEC of the project proposed development area in the Olifants River.

Quaternary	PES	EIS	TEC
B52A	Class D: Largely modified	Moderate	C-D

CHAPTER 5. EROSION, SCOUR AND SEDIMENTATION

5.1. Riverbank Erosion and Scour Assessment

Visible erosion and localised bank instability were recorded during the inspection. These conditions may be aggravated by concentrated flow, disturbance of bank vegetation, changes in channel geometry, or poorly controlled runoff from approach embankments. The final design should assess bank stability and identify appropriate protection measures based on the local hydraulic and geotechnical conditions.

Scour was observed particularly along the right bank facing downstream (Figure 5.1). This finding warrants further investigation because local scour can undermine bridge foundations and affect the stability of abutments and associated infrastructure. The assessment distinguished between long-term bed degradation, contraction scour, and local scour around piers and abutments. Scour calculations should be undertaken using appropriate engineering methods and coordinated with the geotechnical investigation. Foundation embedment and protection requirements should be based on the completed assessment.



Figure 5.3: Scouring and incision of the right bank due to high energy erosive power of water

5.2. Channel Morphology, Bank Erosion, Sediment Transport and Evidence of Channel Instability

The site inspection conducted on 3 October 2026 identified erosion and channel incision along the right bank of the Olifants River, when viewed facing downstream. Sediment deposits were also observed along the left bank, together with evidence of previous elevated flows in the form of flood deposits, accumulated debris and vegetation damage.

The coexistence of bank erosion, channel incision and sediment deposition suggests that the river reach may be experiencing active channel adjustment. These features are consistent with possible lateral bank erosion and localised bed degradation, although the rate, extent and underlying causes of channel change have not yet been established through repeat surveys or quantitative geomorphological analysis for different seasons, this once-off survey established an important fluvial geomorphology related to the project proposed development area in the Olifants River.

The observed erosion may be associated with concentrated flow, local channel curvature, variations in bank material, changes in sediment supply, riparian vegetation condition or the effects of previous flood events. Visual observations, together with vertical and horizontal bank measurements at bankfull stage, indicate a possible shift of the main current towards the right bank, potentially contributing to increased erosion along that bank.

Sediment deposits observed along the left bank indicate a possible depositional bench or bar associated with locally reduced flow velocities. These features highlight the importance of channel morphology and bank stability, which should be factored prominently into the bridge design. Potential bank retreat, changes in bed level and localised scour should be carefully considered when finalising the bridge alignment, abutment positions and foundation requirements to ensure the long-term stability and safety of the structure.

The observed sediment deposits and heterogeneous bed material indicate active sediment transport and deposition (Figure 5.2). The bridge design should avoid

unnecessary channel constriction and consider the potential for sediment accumulation around bridge components. Construction activities should minimise sediment mobilisation through suitable erosion and sediment-control measures.



Figure 5.2: Observed sediment deposits and heterogenous bed material on the left bank facing river downstream.

5.3. Potential Channel Migration and Geomorphological Instability

The erosion on one bank and sediment build-up on the opposite bank suggest that the river may be slowly shifting sideways. This movement could change the river's main flow path, affect how floodwater moves, and weaken the bridge approaches and foundations over time. The field observations suggest that the river channel is changing, but there is not enough evidence to confirm the direction or speed of this movement, whether the river channel is stable in the long term, or whether the river could change to a completely different flow path.

If the channel is unstable, possible future changes in the river's course and flow direction should be considered carefully in the current bridge design. This is important to ensure that the bridge opening is wide enough and that the approach embankments remain stable. The sediment deposits on the left bank should also be considered, as this area may form part of the flood flow path. Sediment build-up, vegetation growth and

changes in the river channel may reduce the space available for floodwater to flow during future floods.

5.4. Implications for the Proposed Bridge

The observed right-bank erosion, channel incision and localised scour have important implications for the design and long-term performance of the proposed Apel–Nkotokwane Bridge and Access Roads. Potential failure mechanisms include undermining of abutments or piers, loss of support due to local or contraction scour, erosion of approach embankments, exposure of foundations and changes in flow distribution around the bridge structure. Continued channel adjustment could also affect the stability of the crossing and its approaches.

The current bridge design should consider the river flow, channel changes and ground conditions at the site. The bridge and geotechnical engineers should review the planned foundation type and depth, abutment design and erosion protection to ensure they are suitable for the expected flood conditions and calculated scour depths.

The foundations on both sides of the bridge should not be designed at different depths based only on the erosion observed along the right bank. Any differences in foundation depth or erosion protection should be based on the surveyed river channel, flood flow, expected scour and ground conditions. The current bridge design should also be checked to ensure that the bridge opening can safely pass the expected design floods without causing excessive rises in water levels, concentrating the flow, blocking floodwater or increasing erosion upstream and downstream of the bridge.

5.5. Recommended Protection Measures

Depending on the results of the river flow and ground assessments, the following measures may be needed:

- Rock protection to reduce erosion along the riverbanks.
- Gabions or other protective structures to keep the riverbanks stable.
- Planting vegetation to strengthen the banks, where it does not block floodwater.
- Protecting bridge approaches and drainage outlets to prevent erosion.

- Strong foundations and scour protection to stop flowing water from washing away the soil around the bridge foundations.
- Regular bridge inspections after major floods to check for damage and changes in the river channel.

The final choice of protection measures should be based on the river flow, flood conditions, soil type, and ground conditions at the proposed bridge site and access roads.

CHAPTER 6. CONSTRUCTION AND OPERATIONAL HYDROLOGICAL RISK ASSESSMENT

Risk assessment involves identifying what could cause harm, how likely it is to happen, and what the effects would be if it happened. The net consequence is established by the following equation:

Consequence = (Duration + Extent + Irreplaceability of resource) x Severity

The environmental significance of an impact was determined by multiplying the consequence by probability. The risk significance rating is summarised in Table 6.1. Hydrological risks associated with the construction and preparation and post-construction phases of the project were identified and are presented in Table 6.2 and 6.3. No closure or decommissioning phase risks are anticipated for this project.

Table 6.1. Risk rating scale

Criteria	Rating Scales
Significance	Very high – negative (-49 to -66)
	High-negative (-37 to -48)
	Moderate-negative (-25 to -36)
	Low-negative (-13 to -24)
	Neutral- very low (0 to -12)
	Low-positive (0 to 12)
	Moderate-positive (13 to 24)
	High-positive (24 to 48)
	Very high -positive (49 to 66)

6.1. Construction-phase risks

Construction near a flowing river can create temporary blockages, increase soil erosion and expose workers and equipment to unexpected floods.

Possible risks include:

- Flooding of construction areas.
- Damage to temporary access roads.
- Blocking the river with machinery, building materials or temporary structures.
- Uncontrolled changes to the river's flow.
- Erosion of exposed riverbanks and dug-up ground.

- Soil and sediment washing into the river during construction.
- Water pollution from fuel, concrete wash water and construction waste.
- Damage to wetlands and plants along the riverbanks.
- Unsafe working conditions when river levels rise.

Table 6.2. Expected hydrological impacts during the construction/preparation phase

			Pre-mitigation								Post-mitigation						
Component being impacted on	**Activity which may cause impact**	**Activity**	**Duration (D)**	**Extent (E)**	**Potential for impact on irreplaceable resources**	**Severity (S)**	**Consequence (C)**	**Probability (P)**	**Significance**	**Recommended mitigation measures**	**Duration (D)**	**Extent (E)**	**Potential for impact on irreplaceable resources**	**Severity (S)**	**Consequence (C)**	**Probability (P)**	**Significance**
Unsaturated zone soils and aquifer table	Disturbing unsaturated zone during soil excavations/construction activities	Net results of earthworks and construction	Medium Term (3)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	-Only excavated areas apply to the project area -Backfill the material in the same order it was excavated to reduce contamination of deeper soils with shallow oxidised soils - Cover excavated soils with a temporary liner to prevent contamination -Retain as much indigenous vegetation as possible - exposed soils are to be protected using a suitable covering or revegetating	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (1)	Neutral/ Negligible (0 to -12) (-6)
	Poor quality seepage from machinery used to excavate soils. Oil, grease and fuel leaks could lead to hydrocarbon contamination of the unsaturated zone soils which could percolate into the shallow aquifer	Net results of earthworks and construction	Medium Term (3)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	-Park heavy machinery in lined areas and place drip trays under vehicles at the site -Visual soil assessments for signs of contamination during construction (monthly)	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (1)	Neutral/ Negligible (0 to -12) (-6)
Poor quality seepage from machinery used to excavate soils. Oil,	River pollution from fuel, oil, and concrete	Net results of earthworks and construction	Medium Term (3)	Site (2)	Yes (1)	High (-3)	Low negative (-18)	Definite (2)	Moderate negative (-36)	Store hazardous substances in bounded areas; maintain equipment and vehicles;	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (3)	Low negative (-18)

grease and fuel leaks could lead to hydrocarbon contamination of the unsaturated zone soils which could percolate into the shallow aquifer										provide spill kits; promptly contain and remediate spills; inspect potentially contaminated areas regularly.							
Physical water quality, instream habitat and biota	Sedimentation and increased turbidity	Net results of earthworks and construction	Medium Term (3)	Ste (2)	Yes (1)	High (-3)	Low negative (-18)	Definite (2)	Moderate negative (-36)	Maintain vegetative cover, stabilise eroded areas, minimise disturbance during maintenance and repair drainage outlets	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3)	Low negative (-18)
Flow and geomorphological, regimes, and aquatic biota (longitudinal connectivity and migration)	Temporary obstruction or diversion of river flow	Net results of earthworks and construction	Medium Term (3)	Site (3)	Ye (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Maintain safe and reliable bridge access and prevent unnecessary disturbance of nearby riverbanks Maintain the drainage infrastructure and ensure that runoff is discharged in a controlled manner without increasing erosion or flooding downstream	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (3)	Low negative (-18)
Local hydrological regime , riverbank stability and upstream and downstream surface water quality and instream habitat	Flooding and damage to temporary access roads	Net results of earthworks and construction	Medium Term (3)	Site (3)	Yes (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Undertake periodic structural inspections, maintain drainage and scour protection, implement flood-response and access restriction procedures	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3	Low negative (-18)
Riparian habitat and soil integrity, and bank stability and	Riverbank and embankment erosion	Net results of earthworks and construction	Medium Term (3)	Site (3)	Yes (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Maintain erosion protection, stabilise exposed soil, inspect drainage	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3)	Low negative (-18)

morphology										outlets and repair erosion promptly							
Shallow groundwater, soil profile integrity and surface water quality and riparian ecosystem health and downstream water users (domestic and agriculture)	Soil, surface water, and shallow groundwater contamination	Net results of earthworks and construction	Medium Term (3)	Site (2)	Yes (1)	Moderate (-2)	Neutral -very low (-12)	Definite (2)	Low negative (-24)	Prevent discharge of contaminated runoff, implement spill response procedures, inspect drainage outlets and address pollution incidents immediately	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (1)	-6 (Neutral-very low)
Biological and structural component of the watercourse	Damage to riparian vegetation and aquatic habitats	Net results of earthworks and construction	Medium Term (3)	Site (3)	Yes (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Restrict maintenance to designated areas, avoid unnecessary vegetation clearance, rehabilitate disturbed areas with indigenous species	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3)	Low negative (-18)
Structural hydrological change	Alteration or modification of natural drainage and flow distribution	Net results of earthworks and construction	Medium Term (3)	Site (3)	Yes (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Maintain culverts and drainage channels, prevent blockages, inspect the drainage system after significant rainfall and repair defects	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3)	Low negative (-18)
Hydraulic capacity and flood routing, structural integrity of permanent infrastructure and occupational health and safety worker life and capital assets	Flood related safety risks to workers; and equipment, and flood flow obstruction and bridge scour	Net results of earthworks and construction	Medium Term (3)	Site (3)	Yes (1)	High (-3)	Low negative (-21)	Definite (2)	High negative (-42)	Ensure adequate hydraulic capacity, maintain flood conveyance, inspect bridge foundations and bridge abutments for scour, remove debris where safe and appropriate	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (–6)	Probable (3)	Low negative (-18)
Primary surface water receiver – Olifants River	Surface water contamination, and sedimentation from the following activities: Equipment and vehicles are washed in the water bodies (when there is water). Erosion and	Net results of earthworks and construction	Medium Term (3)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	-Visual inspections of all vehicles entering and operating at the sites	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (1)	Neutral/ Negligible (0 to -12) (-6)

	sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather), and Alteration of natural drainage lines which may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion																

6.2. Temporary River diversions

Any proposed diversion, cofferdam, temporary crossing or in-channel working platform should be evaluated before construction. The construction method must demonstrate that temporary works will not create unacceptable upstream flooding, downstream erosion or obstruction of the river's natural flow. The contractor should prepare an approved method statement and flood-response procedure before commencing work in or adjacent to the watercourse.

6.3. Operational risks

Operational risks include:

- Bridge overtopping or approach-road washaway.
- Flood debris accumulating against piers or abutments.
- Scour and foundation exposure.
- Bank erosion and embankment instability.
- Changes in flood levels or flow distribution.
- Sediment deposition or channel adjustment.
- Deterioration of erosion-protection structures.

These risks should be addressed through the completed design, construction quality control, and a long-term inspection and maintenance programme.

Table 6.3: Expected hydrological impacts during the operational phase

			Pre-mitigation								Post-mitigation						
Component being impacted on	**Activity which may cause impact**	**Activity**	**Duration (D)**	**Extent (E)**	**Potential for impact on irreplaceable resources (I)**	**Severity (S)**	**Consequence (C)**	**Probability (P)**	**Significance**	**Recommended mitigation measures**	**Duration (D)**	**Extent (E)**	**Potential for impact on irreplaceable resources**	**Severity (S)**	**Consequence (C)**	**Probability (P)**	**Significance**
Unsaturated zone soils and aquifer table	Erosion reduction	Erosion reduction due to installed gabions	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	**No mitigation required**							
Physical water quality, instream habitat and biota	Sedimentation reduction	Sedimentation reduction due to installed retention basins and deep sumps	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	**No mitigation required**							
Unsaturated zone soils and shallow aquifer	Accidental fuel, oil and lubricant leaks from vehicles using the bridge and access roads or during maintenance	Operation and maintenance of bridge and access roads	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (1)	Neutral – very low (0 to -12) (-12)	No mitigation required							
Primary surface water receiver (Olifants River)	Contamination from vehicle-related spills and polluted stormwater runoff	Routine use of bridge and access roads	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (1)	Neutral – very low (0 to -12) (-12)	No mitigation required							
Olifants River and associated aquatic habitats	Increased stormwater runoff from paved road surfaces, potentially increasing erosion and sediment transport	Operation of access roads and bridge approaches	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (1)	Neutral – very low (0 to -12) (-12)	No mitigation required							
Riverbanks and embankments	Localised erosion caused by concentrated runoff from bridge approaches, road embankments and drainage outlets	Operation and stormwater discharge	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (1)	Neutral – very low (0 to -12) (-12)	No mitigation required							
Olifants River channel and bridge foundations	Obstruction of flood flows, increased turbulence or localised scour around bridge piers and abutments	Permanent presence of bridge infrastructure during flood events	Long Term (4)	Site (3)	Yes (1)	High positive (3)	Slightly detrimental (-13 to -24) (-24)	Definite (1)	Low negative (-13 to -24) (-21)	No mitigation required							
Natural drainage systems and surface water flow paths	Modification of local drainage patterns by road embankments, culverts and stormwater infrastructure	Permanent presence and operation of bridge and access roads	Long Term (4)	Site (2)	Yes (1)	Moderate negative (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (1)	Neutral – very low (0 to -12) (-12)	No mitigation required							
Bridge, access roads and surrounding land	Flooding and damage to infrastructure during high-flow events	Operation during extreme rainfall and flood events	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low negative (0 to -12) (-24)	No mitigation required							
Riparian vegetation	Limited disturbance during periodic	Maintenance of bridge,	Long Term (4)	Site (3)	Yes (1)	High (-3)	Slightly detrimental	Definite (2)	High negative (0	No mitigation required							

and aquatic habitats	maintenance and vegetation management	road verges and drainage structures					(-7 to -12) (-12)		to -12) (-42)								
Disturbed soils, road embankments and riparian areas	Stabilisation and revegetation of disturbed areas following construction, reducing erosion and sediment delivery to the river	Post-construction rehabilitation and ongoing vegetation establishment	Long Term (4)	Site (2)	Yes (1)	Moderate positive (2)	Low positive (0 to 12) (12)	Definite (1)	Low positive (0 to 12) (12)	No mitigation required							
Surface water drainage and surrounding access network	Improved stormwater conveyance where designed drainage structures replace poorly controlled or informal drainage pathways	Operation of bridge and access roads	Long Term (4)	Site (2)	Yes (1)	Moderate positive (2)	Low positive (0 to 12) (12)	Definite (1)	Low positive (0 to 12) (12)	No mitigation required							
Bridge, access roads and surrounding land	Flooding and damage to infrastructure during high flows	Operation during extreme rainfall and flood events	Long Term (4)	Site (3)	Yes (1)	High negative (-3)	Low positive (0 to 12) (12)	Definite (2)	Low negative (0 to -12) (-12)	No mitigation required							
Riparian vegetation and aquatic habitats	Limited disturbance during periodic maintenance and vegetation management	Maintenance of the bridge, road verges drainage structures	Short-Term (2)	Site (2)	Yes (1)	Low (-1)	Neutral or negligible (0 to -6) (-6)	Definite (2)	Low negative (0 to -12) (-12)	No mitigation required							
Riverbanks and riparian areas	Reduced reliance on informal river crossings, where these currently occur, potentially reducing direct disturbance of riverbanks	Use of the completed bridge and access road	Long Term (4)	Site (2)	Yes (1)	Moderate positive (2)	Low positive (0 to 12) (12)	Definite (1)	Low positive (0 to 12) (12)	No mitigation required							
Reduced disturbance from informal crossings		Disturbance of nearby riverbanks due to human induced influences	Long Term (4)	Site (2)	Yes (1)	Moderate positive (2)	Low positive (0 to 12) (12)	Definite (1)	Low positive (0 to 12) (12)	No mitigation required							
Primary surface water receiver – Olifants River	Surface water contamination, and sedimentation from the following activities: Equipment and vehicles are washed in the water bodies (when there is water). Erosion and sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather), and Alteration of natural drainage lines which may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion	Net results of earthworks and construction	Long Term (4)	Site (2)	Yes (1)	Moderate (-2)	Slightly detrimental (-7 to -12) (-12)	Definite (2)	Low-negative (-13 to -24) (-24)	-Visual inspections of all vehicles entering and operating at the sites	Medium Term (3)	Site (2)	Yes (1)	Low (-1)	Negligible (-6 to 0) (-6)	Probable (1)	Neutral/ Negligible (0 to -12) (-6)

6.4. Application of the River Continuum Concept to the proposed bridge construction and road upgrading

The River Continuum Concept (RCC), as described by Vannote et al. (1980), provides a conceptual framework for assessing the potential effects of the proposed bridge construction on aquatic ecosystem structure and function. The RCC recognises that riverine physical conditions, organic matter transport and utilisation, and biological communities change along the longitudinal river gradient and that these processes are ecologically interconnected.

In the context of the proposed development, the RCC should inform the assessment of potential changes to flow continuity, sediment transport, channel morphology, water quality, organic matter inputs and aquatic habitat availability. Construction activities, including temporary river diversions, in-channel works, bank excavation and sediment mobilisation, may alter these processes locally and potentially influence downstream habitats and biological communities.

Potential ecological receptors include rheophilic fish such as *Labeobarbus marequensis*, *Labeo cylindricus* and *Labeo molybdinus*, other fish species including *Pseudocrenilabrus philander*, *Coptodon rendalli* and *Oreochromis mossambicus*, as well as aquatic macroinvertebrates, diatoms, periphyton, phytoplankton and other aquatic organisms. Potential impacts include habitat disturbance, disruption of aquatic connectivity, changes in benthic substrate conditions, altered primary production, degradation of food resources and deterioration of water quality.

The RCC should consequently be incorporated into the aquatic ecological baseline assessment, construction and operational impact assessment, mitigation planning and post-construction monitoring programme. Attention should be given to maintaining natural flow and sediment processes, protecting sensitive aquatic habitats, preventing pollution, minimising channel disturbance and assessing whether the proposed bridge will create persistent discontinuities in ecological processes along the river. The application of the RCC should be supported by site-specific biological, water-quality, geomorphological and hydraulic information. The significance of predicted impacts should be determined from the ecological sensitivity of the receiving river, the extent

and duration of disturbance, the species and habitats present, and the effectiveness of the proposed mitigation measures.

6.5. Surface water quality monitoring plan for the Olifants River

Bridge construction and access road construction will take place directly in the Olifants River. These activities may pollute the river through spills of fuel, oil, cement, concrete, chemicals and other construction materials. Construction may also increase the amount of soil entering the river and change the flow of water. Changes in river flow may encourage algal growth. Too many algae can reduce oxygen levels in the water and cause fish to die. A surface water quality monitoring plan must therefore be followed to protect the river and its aquatic life. The Contractor must take steps to prevent pollution. These include keeping spill kits on site, maintaining construction equipment and storing fuel and chemicals safely. If a spill occurs, the work causing the spill must be stopped immediately, where it is safe to do so. The spill must be contained to prevent it from spreading into the river. The Site Manager and Environmental Control Officer (ECO) must be informed immediately.

Daily visual inspections must be carried out during construction work in the river. Formal environmental inspections must also be done monthly. Inspections must cover the construction areas, riverbanks and the river sections upstream and downstream of the work area. The inspections must look for oil on the water, unusual water colour or smells, muddy water, cement or concrete waste, excessive algae and dead or distressed fish. Additional inspections must be carried out immediately if a spill occurs or signs of pollution are noticed. If a spill occurs or pollution is suspected, water, soil and/or sediment samples must be collected, depending on where the spill occurred and the type of material released. Water samples should be collected upstream of the spill to check the normal water quality, at the affected area and downstream to determine how far the pollution has spread. Soil and/or sediment samples must be collected if the riverbed, riverbanks or nearby soil may have been contaminated. All samples must be sent to an accredited laboratory for urgent analysis. The tests must be selected according to the type of pollution and may include pH, turbidity, suspended solids, oil, fuel and harmful chemicals or metals.

The monitoring plan must also include checks for algal growth because changes in river flow may increase the risk of algal blooms. If unusual algal growth is observed, water samples must be collected to measure chlorophyll-a levels, which indicate the abundance of algae in the water. Dissolved oxygen levels must also be checked to determine whether there is enough oxygen in the water for fish and other aquatic life. If low oxygen levels, excessive algae or dead fish are observed, the ECO must be informed immediately. Further water sampling and specialist assessment must be carried out where necessary.

The Contractor must clean up spills safely, remove contaminated materials and dispose of them at an approved facility. Follow-up inspections and sampling must be done where necessary to check whether the clean-up measures have worked. The Developer or landowner must ensure that the monitoring plan is followed. The ECO must carry out spot checks, review laboratory results, keep records of pollution incidents and check that corrective measures have been completed. Any required reports must be submitted to the relevant authorities in line with applicable legal requirements.

Monitoring frequency:

- Daily visual inspections during active construction work in the river.
- Formal environmental inspections every month.
- Immediate inspections and sampling when a spill or possible pollution is identified.
- Follow-up inspections and sampling until the pollution has been controlled and the ECO is satisfied that the necessary corrective measures have been completed.

6.6. Overall assessment

The operational phase is expected to have a lower overall hydrological impact than the construction phase, because excavation, extensive soil disturbance, vegetation clearance and in-channel construction activities will no longer be undertaken. The principal residual risks will be associated with stormwater runoff, localised erosion, accidental pollution, bridge scour and flood damage. These risks should be managed through appropriate hydraulic design, routine inspection and maintenance, and timely rehabilitation.

Positive impacts may include stabilisation of disturbed areas, improved management of stormwater and reduced disturbance associated with informal river crossings, where applicable. These benefits depend on the effectiveness of rehabilitation, drainage design and continued maintenance.

CHAPTER 7. IMPACT ASSESSMENT AND MITIGATION

7.1. Assessment framework

Hydrological impacts were assessed by considering the existing environment, the proposed development, the nature and extent of the potential impact, its duration, intensity, spatial scale, reversibility and likelihood. The significance of impacts was determined using the environmental assessment methodology adopted for the overall project. Where that methodology requires formal impact ratings, the hydrology specialist provided the necessary ratings where necessary. The field observations support the identification of potential impacts but do not provide sufficient evidence to assign defensible final significance ratings for all construction and operational scenarios.

7.2. Hydrological impact register

Table 7.1. Potential impacts and mitigation

Potential impact	Project phase	Recommended mitigation
Alteration of flow conveyance	Construction and operation	Optimise bridge opening and avoid unnecessary channel constriction
Increased upstream flood levels	Operation	Model existing and proposed conditions and revise design if necessary
Localised scour	Construction and operation	Complete scour assessment and provide suitable foundation protection
Riverbank erosion	Construction and operation	Stabilise disturbed banks and manage concentrated runoff
Sediment mobilisation	Construction	Implement erosion and sediment-control measures
Temporary flow obstruction	Construction	Design and manage temporary works to maintain safe flow conveyance
Pollution of the watercourse	Construction and operation	Implement spill prevention and waste-management procedures
Wetland and riparian disturbance	Construction	Minimise the construction footprint and rehabilitate disturbed areas
Flood debris accumulation	Operation	Provide suitable hydraulic clearance and implement inspection and maintenance
Altered sediment continuity	Construction and	Minimise channel constriction and avoid

Potential impact	Project phase	Recommended mitigation
	operation	unnecessary interruption of sediment transport
Climate-related flood uncertainty	Design and operation	Undertake justified sensitivity testing and consider design resilience

7.3. Mitigation hierarchy

Mitigation should follow the sequence of avoidance, minimisation, rehabilitation and, where applicable, compensation.

Avoidance

- Avoid unnecessary disturbance to the active channel, wetlands and riparian areas.
- Locate temporary works and access routes outside sensitive areas where practicable.
- Avoid bridge configurations that unnecessarily constrict the river or obstruct floodplain flow.

Minimisation

- Optimise the bridge opening using hydraulic modelling.
- Limit in-channel works and the duration of temporary flow restrictions.
- Prevent uncontrolled runoff and sediment release.
- Protect foundations, banks and approach embankments against identified erosion and scour mechanisms.
- Prevent fuel, concrete, waste and other contaminants from entering the watercourse.

Rehabilitation

- Reinstate disturbed riverbanks and riparian areas.
- Stabilise exposed soil and drainage outlets.
- Remove temporary obstructions and surplus construction materials.
- Restore disturbed areas using appropriate indigenous vegetation, where suitable.

Compensation

Compensatory measures should only be considered where required by the applicable authorisation process and where residual impacts cannot be avoided, minimised or adequately rehabilitated. Any such measures must be developed in coordination with the environmental assessment team and relevant authorities.

7.4. Channel Asymmetry and Potential Migration

The field inspection recorded erosion and incision along the right bank and sediment deposition along the left bank. This pattern may indicate an asymmetrical distribution of flow and sediment transport across the river channel. The hydraulic assessment should investigate the distribution of flow depths, velocities and shear stresses across the channel under representative low-flow and design-flood conditions. Attention should be given to flow concentration near the right bank, the potential for local scour around bridge abutments and piers, and the influence of the proposed structure on upstream and downstream flow distribution.

The assessment should compare the existing channel with the proposed bridge configuration and consider whether the bridge opening, approach embankments or associated protection works could redirect flow or increase erosion at vulnerable locations. Where historical imagery and survey information indicate continuing channel migration, the bridge design should consider the implications for long-term channel stability, approach-road protection and maintenance requirements. The possibility of a major change in channel alignment or avulsion should be evaluated only were supported by geomorphological evidence and the site-specific hydraulic assessment. The final report should document the evidence, uncertainties and design implications. The key point is that a bridge does not automatically require an asymmetrical design because one bank is eroding. The hydraulic and geotechnical evidence must establish whether different foundation or protection requirements are necessary.

7.5. River Continuum Concept

The River Continuum Concept (RCC) describes longitudinal changes in river structure and function and the relationships between physical processes and ecological communities along a river system. Bridge construction can potentially affect processes

relevant to this concept, including longitudinal movement of water and sediment, transport of organic material, aquatic organism movement, and connectivity between upstream and downstream habitats.

The hydrology specialist should work with the Aquatic Biodiversity Specialist to determine how the proposed crossing may influence these processes.

The collaboration should address:

- Changes in flow depth, velocity and seasonal flow patterns.
- Potential barriers to aquatic organism movement.
- Alteration of sediment transport and channel substrate.
- Changes in the transport and accumulation of organic matter.
- Potential impacts on habitat continuity and downstream receiving environments.
- The relationship between hydraulic changes and aquatic biodiversity responses.

The bridge design should maintain the natural channel as far as practicable, avoid unnecessary bed elevation changes and channel constriction, and minimise barriers to ecological connectivity. The hydrological contribution to the RCC assessment should be finalised using the hydraulic model outputs and the ecological drivers and responses identified in the Aquatic Biodiversity Impact Assessment.

CHAPTER 8. INPUTS TO THE ENVIRONMENTAL MANAGEMENT PROGRAMME

8.1. Input to Environmental Management Programme based on the potential management aspect and minimum requirement that may need to be followed or adhered to.

The hydrology specialist recommends that the Environmental Management Programme (EMPr) include the following requirements as indicated in Table 8.1.

Table 8.1. Recommended EMPr measures

Management aspect	Minimum requirement
Work near the river	Clearly demarcate authorised work areas and minimise disturbance
Temporary works	Approve method statements and maintain safe flow conveyance
Flood preparedness	Establish monitoring, warning, evacuation and equipment-protection procedures
Erosion control	Stabilise exposed soils, banks and drainage outlets
Sediment control	Prevent sediment-laden runoff from entering the river
Pollution prevention	Provide spill controls and prohibit uncontrolled discharge of contaminants
Waste management	Collect, contain and remove construction waste
Wetland protection	Avoid unnecessary disturbance and rehabilitate affected areas
Flow obstruction	Keep the channel clear of unnecessary plant, materials and debris
Rehabilitation	Reinstate disturbed banks and riparian areas where practicable
Operational inspections	Inspect for scour, erosion, debris and structural damage
Incident reporting	Record pollution, flooding, erosion and other hydrological incidents
Corrective action	Implement and document appropriate remedial measures

The final EMPr requirements should be consistent and align with the approved bridge design, construction method statements and applicable authorisation conditions.

8.2. Implications for Foundation Design and Scour Protection

The erosion and deepening of the riverbed observed along the right bank show that this area needs a detailed assessment. The final bridge design should consider the risk of further riverbed lowering, erosion caused by water flowing through the bridge opening,

and erosion around the bridge supports and abutments. The bridge and geotechnical engineers should determine the foundation type and depth based on the calculated erosion depth, ground conditions, bridge loads and possible future changes in the river channel. Deep foundations, such as piles, may be used if the assessment shows that they are needed. The decision to use piles must be based on the engineering and ground investigations, not only on what was observed during the site visit.

Suitable protection should also be provided to reduce erosion around the bridge. Depending on the assessment results, this may include rock protection, gabions, reinforced riverbanks, retaining structures, protection at the bottom of the riverbanks and replanting disturbed areas with suitable vegetation. The protection measures must be properly designed to avoid causing more erosion upstream or downstream. Their effects on river flow, sediment movement and floodwater flow must also be considered before construction.

8.3. Bridge Opening and Long-Term Channel Stability

The bridge opening and approach embankments should be checked against the current river channel, the areas where floodwater flows and possible future changes in the river channel. The bridge design should avoid making the river channel too narrow and allow enough space for floodwater to pass safely. If the assessment shows that the river may shift sideways over time, this risk should be considered when deciding on the bridge position, riverbank protection and future inspection needs. The design should not assume that the river will flow around the bridge or suddenly change its course unless the available evidence supports this possibility.

8.4. Construction and Public Safety Considerations

Where active erosion has produced steep or undercut banks, the contractor should assess bank-collapse hazards within the construction area and establish appropriate exclusion zones, access controls and temporary protective measures. If the affected riverbank is accessible to schoolchildren or members of the public near Gwara Gwara Primary School, the project team should verify the location and proximity of the hazard and coordinate appropriate public-safety measures with the relevant authorities and community representatives. Construction activities should not commence in an

unstable bank area until the site-specific risks have been assessed, and suitable controls have been implemented. Any permanent stabilisation works should be based on the approved engineering design and the required environmental authorisations.

CHAPTER 9. CONCLUSIONS AND SPECIALIST OPINION STATEMENT

9.1. Conclusions

Based on the investigation, the following conclusions were made:

The site visits on 3 October 2026 found that the river is flowing and has a clear channel. Water was also entering from a tributary. Signs of past high-water levels, riverbank erosion, a deep riverbed and sediment build-up were observed. Erosion and riverbed deepening were more noticeable along the right bank when facing downstream, while sediment had built up along the left bank. These observations suggest that the river channel may be changing and could move sideways over time. This must be considered carefully in the current design of the proposed Apel–Nkotokwane bridge and access roads.

The available field evidence does not independently establish the rate or direction of channel migration, the magnitude of design flood events, the location of the thalweg during extreme flows or the future likelihood of channel avulsion. However, the current bridge design should consider the results of the flood and river flow assessment. This includes the size of the bridge opening, flood levels, any rise in water levels caused by the bridge, the space between floodwater and the bridge deck, water speed and the depth of possible erosion around the foundations. The engineers must use the river flow results and ground conditions to decide on the foundation type and depth, abutment design, riverbank protection and measures to keep the approach roads stable.

The seasonal tributary near Nkotokwane village, next to Gwara Gwara Primary School, should be considered in the design of both the proposed bridge and access roads. The tributary carries water into the main river during rainfall and may affect flood levels, drainage, erosion and sediment movement around the bridge and road approaches. Its flow and potential impact on the school and public access routes should therefore be considered in the design.

Specialist opinion: The site observations and completed hydrological and hydraulic assessments identified important river flow and riverbank stability issues that must be considered in the current bridge and access road design. The design should account for flood levels, flow speeds, possible erosion around the bridge foundations, changes in the

river channel and flows from the seasonal tributary near Nkotokwane village. Suitable drainage structures, foundation depths, riverbank protection and access-road stabilisation measures should be based on the assessment findings and ground conditions.

The proposed bridge and access roads should be considered acceptable from a hydrology perspective only if the assessment findings are included in the design, appropriate mitigation measures are applied, and all required environmental and water-use approvals are in place.

9.2. Avoidance areas and protective buffers

Stabilising the banks of the river will help prevent or reduce any environmental degradation and water should be allowed to flow downstream to maintain the environmental water requirements (EWR). The overall impact on the hydrological cycle will be neutral and largely positive for the riverbanks and soils associated with the project.

9.3. Mitigation measures for inclusion in the EMPr

Based on the hydrology and freshwater assessment for the proposed bridge across the Olifants (Lepelle) River between Apel and Nkotokwane villages, the following measures should be included in the Environmental Management Programme (EMPr) to reduce the impacts of construction on the river and surrounding environment. The summarised information pertaining to mitigation measures prominent for inclusion in the EMPr and the responsible persons are depicted in Table 9.1.

9.3.1. Flood prevention and control

Carry out construction between April and September, where possible, to reduce the risk of flooding.

- Check weather forecasts and river water levels regularly.
- Stop work near the river when heavy rain or rising water levels create a safety risk.
- Keep construction materials, machinery and temporary structures away from areas that may flood.

- Keep the river channel clear so that water can flow freely.
- Ensure that the bridge opening is large enough to allow floodwater to pass safely.
- Prepare an emergency plan for floods, including safe routes for workers and machinery.
- Inspect the site after heavy rain or flooding and repair any damage.

9.3.2. Protection of aquatic life

- Clear vegetation only where construction is necessary.
- Avoid unnecessary disturbance of the riverbed, riverbanks, wetlands and nearby habitats.
- Keep machinery out of the river wherever possible.
- Prevent fuel, oil, cement and other harmful materials from entering the river.
- Do not dump soil, waste or building materials into the river.
- Use suitable measures to stop soil from washing into the river.
- Protect natural vegetation along the riverbanks wherever possible.
- Replant disturbed areas with suitable indigenous plants after construction.
- Follow the recommendations of the aquatic biodiversity specialist and obtain the required approvals before working in the river.

9.3.3. Protection of natural river flow

- Keep the river flowing naturally during construction as far as possible.
- Do not divert the river without proper planning and the required approvals.
- Prevent machinery, materials and temporary structures from blocking the river.
- Check temporary river crossings and diversion structures regularly.
- Ensure that the bridge does not cause excessive flooding upstream or increase erosion downstream.
- Avoid directing large amounts of water towards the riverbanks or nearby properties.
- Remove temporary structures and blockages after construction.
- Check for changes in river flow, erosion and sediment build-up during and after construction.

9.3.4. Prevention of riverbank erosion

- Limit digging and soil disturbance near the river to the areas needed for construction.
- Stabilise exposed soil and riverbanks as soon as possible.
- Use rocks, gabions or other suitable protection where needed.
- Protect the bridge approaches and drainage outlets from erosion.
- Control stormwater from construction areas to prevent soil from washing into the river.
- Inspect the riverbanks regularly for signs of erosion.
- Repair damaged areas as soon as possible.

9.3.5. Protection of bridge foundations

- Ensure that the bridge and geotechnical engineers check the planned foundations and erosion protection.
- Base foundation depth on the soil conditions, expected floods and the depth of possible scour.
- Consider the erosion observed on the right bank and sediment deposits on the left bank in the bridge design.
- Ensure that the design considers possible changes in the river's flow direction and channel.
- Inspect the bridge foundations and riverbanks after major floods.
- Repair any damage that may affect bridge safety.

9.3.6. Pollution control during construction

- Store fuel, oil and chemicals in safe areas away from the river.
- Refuel machinery in designated areas where spills can be controlled.
- Keep spill-cleaning materials on site and clean up spills immediately.
- Provide toilets and waste bins for workers.
- Dispose of construction waste at approved sites.
- Do not wash concrete equipment in or near the river.
- Maintain machinery to prevent oil leaks.
- Train workers on how to prevent pollution and respond to emergencies.

9.3.7. Protection of wetlands and riverbank vegetation

- Mark sensitive areas where construction is not allowed before work begins.
- Keep machinery and workers out of wetlands and sensitive riverbank areas.
- Avoid removing natural vegetation unless necessary for the approved construction work.
- Remove invasive plants where required and dispose of them properly.
- Replant disturbed areas with suitable indigenous plants.
- Check restored areas to ensure that plants are growing and erosion is under control.

9.3.8. Monitoring and inspections

- Inspect the construction site regularly to check that environmental measures are followed.
- Check river levels, erosion, sediment build-up and signs of pollution.
- Inspect erosion protection after heavy rainfall.
- Record environmental problems and the actions taken to fix them.
- Report serious pollution or erosion incidents to the relevant authorities where required.
- Inspect the site after construction to ensure that temporary structures are removed and disturbed areas are restored.
- Inspect the bridge, foundations and riverbanks after major floods.

Table 9.1: Summary table of inclusion to EMPr

Impact	Required mitigation measure	Responsible person
Flooding	Plan construction between April and September where possible, monitor river levels and prepare an emergency plan.	Contractor and Environmental Control Officer (ECO)
Aquatic life	Protect river habitats, limit vegetation clearing and prevent pollution.	Contractor, ECO and aquatic specialist
Changes to river flow	Keep the river clear and prevent uncontrolled diversions.	Contractor and bridge engineer
Riverbank erosion	Stabilise exposed soil and protect riverbanks where needed.	Contractor and civil engineer

Scour around foundations	Ensure that foundations and scour protection are suitable for the expected floods.	Bridge and geotechnical engineers
Soil entering the river	Control runoff and prevent soil from washing into the river.	Contractor and ECO
Water pollution	Store fuel safely, prevent spills and manage waste properly.	Contractor and ECO
Damage to wetlands	Mark sensitive areas and avoid unnecessary disturbance.	Contractor and ECO
Damage after floods	Inspect the bridge, foundations and riverbanks after major floods.	Road authority and maintenance team

9.4. Reasoned opinion on whether the activity should be authorised

Based on the current activities and the measures proposed to reduce negative impacts, Pragmatic Scientific Services believes that the project should be considered for approval. In general, the project is expected to have positive effects during its operational phase.

The final decision must be made by the relevant government authorities. This decision should consider the expected impacts on the river and surrounding environment, as well as the social and economic benefits of the project. This recommendation is based on the understanding that all proposed mitigation measures and recommendations in the Environmental Management Programme (EMPr) will be followed throughout the project.

From a hydrological perspective, the construction of the bridge and access roads can proceed. However, the engineers and contractors must consider the possibility of the river channel shifting towards the right bank due to channel instability. They must also consider the soil types, river flow, flooding, erosion, and scouring around the bridge foundations.

The wetland on the Apel side must also be considered in the existing bridge layout plan. The wetland shows signs of riverbed incision and bank collapse caused by water flowing across the floodplain. These processes may lead to further land degradation and unexpected changes to the wetland. The bridge layout must therefore consider these risks and ensure that the natural flow of water is not negatively affected. The wetland

buffer area must also be clearly identified, adhered to and included in the bridge layout plan. The design and construction activities should avoid the wetland and its buffer as far as possible to reduce damage and protect the wetland's natural functions. Any proposed activities within or near the wetland buffer must be assessed and managed in line with the applicable environmental requirements.

The engineers and geotechnical specialists must ensure that these factors are included in the existing design to keep the bridge and access roads safe and stable. The design must also consider the expected flood levels, the size of the bridge opening, the protection required for the foundations, and the possible effects on the wetland and its buffer area.

Therefore, from a hydrological perspective, the project can proceed with the construction of the bridge and access roads, provided that the river instability, erosion, scouring, wetland degradation, floodplain water flow, and wetland buffer requirements are properly addressed in the existing bridge layout and design. The relevant engineers and specialists must ensure that these issues are adequately managed and that all required legal and regulatory approvals are obtained.

If the recommended mitigation measures are properly implemented, the impact of flooding is expected to be **moderate**. However, the impacts on aquatic biodiversity and changes to or alteration of river flow are expected to remain **high.**

CHAPTER 10. REFERENCES

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