Aquatic Biodiversity Assessment

Proposed replacement of the bulk water supply pipeline along the R102 Road to the airport precinct, George, Western Cape.

Prepared for Cape EAPrac (Pty) Ltd

Updated in April 2024 due to revised layout with pipeline mostly North of the R102

by

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DECLARATION OF CONSULTANTS INDEPENDANCE

I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;

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• All the particulars furnished by me in this document are true and correct.

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Expertise: > 13 years' experience working on aquatic ecosystems across South Africa, with a focus on the Southern Cape in the last 7 years. Includes research and consulting expertise, having published > 10 water-related research articles and compiled > 450 aquatic specialist reports. Research and consulting have been in a range of sectors including agriculture, urban developments, linear structures, renewable energy, conservation, and mining.

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1. INTRODUCTION

Confluent Environmental Pty (Ltd) were appointed by Cape EAPrac to provide aquatic specialist inputs to the proposed upgrade of the bulk water supply pipeline along the R102 road in George (Figure 1). For most of the route, the pipeline is existing and crosses or is proximal to mapped and unmapped watercourses.

The proposed layout of the pipeline is along the northern side of the R102 (Figure 1). The proposed pipeline crosses four watercourses indicated as A, B, C, D in Figure 1. These are arranged from East to West in accordance with engineering plans which refer to figures in the same direction. Crossings include the Gwaing River (A), wetland areas (B,C) and the toe of a small dam (D).

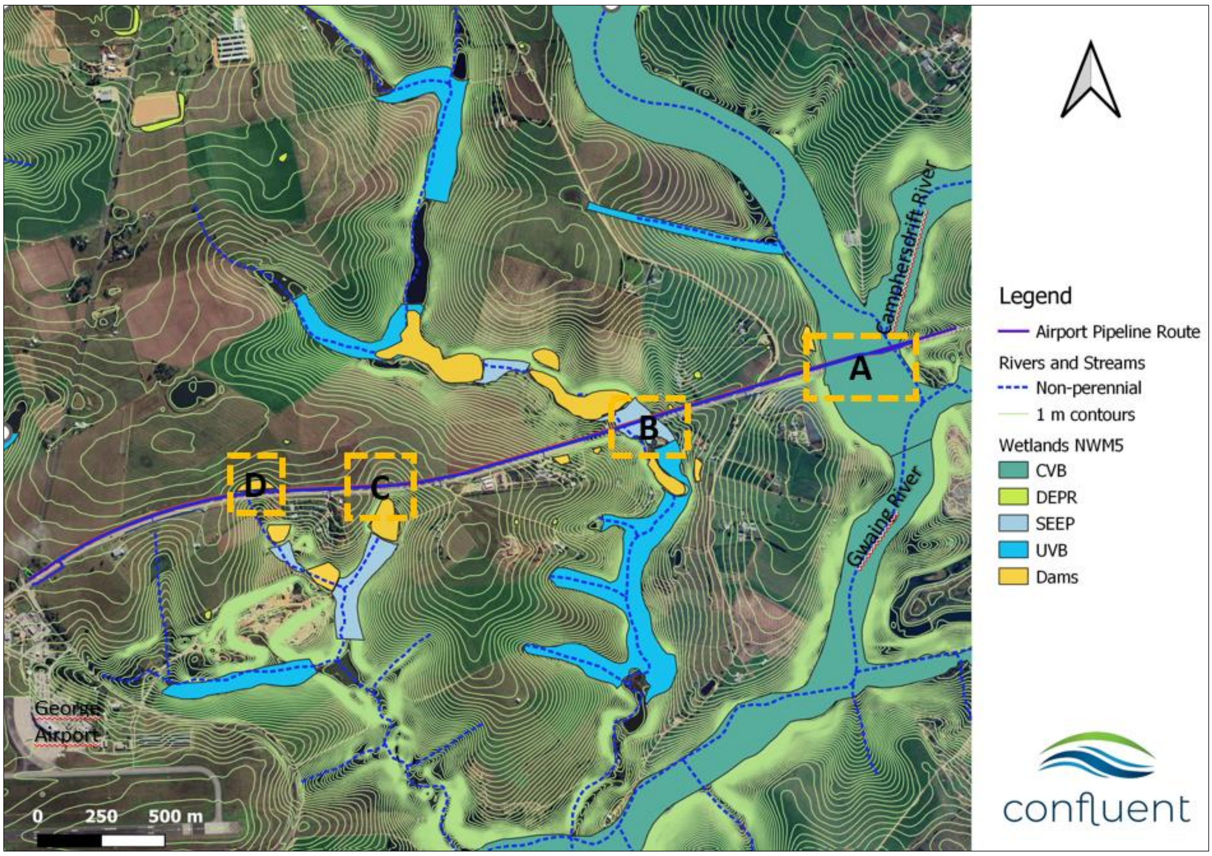


Figure 1. Proposed pipeline route for upgrade along the R102 road showing mapped watercourses, dams and 5 m contours.

1.1 Project Description

As part of their infrastructure development and management mandate, George Municipality needs to replace the existing bulk water supply pipeline from the existing water main on the eastern side of the Gwaing River Bridge along the R102 road to the George Airport. Following is a brief description of key layout and design features:

- 3 Alternative pipeline routes and a Preferred route were provided for assessment. The preferred route was selected after consultation with the development team including inputs from the aquatic specialist.

- The existing pipeline is 200 mm diameter and runs along the road reserve. It is proposed that 3.73 km of this pipeline will be replaced.
- Space within the road reserve is limited over the entire length of the pipeline due to the presence of other linear infrastructure including pipelines, fibre and electrical cables. While it is possible to utilise the road reserve in some areas, the pipeline will cross over from the road reserve approximately into private property north of the road in some places.
- For most of the route, the existing pipeline will not be removed and will remain in position, becoming redundant when the new pipeline is commissioned.
- Horizontal Directional Drilling (HDD) will be used in certain areas where conventional open trenching causing unnecessary disturbance (crossings under the road) or excessive environmental disturbance such as at wetland crossings. This is the case with all Alternative routes as well as the Preferred option.
- Where conventional trenching methods using an excavator will take place, the footprint of disturbance is anticipated as 5 m along both sides of the pipeline. This is defined as the 10 m working area.
- The new pipeline will run along the northern side of the R102, only crossing the road at the start of the route and at the end where it joins to the airport near the road crossing with the R404 (Montagu Street).
- The new pipeline diameter varies from 400 mm steel pipe at the crossing of the Gwaing River at 0 m (Crossing A), decreasing to 355 mm at 650 m, 250 mm at 2 820m.
- The existing pipeline will need to provide continued water supply to the airport precinct and will therefore not be decommissioned until the new pipeline is fully operational. The existing pipeline will not be removed from its current position.

1.2 DFFE Screening Tool Results

According to the Department of Environment, Forestry and Fisheries (DFFE) screening tool, aquatic biodiversity at the site has a **Very High** sensitivity (Figure 2). The sensitivity features identified are three different wetland hydrogeomorphic units listed as a depression, seep and valley bottom wetland in the Eastern Fynbos-Renosterveld Region. As can be seen in Figure 2, these features are all associated with the Gwaing River. No other features are highlighted by the screening tool and the remainder of the route is indicated as low sensitivity.

The scope of work for this report is guided by the legislative requirements of the National Environmental Management Act (NEMA) and the National Water Act (NWA; Act No 36 of 1998).

Figure 2. Results of the DFFE Screening Tool which indicate Very High Sensitivity of the Aquatic Biodiversity theme.

1.3 Scope of work

According to the protocols specified in GN 320 (Protocol for the specialist assessment and minimum report content requirements for environmental impacts on aquatic biodiversity) of the National Environmental Management Act (NEMA; Act No. 107 of 1998), assessment and reporting requirements for aquatic biodiversity are associated with a level of environmental sensitivity identified by the national web-based environmental screening tool (screening tool). An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of:

- **Very High** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Specialist Assessment; or
- **Low** sensitivity for aquatic biodiversity, must submit an Aquatic Biodiversity Compliance Statement.

The objectives of this assessment included the following:

- To undertake a desktop analysis and site inspection to verify the sensitivity of aquatic biodiversity as **Very High** or **Low**; and
- Compile an Aquatic Biodiversity Compliance Statement or Aquatic Biodiversity Specialist Assessment based on the site verification of the sensitivity of the site. This includes assessment of the following:

  Interrogation of available desktop resources including:
  - DWS spatial layers (1:50 000 rivers)
  - National Freshwater Ecosystem Priority Areas (NFEPA) spatial layers (Nel *et al.,* 2011)
  - National Wetland Map 5 and Confidence Map (CSIR, 2018)
  - Western Cape Biodiversity Spatial Plan (WCBSP, 2017).

Conduct a site visit to determine the site sensitivity:

- Identification and classification of watercourses within and adjacent to the site according to methods detailed by Ollis *et al*. (2013);
- Determine the watercourse Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) using an appropriate method (if watercourses are present).
- Delineate wetland / riparian areas following methods prescribed by DWAF (2015).
- Determine an appropriate buffer for wetland areas using the site-specific buffer tool developed by Macfarlane and Bredin (2016).

This report will also need to comply with GN4167 (December 2023) of the National Water Act (NWA; Act 36 of 1998) if the proposed development will take place in the area defined as the Regulated Area. In the case of non-perennial rivers or wetlands, any crossings require completion of a Risk Matrix which must be compiled by a SACNASP-registered aquatic scientist to determine the level of risk posed to the watercourse assuming full implementation of all mitigation measures. If the risk is 'Low' then the development can be Generally Authorised, but if the risk is 'Medium' or 'High' then a Water Use License Application will be required.

1.4 Assumptions and Exclusions

This assessment considers the sensitivity and possible impacts to aquatic ecosystems that could be anticipated from the proposed pipeline route and specifications. Should the layout or specifications deviate substantially from the project description this assessment would need to be updated.

Two site visits were undertaken; the first on 16 May 2023 which is considered early Winter, and the second on 25 March 2024 which is considered Autumn. While these seasons are not the ideal time during which to detect sensitive vegetation or biota, the timing is considered adequate for the proposed land use which is a linear development, with a mostly pre-existing footprint of disturbance as the pipeline is adjacent to the R102 road.

2. CATCHMENT CONTEXT

2.1 Catchment Features

The development site is in quaternary catchment K30B in the catchment of the Gwaing River. Watercourses along the pipeline all form tributaries of the Gwaing River. Rainfall is relatively high by South African standards with a Mean Annual Precipitation of 787 mm which can fall with a Very High intensity. Coupled with the Very High erodibility of soils in the area, erosion of soils and stormwater management are factors which must always be carefully considered when planning any development involving earth-moving in this area (Table 1 & Figure 3).

Table 1. Summary of relevant catchment features for the proposed development area.

Feature	Description
Quaternary catchment	K30B
Mean Annual Runoff	300 mm
Mean Annual Precipitation	787 mm
Inherent erosion potential of soils (K-factor)	0.74, Very High
Rainfall intensity	Very High
Ecoregion Level II	20.02, Southeastern coastal belt
NFEPA area	Sub-quaternary reach 9151, no classification.
Mapped Vegetation Type	FFg5: Garden Route Granite Fynbos (Critically Endangered)
Conservation	Ecological Support Area, Critical Biodiversity Area (Terrestrial & Aquatic) WCBSP (2017)

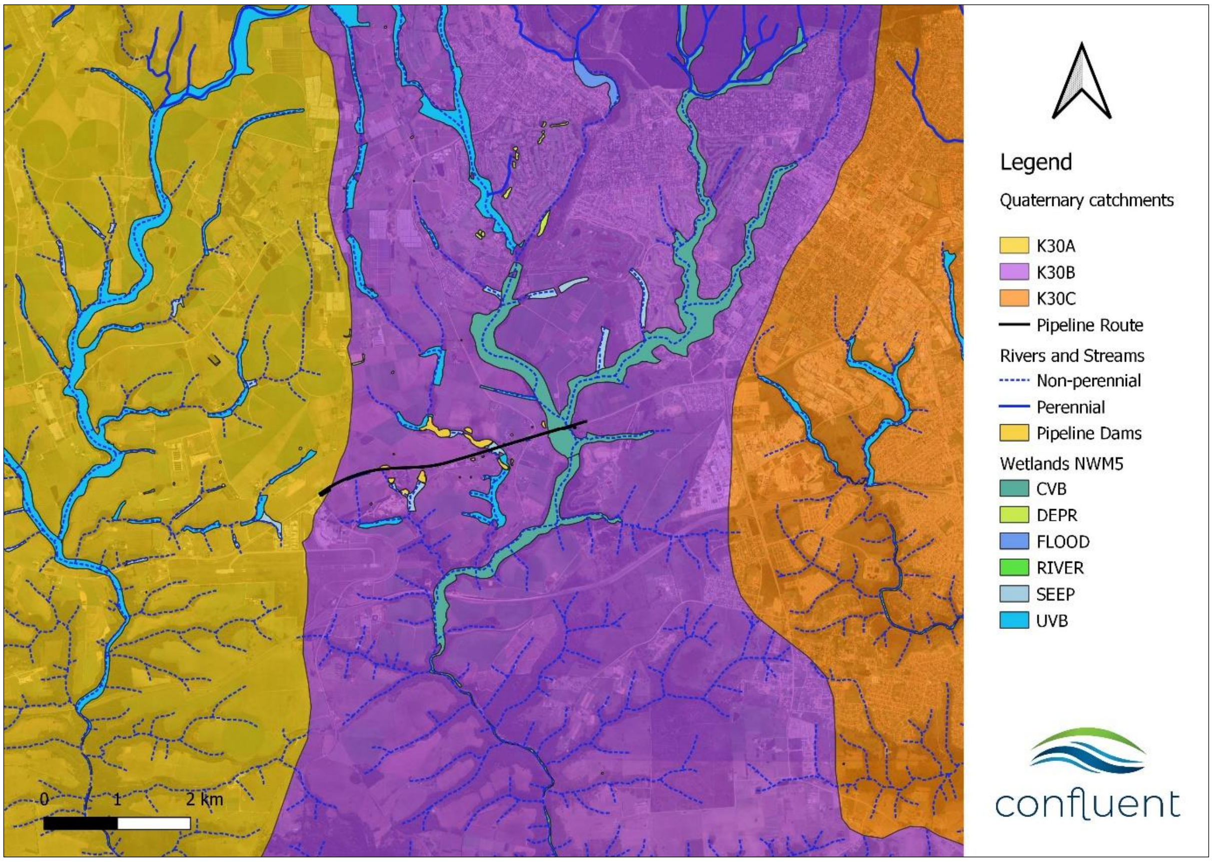


Figure 3. Location of the section of pipeline to be upgraded along the R102 in quaternary catchment K30B.

Rainfall occurs year-round with seasonal peaks in spring and autumn (Figure 4).

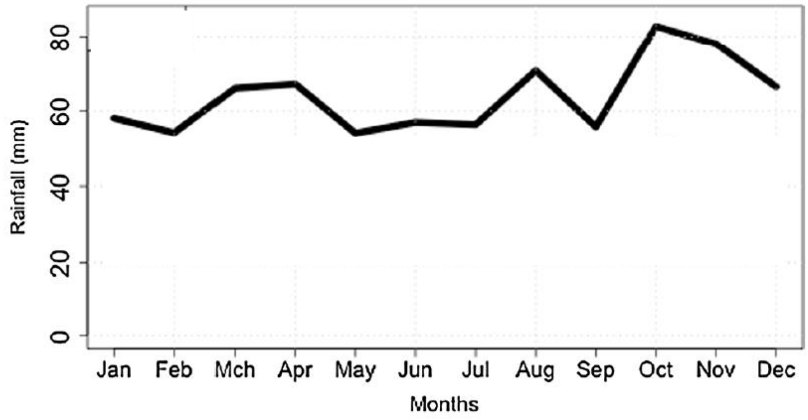


Figure 4. Area-averaged monthly rainfall for the coastal Southern Cape indicating peaks in Mar-Apr, Aug, and Oct. Data averaged between 1979 and 2011 (Engelbrecht *et al*., 2015).

The pipeline is located within the southeastern coastal belt (Ecoregion Level 2:20.02). The terrain is described as closed hills of moderate and high relief and moderately undulating plains. Altitude ranges between 0 – 1 300 m.a.m.s.l. The pipeline is around 167 m.a.m.s.l. at the Gwaing River crossing, and around 196 m.a.m.s.l. near the airport. Topography is undulating and mostly quite flat along the pipeline route (Figure 1).

2.2 Vegetation

The mapped vegetation type along most of the pipeline is mapped as Garden Route Granite Fynbos (FFg5; Critically Endangered; NVM, 2018). Vegetation associated with the Gwaing and Camphersdrift Rivers is Cape Lowland Alluvial Vegetation (Aza2; Critically Endangered). A detailed botanical specialist assessment is available for the pipeline route (Confluent Environmental, Botanical Specialist Assessment 2023).

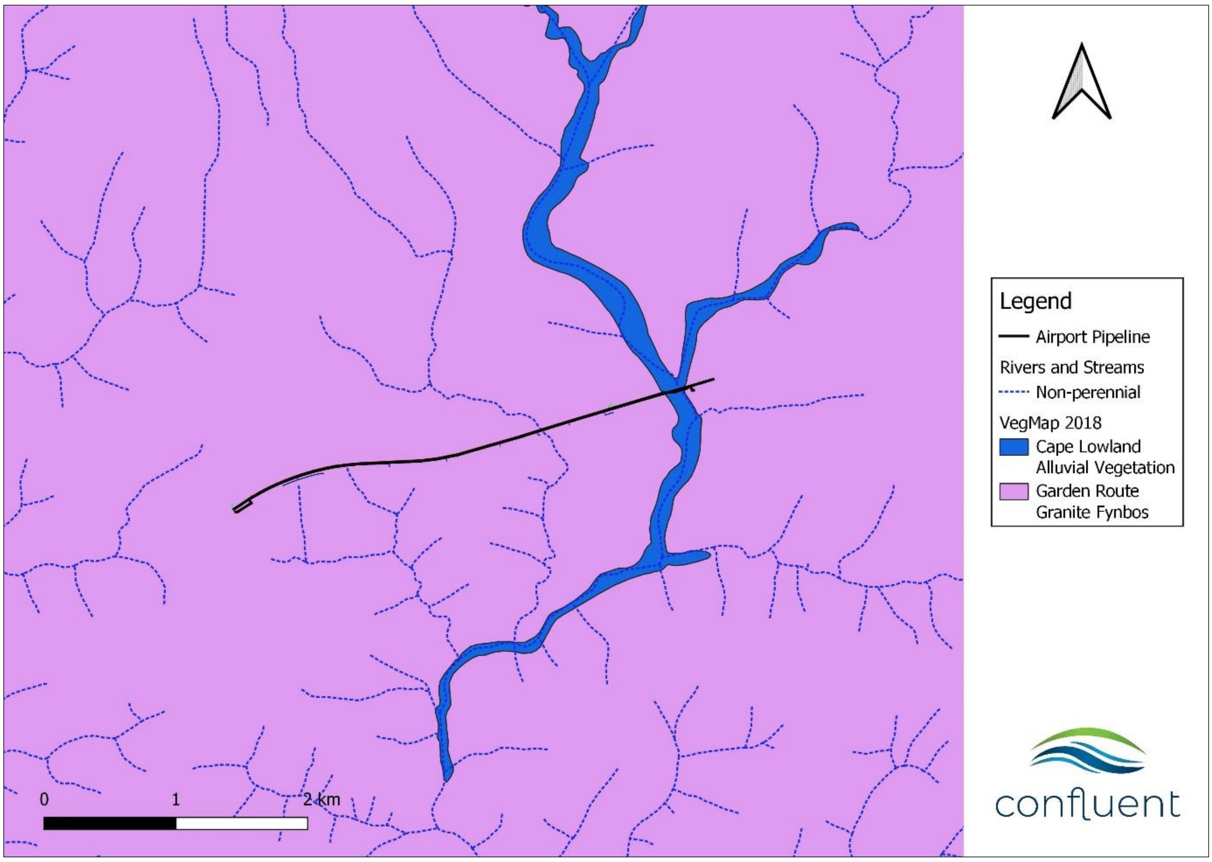


Figure 5. Mapped vegetation types along the pipeline upgrade.

2.3 Conservation and catchment management

2.3.1 WCBSP

The Western Cape Biodiversity Spatial Plan (WCBSP; 2017) excludes the majority of the pipeline route in their prioritised biodiversity planning areas (Figure 6). The areas that are included are all associated with mapped watercourses including the Gwaing River which is identified as a Critical Biodiversity Area 1 (CBA1) and the wetland area further west which is identified as an Ecological Support Area 2 (ESA2; Crossing area 2).

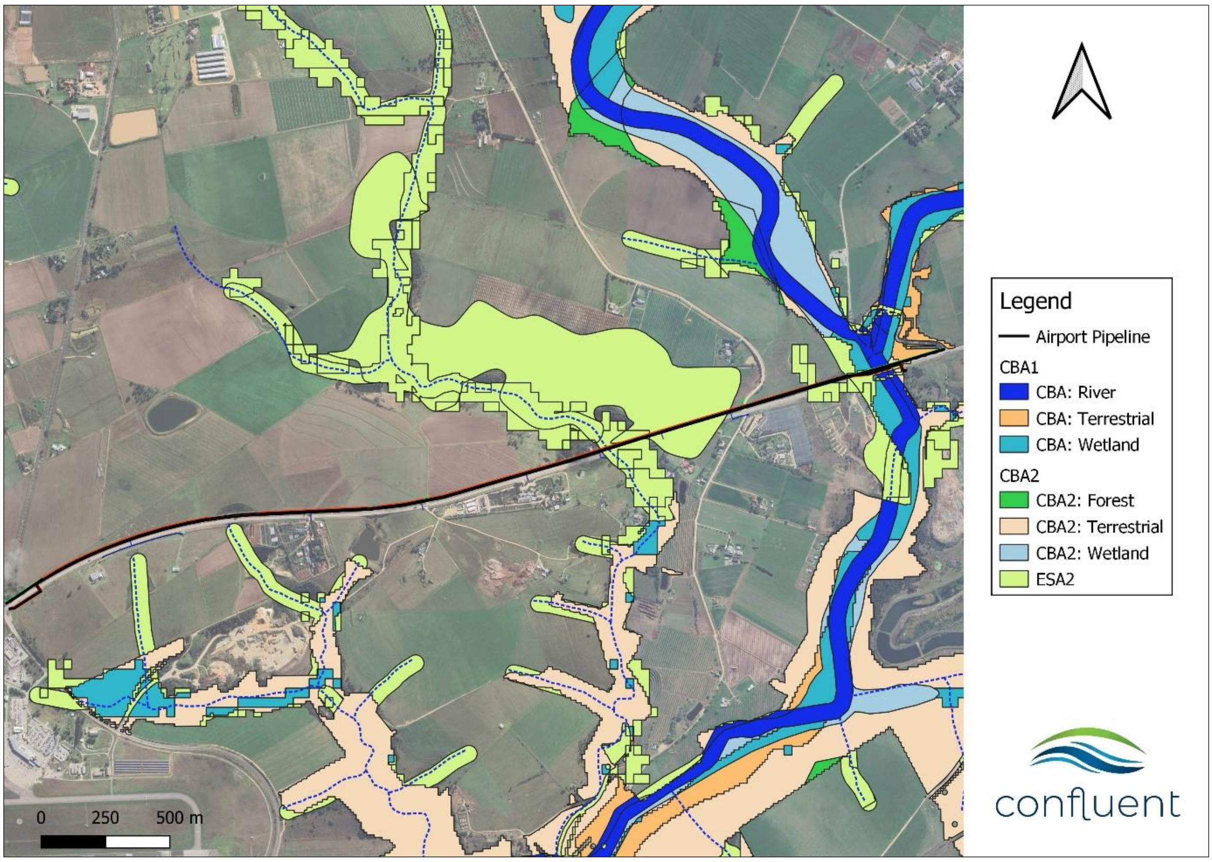


Figure 6. Proposed pipeline upgrade in relation to biodiversity planning areas (Western Cape Biodiversity Spatial Plan, 2017).

Necessary actions in relation to the WCBSP are to ensure that the pipeline upgrade does not negatively impact sites with a high biodiversity classification. The definition and management objectives for each of the mapped categories is explained in Table 2.

Table 2. Definitions and objectives for conservation categories identified in the Western Cape Biodiversity Spatial Plan (WCBSP, 2017).

WCBSP Category	Definition	Management Objective
Critical Biodiversity Area 1 (CBA1)	Areas in a natural condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure.	Maintain in a natural or near-natural state, with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.
Ecological Support Area 2 (ESA2)	Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of PAs or CBAs, and are often vital for delivering ecosystem services.	Restore and/or manage to minimize impact on ecological processes and ecological infrastructure functioning, especially soil and water-related services, and to allow for faunal movement.

2.3.2 NFEPA

According to the National Freshwater Ecosystem Priority Atlas (NFEPA; Nel *et al*., 2011) the sub-quaternary reach (SQR 9151) is not classified at any level. The pipeline crossing over the Gwaing River is immediately downstream of SQR 9115 associated with the Camphersdrift River system which is classified as a Fish Support Area. However, as the pipeline crossing is downstream of this feature and will be attached to the bridge itself, there is little conceivable way in which the pipeline upgrade can have any impact on this feature.

2.3.3 Strategic Water Source Area

Aquatic biodiversity within the site has been identified as Very High. One of the reasons is that the site falls within the Outeniqua Strategic Water Source Area for surface water (SWSA-sw). SWSAs are defined as areas of land that supply a disproportionate (ie. Relatively large) quantity of mean annual runoff in relation to their size and are therefore considered nationally relevant (Le Maitre *et al*., 2018). A key objective in the management of SWSAs is to ensure the quantity and quality of water within and flowing from SWSAs is protected from developments that cause unacceptable and irreparable impacts. The installation and operation of the pipeline is not expected to impact the on either the quality of quantity of water flowing from the SWSA.

2.4 Mapped Watercourses

Mapped watercourses include non-perennial drainage lines and wetlands according to the National Wetland Map (5) and the NFEPA atlas. A number of small dams are proximal to the pipeline and have therefore been included (Figure 1).

2.5 Historical assessment

The earliest imagery available for the project area is from December of 1936 (Figure 7). At this time the R102 road was not yet constructed, however three years later in the December 1939 image the road is visible in the landscape. The R102 Road has therefore been existence in this area for over 80 years. Even in the earliest image before the construction of the road, it is evident that the site was already largely transformed for agricultural purposes, with little to no natural vegetation visible in the landscape. In the 1930s, all the vegetation around the rivers and streams of the road was also transformed for agricultural purposes. Over time, agriculture and general disturbance around the road seems to have intensified (with more recent appearances of the quarry near the airport and the George landfill and wastewater treatment works). No transformed vegetation was seen to recover to a more natural state, except in localised sections around drainage lines and the Gwaing River, but even here the little vegetation that grew back was likely mostly invasive species. This was likely the case since vegetation along these drainage lines today is highly invaded, mainly by black wattle (*Acacia mearnsii*) and bugweed (*Solanum mauritianum*).

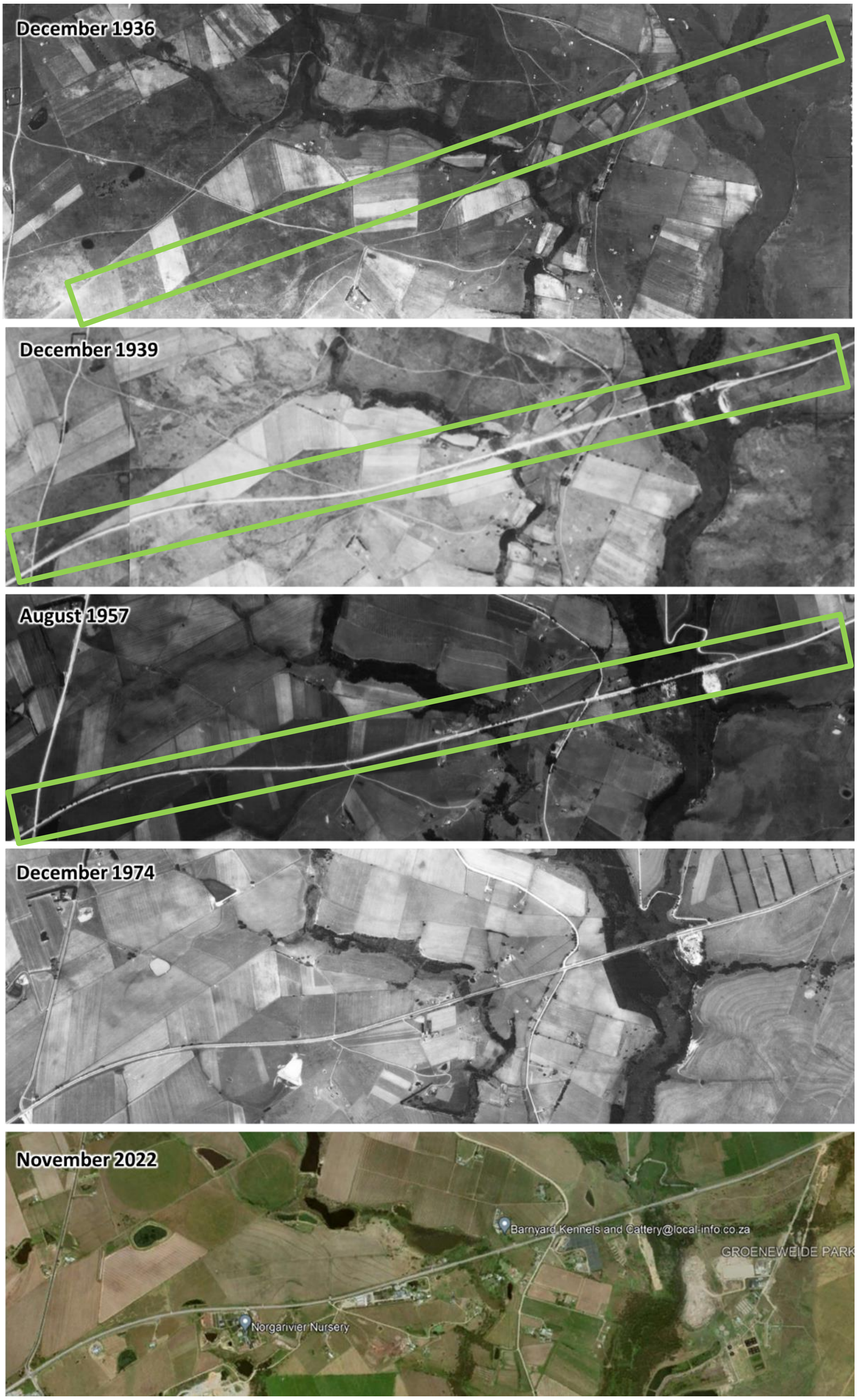


Figure 7. Historical photos showing the pipeline route along the R102 between 1936 and 2022 (CD:NGI & Google Earth imagery).

3. SITE ASSESSMENT

3.1 Site Visit

The site was visited on 16 May 2023 and again on 25 March 2024. Weather was clear and no rain had fallen within the preceding 48 hrs for both site visits. The full length of the pipeline section to be upgraded was walked and driven. Every mapped or suspected watercourse was fully inspected to verify and classify watercourses as defined by the National Water Act (Act No. 36 of 1998) within the pipeline route. The remainder of this assessment will focus on potentially affected watercourses only.

3.2 Watercourse Crossing Points

The site visit confirmed the presence of four watercourses that are crossed by the pipeline upgrade (Figure 1). As the existing pipeline and other pipelines are already existing at some of the crossings, these watercourses have already been impacted not only by initial disturbance for construction of existing pipelines and periodic ongoing maintenance, but by the presence of the road itself. A summary of relevant features is provided for each crossing point in Table 3 and a description of each layout option is provided here.

CROSSING A

All options provided across the Gwaing River at this point attached to the bridge along with other existing pipelines as pictured. West of the bridge, the Preferred (green) option is routed closer to the road than Route 3. The latter will result in the disturbance of a greater footprint of wetland vegetation than the Preferred option, and for this reason the Preferred option is the better choice at this crossing point.

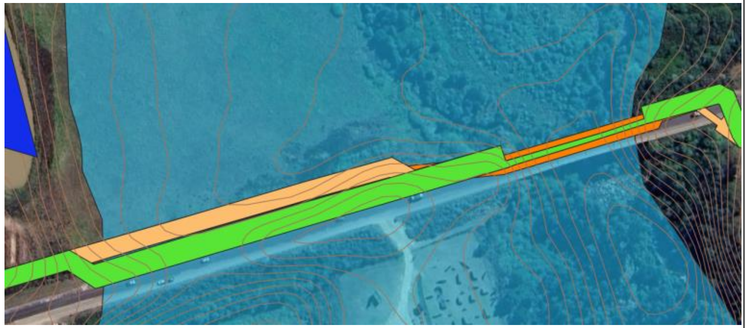
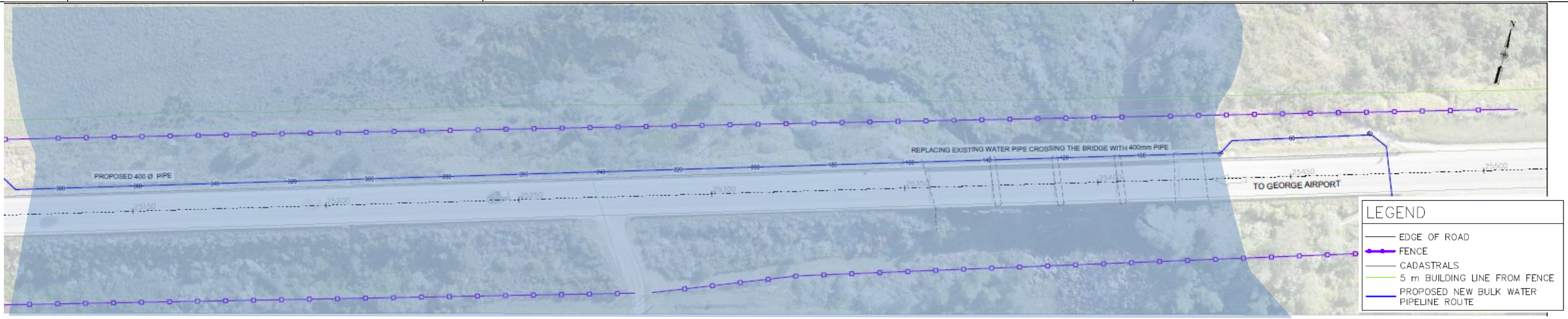
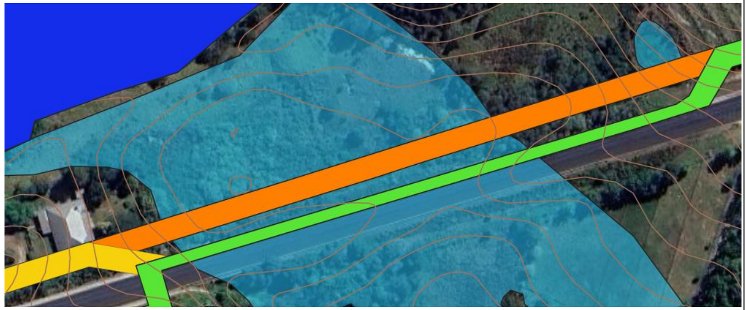
CROSSING B

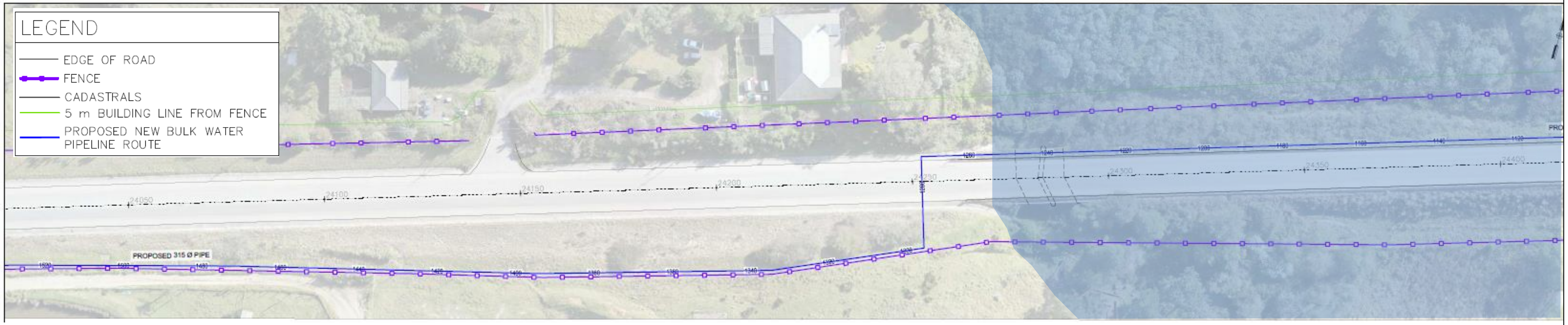
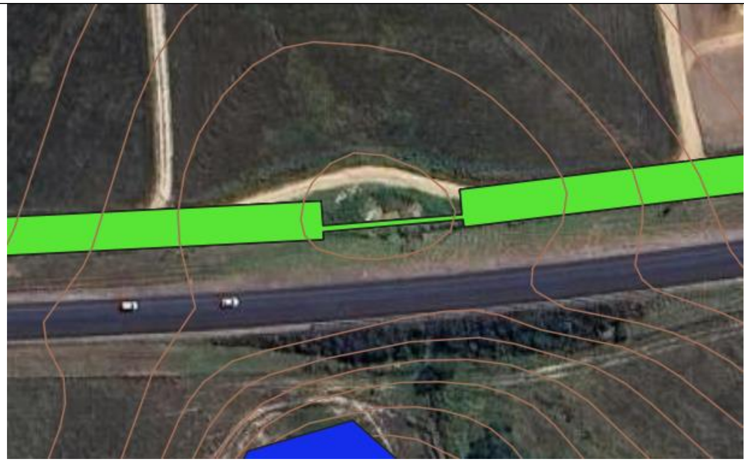
The Preferred Option is to mount the pipeline (preferably in steel at this point) along the top of the culvert which minimises the impact to this wetland and ties into the existing infrastructure and disturbance footprint. The Alternative Route 1 would install the pipeline through the bed of the wetland using conventional trenching. This would create additional disturbance and is therefore not the preferred option here.

CROSSING C & D

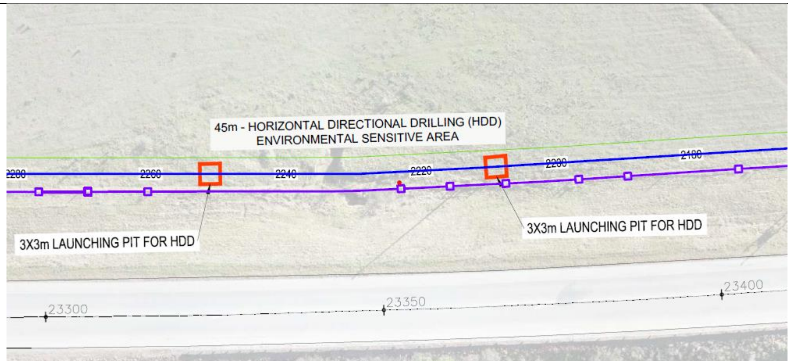
All layout/route options cross these two points in the same way, using Horizontal Directional Drilling across the sensitive feature.

Table 3. Summary of watercourses crossed by the pipeline to be upgraded. Green = Preferred route; Pink = Route 3; Orange = Route 1. Route 2 does not appear on the layout because it is overlapped at each watercourse crossing by another route option. Thin line options in Crossings C and D are areas of Horizontal Directional Drilling which are consistent across all route options. Width of the pipeline route shown is inclusive of disturbance footprint.

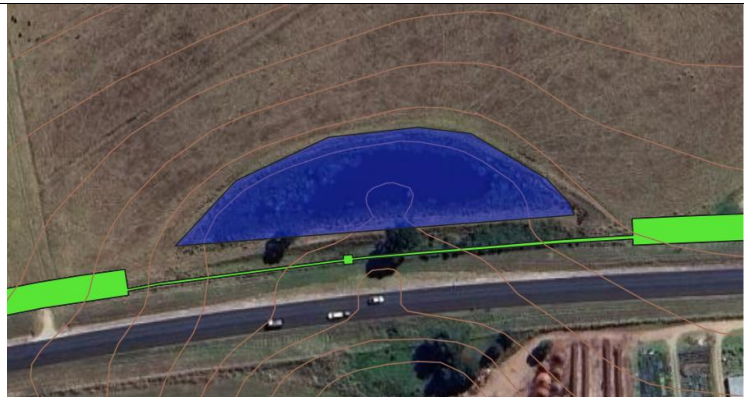
Label	Photo	Aerial layout	Notes
A			**Gwaing River** Channelled Valley Bottom Wetland and associated enhanced wetland due to stormwater runoff to the west. Existing pipeline route above river on bridge and above wetland along road embankment.
			
B			**Norga River** Channelled Valley Bottom Wetland dammed upstream of the road. Major interception of flow by dam. Channelled spillway from dam leads to culvert under road. The preferred option crossing would be mounting the pipeline on top of the existing culvert (see arrow).

<table>
<tr><td colspan="4">
</td></tr>
<tr><td>C</td><td></td><td></td><td>Possible Wetland
Historic temporary seep significantly disturbed due to intensive grazing road construction and subsequent erosion and slumping of soil.
Pipeline installed using Horizontal Directional Drilling at this point. This represents a precautionary approach.</td></tr>
<tr><td colspan="4"></td></tr>
</table>

LEGEND
- EDGE OF ROAD
- FENCE
- CADASTRALS
- 5 m BUILDING LINE FROM FENCE
- PROPOSED NEW BULK WATER PIPELINE ROUTE

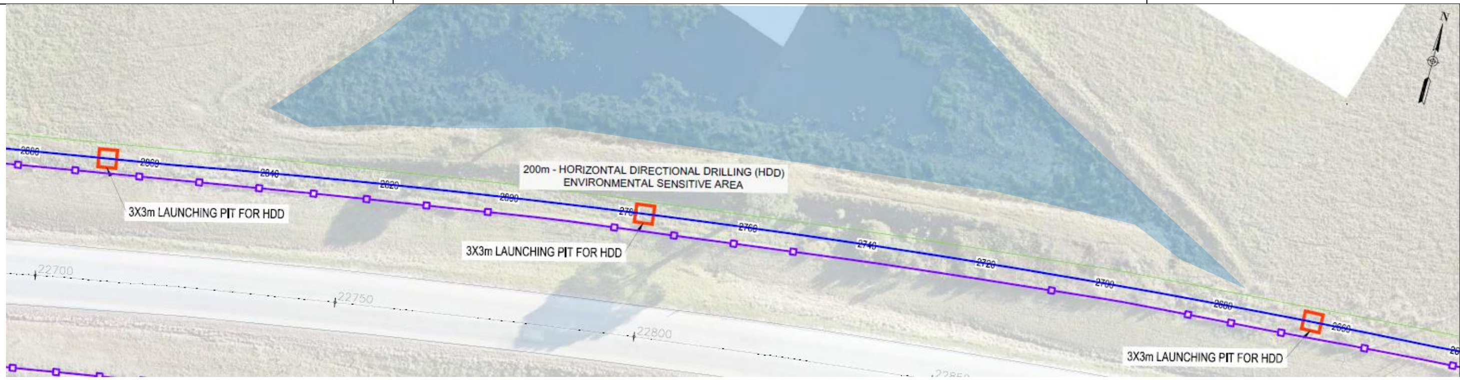


D



Dam

Probably old seep which was excavated for a dam. New pipeline route through highly disturbed vegetation impacted by existing road, dam embankment and alien vegetation.
Pipeline installed using Horizontal Directional Drilling at this point.



3.3 Eco-classification

3.3.1 Gwaing River: Crossing A

The Breede-Olifants Catchment Management Agency (BOCMA) completed an assessment of major rivers in the Water Management Area (DWS, 2018) for the purpose of determining Resource Quality Objectives.

The Gwaing River was assessed, and the Present Ecological State (PES) was classified as **E, Seriously Modified**. The Target Ecological Category (TEC) is to maintain the PES at this level. The Gwaing River at the bridge crossing has an extensive area of wetland outside of the main channel which has a high abundance of indigenous wetland vegetation, although this is interspersed with alien vegetation to varying degrees of severity. The localised ecological condition of the river at the point of the road / pipeline crossing is a better category than the greater river system, particularly because the wetland area adjacent to the channel is intact with a high abundance of indigenous vegetation (Figure 8). The pipeline traverses a significant area of wetland west of the Gwaing River which is significantly enhanced by stormwater runoff from the road. The Gwaing River at this point is classified as a <u>channelled valley-bottom wetland</u> (Ollis *et al*., 2013).

Figure 8. The Gwaing River crossing area A.

3.3.2 Norga River: Crossing B

This wetland is classified as a **valley-bottom wetland**, although it is not certain whether it was channelled or unchanneled in its reference state, although it is now channelled. The wetland at this point is already crossed by the road and several other pipelines which are suspended on concrete supports parallel to the road (Figure 9). The wetland is highly modified by the presence of an upstream dam (one of several in the catchment), the embankment of which is no more than 40 m from the road. The dam's spillway has been excavated into the wetland to guide overflowing water to the culvert beneath the road. Vegetation in the footprint of the crossing is a mixture of indigenous and numerous alien invasive species, with the latter including Poplar trees (*Populus* sp.), Pampas grass (*Cortaderia selloana*), Bugweed (*Solanum mauritianum*), Brambles (*Rubus* sp.) and Castor Bean (*Ricinus communis*). Downstream of the road, the wetland is in a more natural condition, but has been infilled to an extent for the construction of private cottages.

Figure 9. Wetland at crossing point B showing typical vegetation (top) and the existing pipelines opposite the culvert beneath the road (below).

3.3.3 Wetland Crossing C

This wetland area is very minor in extent, measuring approximately 400 square meters. It is largely disconnected from the downstream wetland area by the road, although a culvert does provide for the movement of surface flow which is expected to be very minimal given the mostly flat topography and small catchment area. No wetland vegetation is present, as it has been converted to pasture for grazing. The wettest area is actively eroding and would benefit from exclusion of cattle grazing and trampling. The wetland is classified as a **seep** at the start of a wetland system downstream which has a seasonal hydrological regime which was indicated by soil auger samples (Figure 10).

Figure 10. Photos from crossing point C which is classified as a seep wetland.

3.3.4 Watercourse Crossing D

The last watercourse crossed by the pipeline before it reaches the airport precinct is a small dam. The dam was likely a **headwater seep** before being excavated and dammed. The volume of water stored is minor, and it is likely that it was / is used for livestock watering. Extensive wetland vegetation has established around the dam, and it has developed significant ecological structure and function. The proposed pipeline is planned for installation along the toe of the dam parallel to the road using horizontal directional drilling to minimise any structural or ecological risk to the dam.

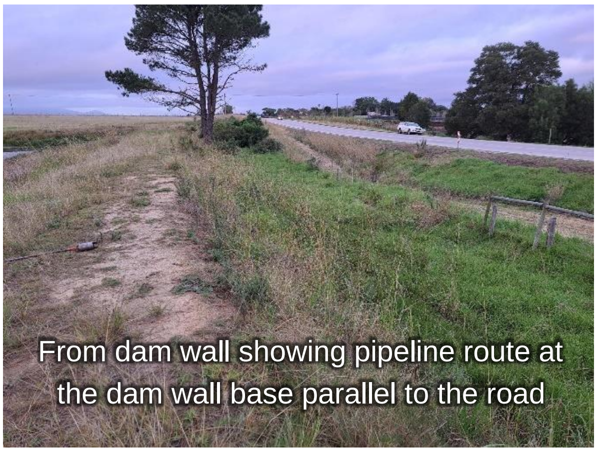


Figure 11. Crossing point D showing the dam (left) and dam embankment with road parallel.

The Present Ecological State of wetlands at crossing points B, C and D were determined using the revised WET-Health Level 1B assessment developed by Macfarlane et al. (2020). Methods are provided in Appendix 1 and the results are provided in Table 4.

Table 4. Summary of Present Ecological State categories assessed at each wetland crossing.

Watercourse	Hydrology	Geomorphology	Water Quality	Vegetation	Combined PES
Crossing B: Norga River	E	E	C	D	**D**
Crossing C: Seep	C	C	C	D	**C**
Crossing D: Seep	D	D	C	D	**D**

4. LEGISLATION IMPLICATIONS

4.1 National Environmental Management Act

According to the Department of Environment, Forestry and Fisheries (DFFE) screening tool, aquatic biodiversity at the site has a **Very High** sensitivity (Figure 2), and this was confirmed during the desktop and site assessment. The Very High sensitivity is due to the presence of 4 watercourse crossings along the pipeline route. According to the protocols specified in GN 320 (Protocol for the specialist assessment and minimum report content requirements for environmental impacts on aquatic biodiversity) of the National Environmental Management

Act (NEMA; Act No. 107 of 1998) this means that an Impact Assessment report must be complied.

4.2 National Water Act

According to GN4167 of December 2023 in terms of the National Water Act the proposed pipeline upgrade constitutes Section 21 c) and i) water uses. The pipeline is physically crossing the four watercourses which means that a Risk Matrix must be compiled to determine whether a General Authorisation (GA for Low Risk) or Water Use License (WUL for High Risk) must be undertaken. The Risk Matrix focusses on the Preferred Route given that this was determined as the preferred route for crossing of watercourses.

5. IMPACT ASSESSMENT

Methods for the impact assessment are provided in Appendix 2. Several meetings were held between the engineering (SMEC) and environmental team (Cape EAPrac and Confluent) to discuss potentially sensitive areas of the pipeline route and how these could best be navigated to avoid and minimise impacts. Therefore, following the mitigation hierarchy. The resulting Preferred Pipeline layout was selected, and alternative methods of installation such as the horizontal directional drilling at Crossings C and D address the design and layout phase of the impact assessment process. The remaining aspects of the assessment therefore focus on the No-Go development option, and the construction and operational phase of the proposed pipeline.

5.1 No-Go Development Option

The No-Go Development Option would result in no pipeline upgrade and would therefore limit development in the airport precinct and surrounding areas due to limited potable water supply. As the proposed pipeline upgrade aims to increase the capacity of an existing pipeline which travels along existing linear infrastructure (the road), the No-Go Development is not considered practical given the requirement for growth in George. The airport precinct as a development node also represents an important strategic area for growth.

5.2 Construction Phase

5.2.1 Impact: Comparison of Construction Phase Impacts Between Layout Options

The main difference for consideration in the different layout options is at Crossing A and B because the proposed layouts for Crossings C and D are all the same (HDD). Layout alternatives refer to Table 3.

At Crossing A, the Preferred route had a predicted negligible negative impact during the construction phase, while Route 3 which is located further away from the road had a slightly higher negative impact rated as a minor negative (Table 5).

Table 5. Comparative impact assessment for the Preferred compared to Route 3 during the construction phase at Crossing A.

CROSSING A		
	Preferred Route	**Route 3 (pink)**
Duration	Short-term	Short-term
Extent	Limited	Limited
Intensity	Low	Moderate
Probability	Probable	Almost Certain
Significance	**Negligible - negative**	**Minor - negative**
Confidence	High	High
Reversibility	High	High
Resource Irreplaceability	Low	Low

A comparison between the Preferred and Route 1 layouts for the combined construction phase impacts expected at Crossing B is shown in Table 6. The preferred option which is attached to the top of the existing culvert has a Negligible Negative impact, which confirms this as the preferred alternative to Route 1 which would require trenching through the wetland, with an associated Minor Negative Impact.

Table 6. Comparative impact assessment for the Preferred compared to Route 1 during the construction phase at Crossing B.

CROSSING B		
	Preferred Route	**Route 1 (orange)**
Duration	Brief	Ongoing
Extent	Very Limited	Limited
Intensity	Negligible	Moderate
Probability	Rare / Improbable	Almost certain / Highly probable
Significance	**Negligible - Negative**	**Minor – Negative**
Confidence	High	High
Reversibility	High	High
Resource Irreplaceability	Low	Low

5.2.2 Impact: Excessive disturbance to wetlands during construction

This impact is applicable to all proposed layouts (including the preferred layout) because excessive disturbance of habitat is possible regardless of the layout. Prior to commencement of construction at each watercourse crossing, the site must be well planned, laid out and managed to avoid unnecessary disturbance to wetland soils and vegetation. This impact is assessed in Table 5 and should be a negligible negative impact if mitigation measures are followed.

Table 7. Construction Phase: Excessive disturbance to wetlands during construction.

Project phase	**Construction**			
Impact	**Excessive disturbance to soil and plants in wetlands**			
Description of impact	**Active vehicles, workers and stored materials in wetland habitat causing unnecessary disturbance**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Prior to construction, the minimum footprint of disturbance must be delineated and should include vehicle access points, material stockpile areas, refuelling areas and actual work areas. The No-Go aera must be delineated 5 m either side of the pipeline route. The delineated No-Go area must be indicated using construction mesh attached to wooden droppers or similar materials. Alternatively, danger tape or wooden stakes could be used if the previously mentioned materials could be stolen, but is less effective. • As far as possible the watercourse should be accessed from a single point only to reduce disturbance to features such as slopes and vegetation. At all crossings attempts should be made to limit access to the side of the watercourse only. • Signage indicating No-Go areas must be printed and placed on fencing. • All contractors must be briefed that vehicles, workers and materials may not encroach into No-Go areas in and around watercourses. • As far as possible, try to keep vehicles out of the watercours, working from the banks from the inside towards the outside to minimise disturbance. Excavators/Backacters should operate from the maximum distance possible to reduce soil compaction and disturbance to vegetation.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	Impact will last between 1 and 5 years	Short term	Impact will last between 1 and 5 years
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Certain / definite	There are sound scientific reasons to expect that the impact will definitely	Likely	The impact may occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	High	The affected environment will be able to recover from the impact	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	This impact can be mitigated to a degree following the recommended mitigation measures, but work will still need to be undertaken resulting in disturbance to wetland habitat.			
Cumulative impacts	If poorly managed, the cumulative impact could be fairly significant given the number of affected watercourses along the route. However, this impact is relatively easy to mitigate.			

5.2.3 Impact: Materials and vehicle management

Again, this impact is applicable to all proposed layouts (including the preferred layout) because inappropriate or careless management of materials and vehicles in aquatic habitat has a degrading effect. The management of materials and vehicles in proximity to wetland habitat must follow the recommended mitigation measures in Table 8 to maintain this impact at a negligible negative level.

Table 8. Construction Phase: Materials and vehicle management.

Project phase	**Construction**			
Impact	**Materials and vehicle management**			
Description of impact	**Pollution of wetlands**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**• All construction materials (topsoil, subsoil, building sand) must be stockpiled as far from the watercourse or slope edge as practically possible. • Materials to be removed must be taken away without delay to reduce the risk of washing into wetlands. • Retain the upper 30cm of topsoil including vegetation during grubbing. This material should be stockpiled separately to other materials, kept uncontaminated, and protected with shadecloth and bunding. • There is limited space to work along the pipeline route, and stockpiled materials must not be placed in a way that they force vehicles to move around them into sensitive wetland habitat. • Vehicle refuelling areas must be located as far from wetlands as possible, and a spill kit must be on hand in case of fuel spills. • Vehicles leaking fuel (diesel or oil) may not be permitted to work on site. • No materials may be dumped into the watercourse.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	Impact will last between 1 and 5 years	Immediate	Impact will self-remedy immediately
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	High	The affected environment will be able to recover from the impact	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Mitigation measures should be applied through the length of the pipeline installation to ensure cumulative impacts are managed.			

5.2.4 Impact: Stormwater runoff from disturbed areas.

Fortunately, watercourse crossing sites are generally quite flat areas without steep banks, which makes mitigation of this impact a bit easier. Although the high intensity rainfall events experienced in George in combination with the low soil permeability of clay soils in the area mean that runoff rates can be high even on relatively low gradient slopes. If all mitigation measures are implemented then this impact is considered a Negligible negative (Table 9).

Table 9. Construction Phase: Stormwater runoff from disturbed areas.

Project phase	**Construction**			
Impact	**Stormwater runoff from disturbed areas**			
Description of impact	**Erosion of soil from disturbed areas resulting in downstream deposition and destabilisation of banks**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Weekly and daily checks for predicted rainfall. Proactive steps to be taken in response to predicted rainfall. • Do not continue work during rainfall, and ensure the site is prepared to minimise erosion and sediment-laden runoff in advance of rainfall. • The site office / vehicle should have a store of materials suitable for rapid preparation and response to rainfall such as shade-cloth (silt-fencing & check dams), wooden droppers, sand bags, hessian fabric, and fencing wire. • All material stores should be kept on flat areas and be bunded to prevent material loss during rainfall. • Soil from the trench for installation of the pipeline should be preferably placed on the upslope side of the trench so it washes back into it in the event of rain, and not down the slope to wetland habitat. Alternatively, short lengths of trenching must be undertaken at a time when rainfall is predicted to reduce the risk of soil washing downslope. • Monitor the site during / following periods of rainfall, and install check dams at points where runoff collects using sand bags and haybales with hessian or shade cloth (90%). • Following rainfall, water pumped out of trenches or other excavations must not be directed to the watercourse. A temporary coffer dam can be created using shadecloth as a filter material to contain silt-laden water which can then flow through vegetation into the watercourse where feasible.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	Impact will last between 1 and 5 years	Brief	Impact will not last longer than 1 year
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	Risk reduction is dependent on proactive and reactive mitigation measures as contruction progresses across the site. Adaptive management to stormwater management during construction is essential.			
Cumulative impacts	Not applicable			

5.2.5 Impact: Incomplete post-construction rehabilitation

As installation of the pipeline concludes both at watercourse crossings and elsewhere along the pipeline route, the topsoil that was put aside during the construction phase must be replaced and the area revegetated to promote stabilisation of the soil. If this is not well implemented and followed up the area will be prone to erosion and invasion by alien vegetation. This impact is likely to be a Negligible negative if all mitigation measures are implemented (Table 10).

Table 10. Construction Phase: Incomplete post-construction rehabilitation.

Project phase	**Construction**			
Impact	**Post-construction rehabilitation and site closure**			
Description of impact	**Loss of topsoil and vegetation without replacement renders areas vulnerable to erosiona and invasive plants**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Ensure all soil surfaces are reshaped to avoid preferential flow paths and very steep gradients. • All areas disturbed during the construction phase must have topsoil from the site mixed with indigenous grass seed (Stenotaphrum secondatum and Cyonodon dactylon) replaced to a depth of 30 cm above subsoils. • Where sloping areas occur it will be necessary to stake a cover of soil saver matting over the grass seed / top soil mix to prevent movement downslope until vegetation can establish. • Alien vegetation must be removed 2 months and 6 months post replacement of the soil until the grass / indigenous vegetation is established. • Ensure any litter from construction works or personnel is removed from the site. No litter, food scraps, or waste materials can be left at the site.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Short term	Impact will last between 1 and 5 years
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	If this aspect is not well managed, it will contribute further to extensive alien vegetation establishment in the area, compounding this negative impact.			

5.3 Operational Phase

5.3.1 Impact: Comparison of Operational Phase Impacts Between Layout Options

The main difference for consideration in the different layout options is at Crossing A and B because the proposed layouts for Crossings C and D are all the same (HDD). Layout alternatives refer to Table 3. Impacts considered would mainly be related to the need for periodic maintenance along the pipeline which has the potential to re-disturb habitat through open trenching, particularly at Crossing A.

At Crossing A, the Preferred route had a predicted negligible negative impact during the operational phase, while Route 3 which is located further away from the road had a slightly lower negative impact rated as a minor negative (Table 5).

Table 11. Comparative impact assessment for the Preferred compared to Route 3 during the construction phase at Crossing A.

CROSSING A		
	Preferred Route	**Route 3 (pink)**
Duration	Short-term	Short-term
Extent	Limited	Limited
Intensity	Low	Moderate
Probability	Probable	Almost Certain
Significance	**Negligible - negative**	**Minor - negative**
Confidence	High	High
Reversibility	High	High
Resource Irreplaceability	Low	Low

A comparison between the Preferred and Route 1 layouts for the combined operational phase impacts expected at Crossing B is shown in Table 12. The preferred option which is attached to the top of the existing culvert has a Negligible Negative impact because maintenance would create little to no impact to the wetland, which confirms this as the preferred alternative to Route 1. The latter would require excavations in the wetland for periodic maintenance which would disturb and degrade habitat.

Table 12. Comparative impact assessment for the Preferred compared to Route 1 during the construction phase at Crossing B.

CROSSING B		
	Preferred Route	**Route 1 (orange)**
Duration	Brief	Ongoing
Extent	Very Limited	Limited
Intensity	Negligible	Moderate
Probability	Rare / Improbable	Almost certain / Highly probable
Significance	**Negligible - Negative**	**Minor – Negative**
Confidence	High	High
Reversibility	High	High
Resource Irreplaceability	Low	Low

5.3.2 Impact: Invasive alien vegetation along the pipeline footprint

Given the extent of alien vegetation in the vicinity of all watercourse crossings it is quite likely that alien vegetation will establish in disturbed areas post-construction which will increase the extent of alien invasion in watercourses. This impact can be effectively mitigated without too much difficulty following measures in Table 13.

Table 13. Operational Phase: Alien invasive vegetation establishment in disturbed areas.

Project phase	**Operation**			
Impact	**Alien vegetation establishment along disturbed areas**			
Description of impact	**Degradation of habitat, increase in extent and density of alien invasive plant species**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• The full length of the newly installed pipeline at each of the 4 watercourse crossing points must be inspected 6- and 12-months following completion of project by the site ECO. The purpose is to ensure disturbed areas are well vegetated with indigenous plants.** **• If alien plants are present it is necessary to appoint a contractor to remove them to ensure the pipeline footprint is clear of alien plants.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Short term	Impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Likely	The impact may occur	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	No applicable			

5.3.3 Impact: Repairs and maintenance of the pipeline

Fortunately, any leaks to the pipeline would discharge potable water to natural water resources which is far less damaging than wastewater. Nonetheless, repairs and maintenance must be timeously addressed and many of the construction phase mitigation measures are applicable. In the mitigated state this impact is considered a negligible negative (Table 14).

Table 14. Operational Phase: Repairs and maintenance to the pipeline.

Project phase	**Operation**			
Impact	**Repairs and maintenance to the pipeline**			
Description of impact	**Renewed wetland disturbance and potential sedimentation**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**• Where the pipeline must be accessed for repairs or maintenance, the same footprint of disturbance applies as that described in the construction phase impact. Ie. 5 m either side of the pipeline. • Any excessive sedimentation that has smothered plants in a wetland must be removed from the wetland by hand using spades, and contours must be reshaped to avoid concentrated flow paths. • Renewed areas of disturbance must be grassed as per mitigation measures in the construction phase to ensure vegetation covers soil vulnerable to erosion or invasion with alien plants. • Alien plants must be removed from the length of the pipeline in each watercourse while works are in progress.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	Impact will last between 1 and 5 years	Brief	Impact will not last longer than 1 year
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Moderate	Natural and/ or social functions and/ or processes are moderately altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

6. RISK MATRIX

The risk matrix undertakes the assessment of risks to watercourses by impacts in their mitigated state. Only the Preferred Layout was assessed in the Risk Matrix given that the application for water use authorisation is only applicable to one layout. The level of risk assigned assumes full implementation of all mitigation measures provided in the impact assessment in the previous section. Although the impacts and associated risks to watercourses were assessed collectively, these were assessed using the worst-case scenario impacts which are open trenching as opposed to horizontal directional drilling or suspension along the bridge (ie. Over the Gwaing River). In this sense, the impacts / risks presented in this and the previous section as actually lower than assessed. However, a more conservative approach was taken to the impact assessment.

The Risk Matrix determined that construction and operational phase impacts projected for the pipeline upgrade have a Low Risk for watercourses at the crossing points (Table 15).

Table 15. Risk Assessment Matrix for proposed replacement of the bulk water supply pipeline along the R102 road in George. Risks calculated for all watercourses assuming full implementation of all control (mitigation) measures.

Phase	Activity	Impact	Risk Ratings
Construction Phase	Excessive disturbance to wetlands during construction	Vehicles, workers and materials in wetland habitat	**LOW**
	Materials and vehicle management	Pollution of water and destruction of wetland habitat	**LOW**
	Stormwater runoff from disturbed areas	Erosion of soil resulting in sedimentation and habitat loss	**LOW**
	Incomplete post-construction rehabilitation	Vegetation and topsoil loss resulting in erosion and establishment of alien plants.	**LOW**
Operational Phase	Invasive alien vegetation along the pipeline footprint	Alien vegetation establishment along disturbed areas.	**LOW**
	Repairs and maintenance to the pipeline	Renewed wetland disturbance and potential sedimentation.	**LOW**

7. CONCLUSIONS

The four watercourses crossed by the proposed pipeline route are already impacted by the presence of the R102 road. The Gwaing and Norga Rivers also have pipelines and electrical / fibre cables that have been laid along them or on the bridge / culverts crossing them. In this sense, there is already a major pre-existing impact which has already undergone construction and is currently in operation.

A series of meetings have been held with the engineering and environmental team to discuss sensitive areas which are primarily the watercourse crossing points. Design and layout modifications were made to avoid and minimise impacts in these areas which include attaching the pipeline to the Gwaing River Bridge at Crossing A, attaching the pipeline to the top of the culverts at Crossing B, and using horizontal directional drilling at Crossings C and D.

Impacts assessed for both the construction and operational phase can be effectively mitigated to negligible negative ratings, and the Risk Matrix determined that the impacts were of a Low Risk to potentially affected watercourses. The Preferred Layout option was confirmed as having an overall Negligible Negative impact which was lower that alternatives assessed for Crossings A and B.

Installation and upgrade of the bulk water pipeline will ensure the sustainable delivery of water to the airport precinct of George and is necessary for the development of George. Provided the mitigation measures recommended in this report are fully implemented and monitored by an ECO and relevant regulating authorities, installation of the pipeline is fully supported and recommended.

8. APPENDICES

8.1 Present Ecological State Methods

The wetland area was assessed using the Level 1B WET-Health assessment tool developed by Macfarlane *et al*. (2020). The tool aims to assess the integrity of a wetland based on catchment land use and wetland modifications, and combines an assessment of hydrological, geomorphological, water quality and vegetation health four modules.

Data collection involved a desktop review of the extent and intensity of catchment land use impacts and was undertaken using historical and recent aerial imagery of the site (Chief Directorate: National Geo-spatial Information and satellites). Fieldwork onsite involved the identification and recording of observable impacts to the wetland at the site of relevant activities as well as at reference points upstream and downstream of the activities, and in the catchment area of the wetland. The magnitude of observed impacts to the hydrological, geomorphological and vegetation components of the wetland were calculated and combined as per the tool to provide a measure of the overall wetland condition of the wetland. Resultant scores were then used to assign the wetland into one of six PES categories as shown in Table 16.

Table 16. Wetland Present Ecological State categories and impact descriptions.

Ecological Category	Description	Impact Score
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications / in good health. A small change in natural habitats and biota may have taken place but the ecosystem functions are still predominantly unchanged.	1 – 1.9
C	Moderately modified / fair condition. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	2 – 3.9
D	Largely modified / poor condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	4 – 5.9
E	Seriously modified / very poor condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.	6 – 7.9
F	Critically modified / totally transformed. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota.	8 - 10

8.2 Ecological Importance and Sensitivity Methods

The revised method for the determination of the EIS of a wetland considers the three following ecological aspects (Rountree *et al*., 2013):

- **Ecological importance and sensitivity**
  - Biodiversity support including rare species and feeding/breeding/migration;
  - Protection status, size and rarity in the landscape context;
  - Sensitivity of the wetland to floods, droughts and water quality fluctuations.
- **Hydro-functional importance**

  - Flood attenuation;
  - Streamflow regulation;
  - Water quality enhancement through sediment trapping and nutrient assimilation;
  - Carbon storage

- **Direct human benefits**

  - Water for human use and harvestable resources;
  - Cultivated foods;
  - Cultural heritage;
  - Tourism, recreation, education and research.

Each criterion is scored between 0 and 4, and the average of each subset of scores is used to derive a score for each of the three components listed above. The highest score is used to determine the overall Importance and Sensitivity category of the wetland system (Table 17).

Table 17.Ecological importance and sensitivity categories for wetlands. Interpretation of average scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

8.3 Impact Assessment Methods

Criteria are ascribed for each predicted impact. These include the intensity (size or degree scale), which also includes the type of impact, being either a positive or negative impact; the duration (temporal scale); and the extent (spatial scale), as well as the probability (likelihood). The methodology is quantitative, whereby professional judgement is used to identify a rating for each criterion based on a seven-point scale (Table 18) and the significance is auto-generated using a spreadsheet through application of the calculations.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** *(*size or degree scale), which also includes the **nature** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is applied to the consequence.

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative.

Table 18. Assessment criteria for the evaluation of impacts

Criteria	Numeric Rating	Category	Description
Duration	1	**Immediate**	Impact will self-remedy immediately
	2	**Brief**	Impact will not last longer than 1 year
	3	**Short term**	Impact will last between 1 and 5 years
	4	**Medium term**	Impact will last between 5 and 10 years
	5	**Long term**	Impact will last between 10 and 15 years
	6	**On-going**	Impact will last between 15 and 20 years
	7	**Permanent**	Impact may be permanent, or in excess of 20 years
Extent	1	**Very limited**	Limited to specific isolated parts of the site
	2	**Limited**	Limited to the site and its immediate surroundings
	3	**Local**	Extending across the site and to nearby settlements
	4	**Municipal area**	Impacts felt at a municipal level
	5	**Regional**	Impacts felt at a regional level
	6	**National**	Impacts felt at a national level
	7	**International**	Impacts felt at an international level
Intensity	1	**Negligible**	Natural and/ or social functions and/ or processes are negligibly altered
	2	**Very low**	Natural and/ or social functions and/ or processes are slightly altered
	3	**Low**	Natural and/ or social functions and/ or processes are somewhat altered
	4	**Moderate**	Natural and/ or social functions and/ or processes are moderately altered
	5	**High**	Natural and/ or social functions and/ or processes are notably altered
	6	**Very high**	Natural and/ or social functions and/ or processes are majorly altered
	7	**Extremely high**	Natural and/ or social functions and/ or processes are severely altered
Probab ility	1	**Highly unlikely / None**	Expected never to happen
	2	**Rare / improbable**	Conceivable, but only in extreme circumstances, and/or might occur for this

Criteria	Numeric Rating	Category	Description
			project although this has rarely been known to result elsewhere
	3	**Unlikely**	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
	4	**Probable**	Has occurred here or elsewhere and could therefore occur
	5	**Likely**	The impact may occur
	6	**Almost certain / Highly probable**	It is most likely that the impact will occur
	7	**Certain / Definite**	There are sound scientific reasons to expect that the impact will definitely occur

When assessing impacts, broader considerations are also considered. These include the level of confidence in the assessment rating; the reversibility of the impact; and the irreplaceability of the resource as set out in (Table 19, Table 20, & Table 21), respectively.

Table 19. Definition of confidence ratings.

Category	Description
Low	Judgement is based on intuition
Medium	Determination is based on common sense and general knowledge
High	Substantive supportive data exists to verify the assessment

Table 20. Definition of reversibility ratings.

Category	Description
Low	The affected environment will not be able to recover from the impact - permanently modified
Medium	The affected environment will only recover from the impact with significant intervention
High	The affected environmental will be able to recover from the impact

Table 21. Definition of irreplaceability ratings.

Category	Description
Low	The resource is not damaged irreparably or is not scarce
Medium	The resource is damaged irreparably but is represented elsewhere

9. REFERENCES

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