Erosion management and realignment of the approved Thembalethu sewerline to accommodate informal human settlement.

Aquatic Specialist Assessment for Proposed Amendment to Water Use License 16/K30C/Cl/2723.

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• 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;

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted to reduce the impact of adjacent land uses on the wetland or riparian area. Buffers are land use specific and are calculated for the specific environmental context and proposed land use.
Characteristics of a watercourse	Means the resource quality of watercourse within the extent of a watercourse.
Construction	Means any works undertaken to initiate or establish activities, site preparation including vegetation removal and ground levelling that may result in impeding or diverting or modifying resource quality.
Delineation of a wetland or riparian habitat	Means delineation of wetlands and riparian habitat according to the methodology as contained in the Department of Water Affairs and Forestry, 2008 publication: A Practical Field Procedure for Delineation of Wetlands and Riparian Areas or amended version.
Diverting	Means to, in any manner, cause the instream flow of water to be rerouted temporarily or permanently.
Flow-altering	Means to, in any manner, alter the instream flow route, speed or quantity of water temporarily or permanently.
Impeding	Means to, in any manner, hinder or obstruct the instream flow of water temporarily or permanently.
Regulated area of a watercourse	a) The outer edge of the 1 in 100-year flood line or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, dams and lakes. b) In the absence of a determined 1 in 100-year flood line or riparian area as contemplated in (a) above the area within 100m of distance from the edge of a watercourse where the edge of the watercourse (excluding floodplains) is the first identifiable annual bank fill flood bench. c) In respect of a wetland: a 500m radius around the delineated boundary (extent) of any wetland (including pans).
Rehabilitation	Means the process of reinstating natural ecological driving forces within part or whole of a degraded watercourse to recover former or desired ecosystem structure, function, biotic composition and associated ecosystem services.
Resource quality	Of a watercourse means the quality of all the aspects of a water resource including: (a) The quantity, pattern, timing, water level and assurance of instream flow; (b) The water quality, including the physical, chemical and biological characteristics of the water; (c) The character and condition of the instream and riparian habitat, and; (d) The characteristics, condition and distribution of the aquatic biota.

ABBREVIATIONS

CBA	Critical Biodiversity Area
EIS	Ecological Importance and Sensitivity
ESA	Ecological Support Area
NEMA	National Environmental Management Act
NWA	National Water Act
PES	Present Ecological State
WCBSP	Western Cape Biodiversity Spatial Plan
WUL(A)	Water Use License (Application)

1. INTRODUCTION

Confluent Environmental was appointed by Cape EAPrac to provide aquatic specialist impacts for the proposed realignment of an approved bulk sewerline in Thembalethu, George (Figure 1). The original alignment was approved by Water Use License number 16/K30C/CI/2723 in December 2014. The original Environmental Authorisation is reference number 16/3/1/1/D2/50/0060/12 which was issued in March 2014. The proposed realignment is for sections on Erf 5006 and Portion 50/197, Thembalethu.

In addition to the proposed realignment, emergency work to repair erosion and stabilise the constructed sewerline at a watercourse crossing on Portion 58/197 Sand Kraal (aka Tylora Farm) has been undertaken in terms of Section 20 of the National Water Act. Permission to undertake this work was granted by the Breede-Olifants Catchment Management Agency (BOCMA). Subsequent to completion of this work, the engineer has now recommended additional support to the watercourse in the form of the following interventions:

- Protect the stream bed below the sewer line crossing in the form of a reno mattress.
- Formalise informal stormwater entering the stream from the east and west which is causing erosion of the banks and jeopardising the sewer line stability.

The above interventions represent new infrastructure proposed but are considered essential in supporting the already approved sewer line. As the area is actively eroding and under continuous pressure due to informal settlement, it would be ideal if these measures could be included in the amendment of the existing Water Use License.

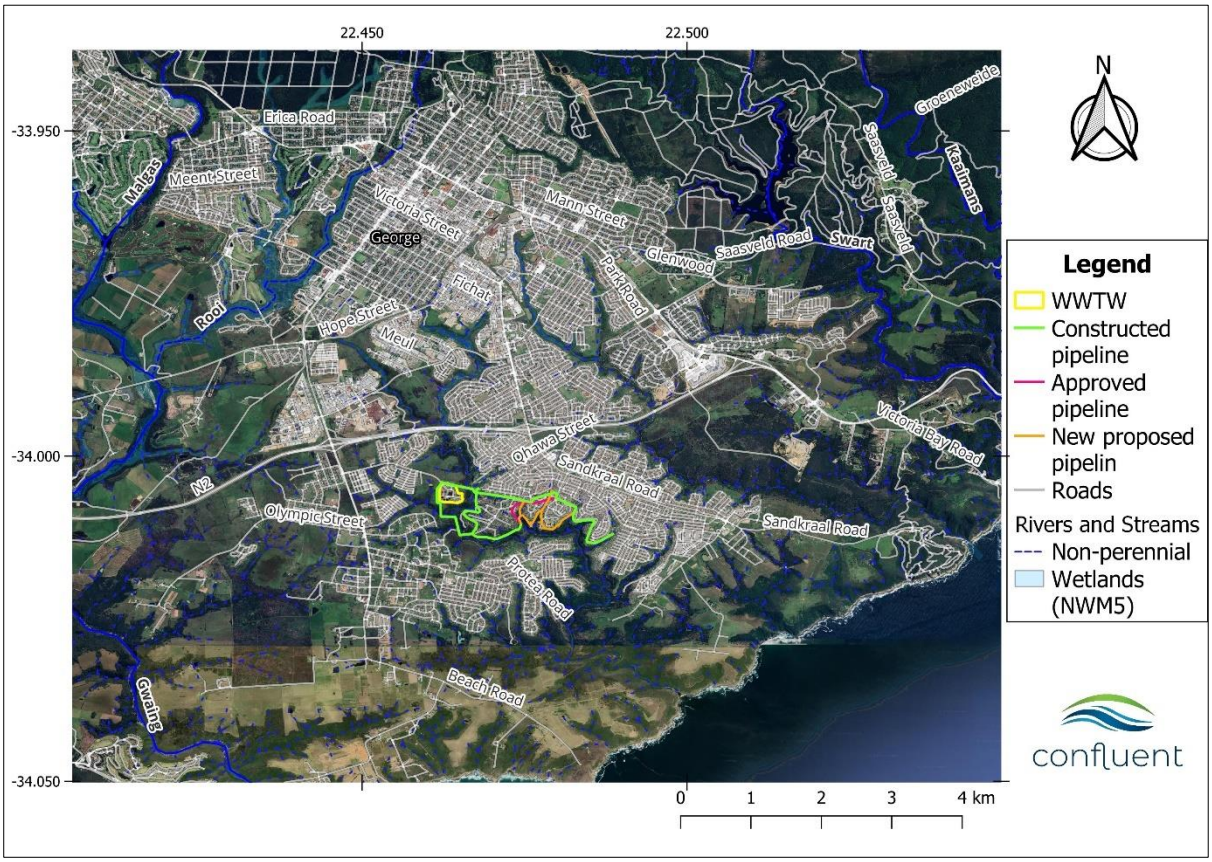


Figure 1. Alignment of the existing and proposed realignment of the bulk sewer line in Thembalethu, George.

The original authorisation approved 6 river crossings and 10 tributary crossings (Appendix 1). A section of the original alignment needs to be moved to accommodate the informal expansion of human settlement since the original approval (Figure 8 and Figure 11). The realignment needs to run below the new human settlement to maintain gravity flow and eventually service these areas once / if formalised in the future (Appendix 2). The realignment places the pipeline closer to three tributaries of the Skaapkop River which are indicated and numbered in Figure 2. These tributaries were crossed in the original layout but are now crossed further downstream.

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).

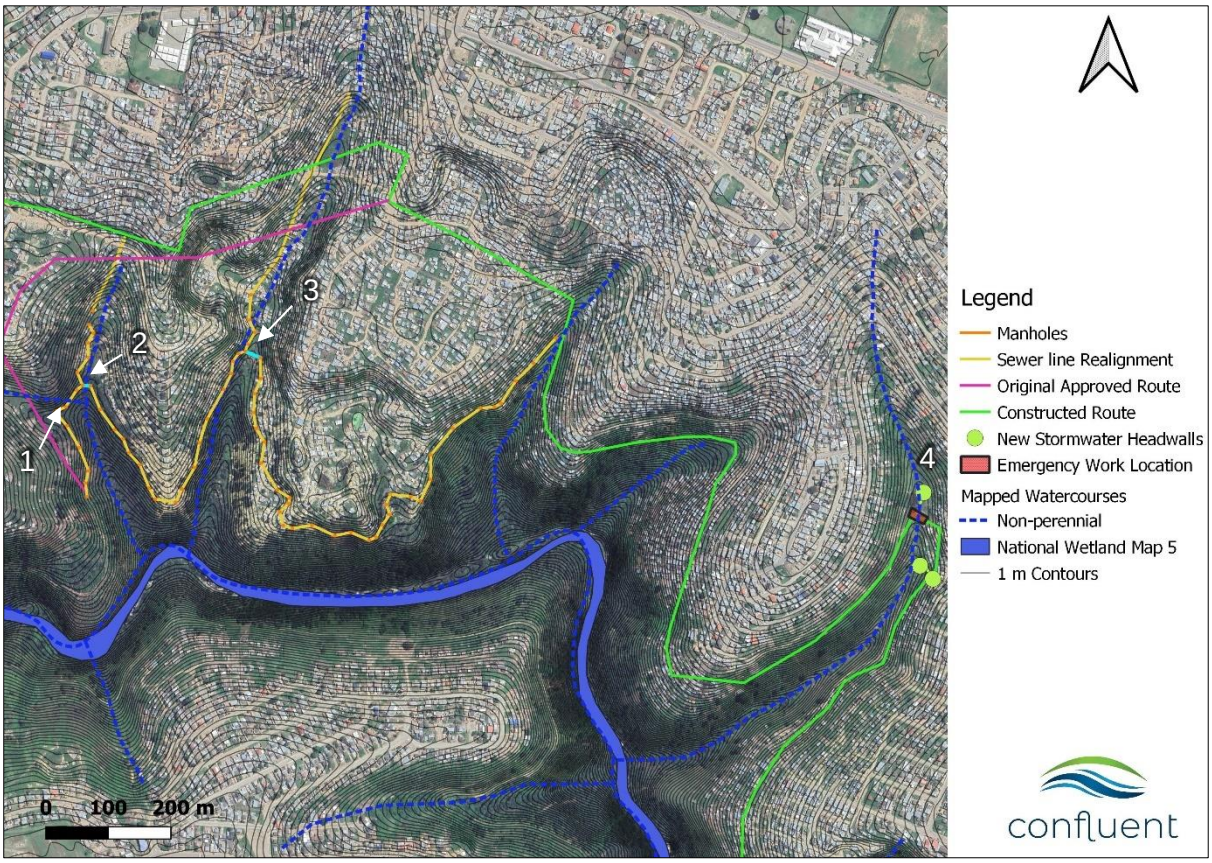


Figure 2. Original approved sewerline (pink) and proposed realignment (yellow) moved towards the Skaapkop River showing crossings at tributaries (1-3) moved south. The new alignment ties into the approved and already constructed pipeline (green).

1.1 Proposed Infrastructure

A detailed, surveyed layout of the pipeline route was provided at the time of writing, but it is understood that the 'as built' pipeline may deviate slightly from this route by 5-10m in either direction depending on site-specific topographical variation, existing erosion on sloped areas, and the location of informal housing. The latter changes frequently making precision-planning a challenge.

It is envisaged that the end result of installing the pipeline will be a level road cut into the slope in places which will enable access and maintenance of the sewer line. An example from an existing portion of the installed sewer line is shown in Figure 3.

Figure 3. Example of the bulk sewer line installed on the opposite side of the Skaapkop River in Pacaltsdorp where the sewerline has become a single lane dirt track following benching.

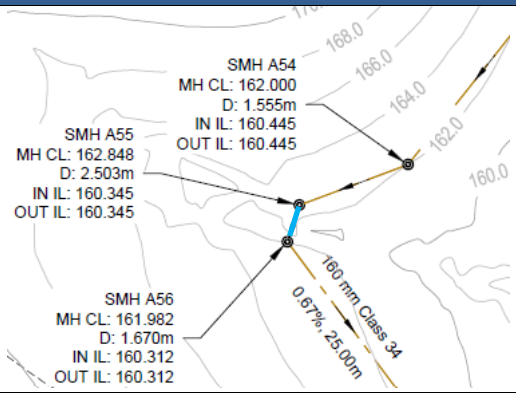
Manhole covers will be custom made security concrete to prevent tampering with drains. Pipes along the realignment are to be uPVC measuring 200 mm diameter with a maximum flow rate of 13 L/s flow rate which includes estimated stormwater ingress.

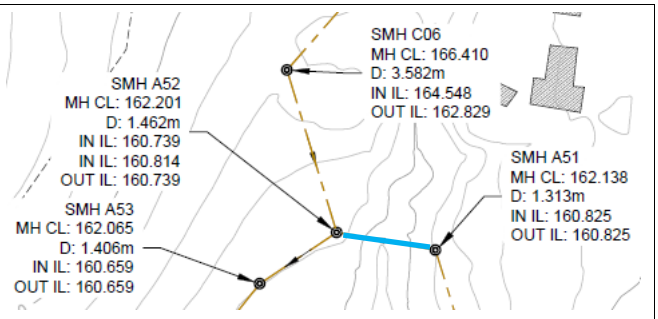
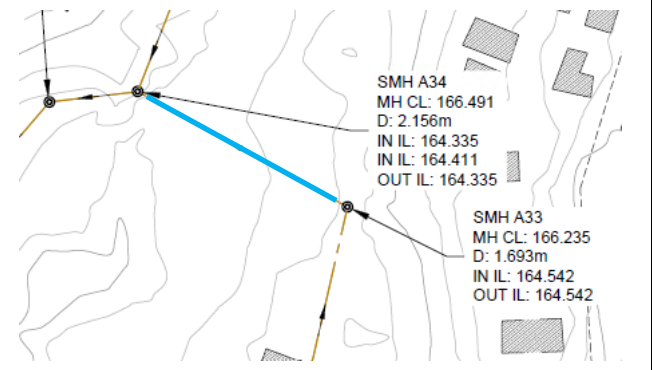
1.1.1 Watercourse Crossings at Realignment

The engineer proposes reinforced concrete bridge structures for the main watercourse crossings because this is less susceptible to wear and tear, theft, and provides cost-effective longevity.

The watercourse crossing locations numbered 1-3 in Figure 2 vary in cross-sectional width and depth and different methods are proposed by the engineering team to enable the pipeline crossing at each location. In all cases an excavator will be required to undertake the earthworks necessary to install the pipeline. The preferred method for crossing each watercourse is provided in Table 1.

Table 1. Location and proposed methods for installing the sewer line across 3 new watercourse locations.

Crossing number	GPS Coordinates* & Property	Proposed Method	Layout and location of crossing (yellow)
1: 5 m across	34° 0'34.27"S 22°28'26.97"E Erf 5006	Dig pipeline into the watercourse bed approximately 1 m deep.	

2: 13 m across	34° 0'32.88"S 22°28'28.19"E Erf 5006	Bridge on concrete supports. Pipeline to be uPVC laid on a bed of sand in a concrete bridge structure.	
3: 31 m across	34° 0'30.34"S 22°28'38.99"E Erf 5006	Bridge on concrete supports above the 1:100 floodline. Pipeline to be uPVC laid on a bed of sand in a concrete bridge structure.	

*** Note that the watercourse crossings may need to shift their final position by no more than 30-40m upstream or downstream dependent on where the strongest geological substrate is located for foundations. This will be informed by a detailed geotechnical study.**

1.1.2 Stabilisation of Bed and Banks

The existing Water Use License authorizes the sewer line crossing at point 4 (See Figure 2; 34 0'41.14S, 22 29'19.68E; Portion 58/197 Sand Kraal / Tylora Farm). This section of sewer line had already been constructed, but was subsequently badly damaged due to flooding and erosion, resulting in a request to undertake emergency repair work to reconstruct the crossing in terms of Section 20 of the National Water Act. Whilst working on the site, the engineer observed that a plunge pool below the sewer line crossing is likely to form which could undermine the gabions recently reconstructed, compromising their stability in the long term and possibly resulting in repeated failure. **The proposal is therefore to protect the stream bed from the fall of water at the toe of the gabions using a reno mattress**. This feature should arguably have been included in the original WULA as erosion at the toe of gabions where a significant fall of water occurs is a common problem. The proposed reno mattress is 6 m wide and 12-15 m long (Figure 4).

Figure 4. Diagram (left) showing plan view of the proposed reno mattress below the sewer line crossing supported by gabions. In addition, the location of a formalised stormwater headwall is proposed upstream (green dotted line). Inset photo shows emergency work undertaken to restore the sewer line crossing with potential for undercutting due to water falling at the toe of the gabions.

An additional point of concern relating to stormwater is along the eastern stream bank where the sewer line approaches the above watercourse crossing. Uncontrolled stormwater currently discharges over the slope creating erosion which will potentially expose the already constructed sewer line. Thus, putting the pipeline at risk of breaking and leaking sewage into the stream below. Where the sewerline crosses this stormwater flow path it is necessary to install protection to prevent further erosion in the form of an upslope reno mattress leading to headwall and concrete pipe which transfers stormwater safely across the sewer line, down the slope and discharges into the stream bed via a reno mattress for protection. The points for this work are indicated in Figure 2 and Figure 5.

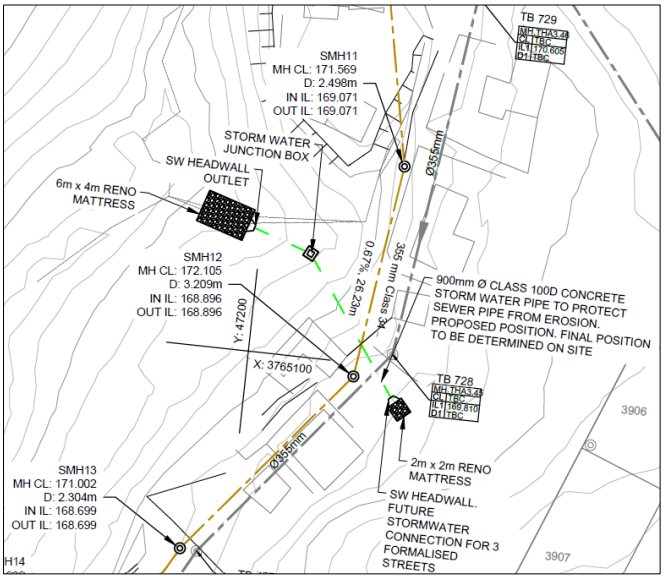


Figure 5. Diagram showing plan view of the proposed stormwater headwall outlets. The upslope headwall discharges to a concrete pipeline which transfers stormwater safely across the sewerline downslope to an outlet where it discharges onto a reno mattress in the stream bed.

Since emergency stabilisation of the sewer line has been completed, it has become evident that the piped inflow continuously blocks up with litter with the result that the water overtops the crossing point and washes down the face of the gabions. As an emergency back up to this situation, the engineer has recommended that the top of the crossing be protected with a reno mattress to ensure that the flow (which is spread) does not cause erosion over the top surface. A basic representation of this proposal is provided in Figure 6.

Figure 6. Photo taken of the almost completed emergency repairs indicating the need for a reno mattress below the piped outlet, and the proposed emergency overflow above the pipe where reno mattress protection is also recommended.

1.2 Key Legislative Requirements

1.2.1 NEMA Screening Tool

According to the screening tool the sensitivity for aquatic biodiversity is **Very High** due to the presence of Critical Biodiversity Areas, non-perennial streams as well as the Skaapkop River to the south of the pipeline route. In addition, the site is located in a Strategic Water Source Area for surface water (SWSA-sw).

According to the protocols specified in GN 1540 (Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(A) and (H) and 44 of the National Environmental Management Act, 1998, when Applying for Environmental Authorisation), 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 screening tool classified the site as being of **Very High** aquatic biodiversity due to the presence of an aquatic Critical Biodiversity Area (CBA) that extends to the north-western most corner of the property. According to the protocol, a site sensitivity verification must be undertaken to confirm the sensitivity of the site as indicated by the screening tool:

- Where the information gathered from the site sensitivity verification differs from the screening tool designation of **Very High** aquatic biodiversity sensitivity, and it is found to be of a **Low** sensitivity, an Aquatic Compliance Statement must be submitted.

The determination of the site sensitivity relied upon the following approaches:

- Interrogation of available desktop resources including:
    - DWS spatial layers;
    - National Freshwater Ecosystem Priority Areas (NFEPA) spatial layers (Nel et al., 2011);
    - National Wetland Map 5 and Confidence Map (CSIR, 2018) – the latest national wetland inventory map for South Africa;
    - Western Cape Biodiversity and Spatial Plan (WCBSP) for Mossel Bay (CapeNature, 2017).
- A site visit during which time the following activities were undertaken:
    - Identification and classification of watercourses within the footprint of the site according to methods detailed in Ollis et al. (2013);
    - Soil augering to confirm the presence of soil indicators (DWAF, 2005) that may indicate the presence of a wetland (if applicable); and
    - Identification of hydrophilic plant species that may indicate the presence of wetland plant species (if applicable).

1.2.2 National Water Act

The Department of Water & Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers.

A watercourse means:

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

For the purposes of this assessment, a wetland area is defined according to the NWA (Act No. 36 of 1998):

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which

land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil".

Wetlands must therefore have one or more of the following attributes to meet the NWA wetland definition (DWAF, 2005):

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

No activity may take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). According to Section 21 (c) and (i) of the National Water Act, an authorization (Water Use License or General Authorisation) is required for any activities that impede or divert the flow of water in a watercourse or alter the bed, banks, course or characteristics of a watercourse. The regulated area of a watercourse for section 21(c) or (i) of the Act water uses means:

a) The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;

b) In the absence of a determined 1 in 100-year flood line or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or

c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.

According to Section 21 (c) and (i) of the NWA, any water use activities that do occur within the regulated area of a watercourse must be assessed using the DWS Risk Assessment Matrix (GN 509) to determine the impact of construction and operational activities on the flow, water quality, habitat and biotic characteristics of the watercourse. Low Risk activities require a General Authorisation (GA), while Medium or High Risk activities require a Water Use License (WUL). In this particular case the majority of the water uses have been previously assessed and approved in an existing WUL and the proposal is to amend the license with the additional / alternate water uses presented in this report. The fact that a WUL was originally required means that the inherent risk in undertaking this work is considered Moderate to High and would require an impact assessment.

2. DESKTOP ASSESSMENT

The site is in quaternary catchment K30C and drains in a southerly direction towards the Skaapkop River (Figure 1 & Table 1). Rainfall is relatively high by South African standards with a Mean Annual Precipitation of 805 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, with problematic areas of erosion already forming part of this assessment.

Table 2. Summary of relevant catchment features for the sewer line area.

Feature	Description
Quaternary catchment	K30C
Mean Annual Runoff	284 mm
Mean Annual Precipitation	805 mm
Inherent erosion potential of soils (K-factor)	0.74, Very High
Rainfall intensity	Very High
Ecoregion Level II	22.02, Southern Coastal Belt
Geomorphological Zone	Not applicable
NFEPA area	Sub-quaternary reach 9144, no classification.
Mapped Vegetation Type	FFg5: Garden Route Granite Fynbos (Critically Endangered)
Conservation	Critical Biodiversity Area 1&2 and Ecological Support Area 1&2 WCBSP (2017)

Rainfall occurs year-round with seasonal peaks in spring and autumn (Figure 7).

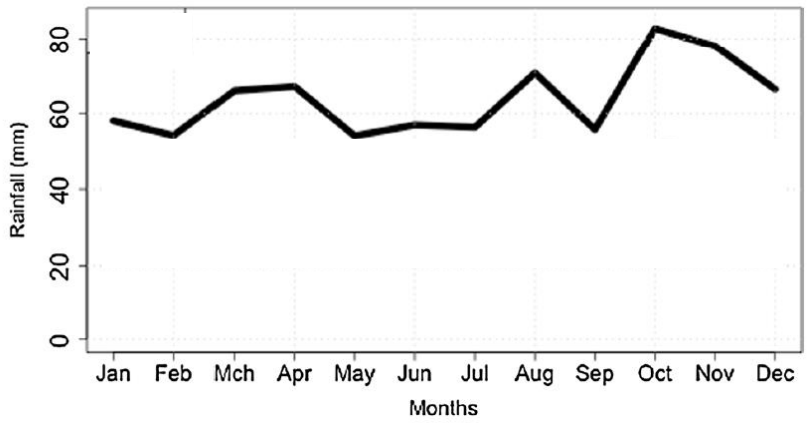


Figure 7. Area-averaged monthly rainfall for the coastal Southern Cape indicating peaks in Mar-Apr, Aug, and Oct. Data averaged between 1979 and 2011 (Engelbrecht et al., 2015).

The project area is located within the the Southern Coastal Belt ecoregion which is characterised by undulating hills and moderately undulating plains on the coastal forelands (Ecoregion Level 2:22.02).

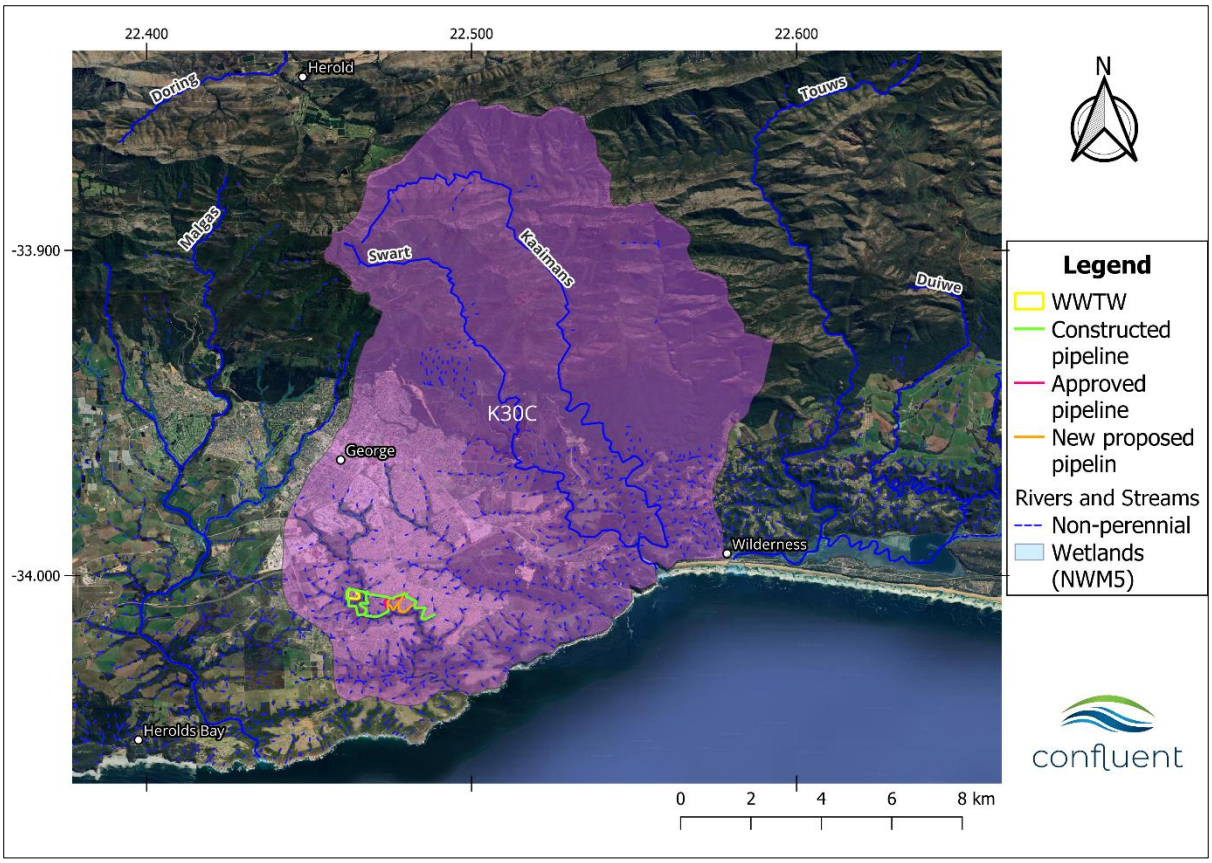


Figure 8. Thembalethu bulk sewerline in quaternary catchment K30C.

2.1 Vegetation

The mapped vegetation type at the site is **Garden Route Granite Fynbos** (FFg5; Critically Endangered; NVM, 2018). Very little natural vegetation associated with the mapped vegetation type remains on the site. The historical imagery assessment provides strong motivation for the assumption that most of plant species originally associated with this vegetation type have been eliminated from the site. The area is also heavily grazed by wandering livestock currently which in addition to the sprawling informal settlement and areas invaded by alien plant species has seriously modified the existing vegetation on site.

2.2 Conservation and Catchment Management

The Western Cape Biodiversity Spatial Plan (WCBSP; 2017) indicates a range of classification areas within or adjacent to the development footprint which must be considered (Figure 9). Most of the realigned pipeline route traverses the edge of areas indicated as Terrestrial Critical Biodiversity Area 1 (CBA1; Figure 9). The emergency work area on the existing pipeline was undertaken in the same category area with Aquatic CBA1 areas immediately downstream, and Ecological Support Areas (ESA2) upstream. The definitions and management objectives for these management classes are described in Table 3.

According to the National Freshwater Ecosystem Priority Atlas (NFEPA; Nel *et al*., 2011) the sub-quaternary reach (SQR 9144) is not classified at any level.

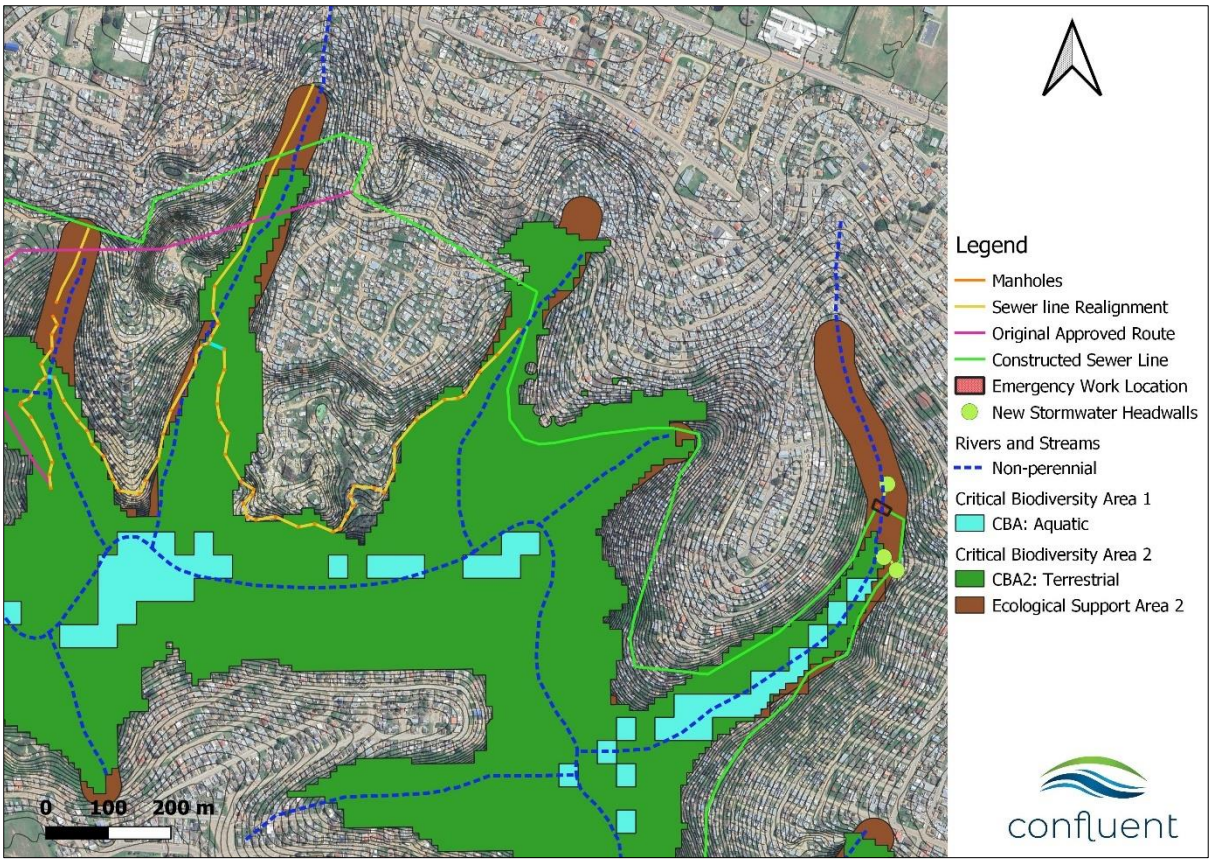


Figure 9. New sewer line alignment in relation to conservation areas identified in the Western Cape Biodiversity Spatial Plan.

Table 3. 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 Strategic Water Source Area

Aquatic biodiversity within the site has been identified as Very High on the basis 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.

2.4 Resource Quality Objectives

Resource Quality Objectives (RQOs) are defined as clear goals (numerical or descriptive statements) relating to the quality of a water resource and are set in accordance to the management class for the resource to ensure the water resource is protected. The purpose of RQOs is to set clear objectives for the resource against which WULs and the related impacts can be evaluated and managed to achieve a balance between the need to protect and utilise the resource.

The Breede-Olifants Catchment Management Agency provides an assessment of major rivers in the Water Management Area (DWS, 2018). The Skaapkop River and tributaries were not included in this assessment.

2.5 Mapped Watercourses

Mapped watercourses including streams, drainage lines, rivers and wetlands are indicated in Figure 10. These indicate the realigned sewer line crossing a number of non-perennial drainage lines which drain to the Skaapkop River in the valley bottom to the South and Southwest of the sewer line. The Skaapkop River is indicated as a river on the NWM5 layer. No mapped wetlands occur in proximity to the realigned pipeline or emergency work area.

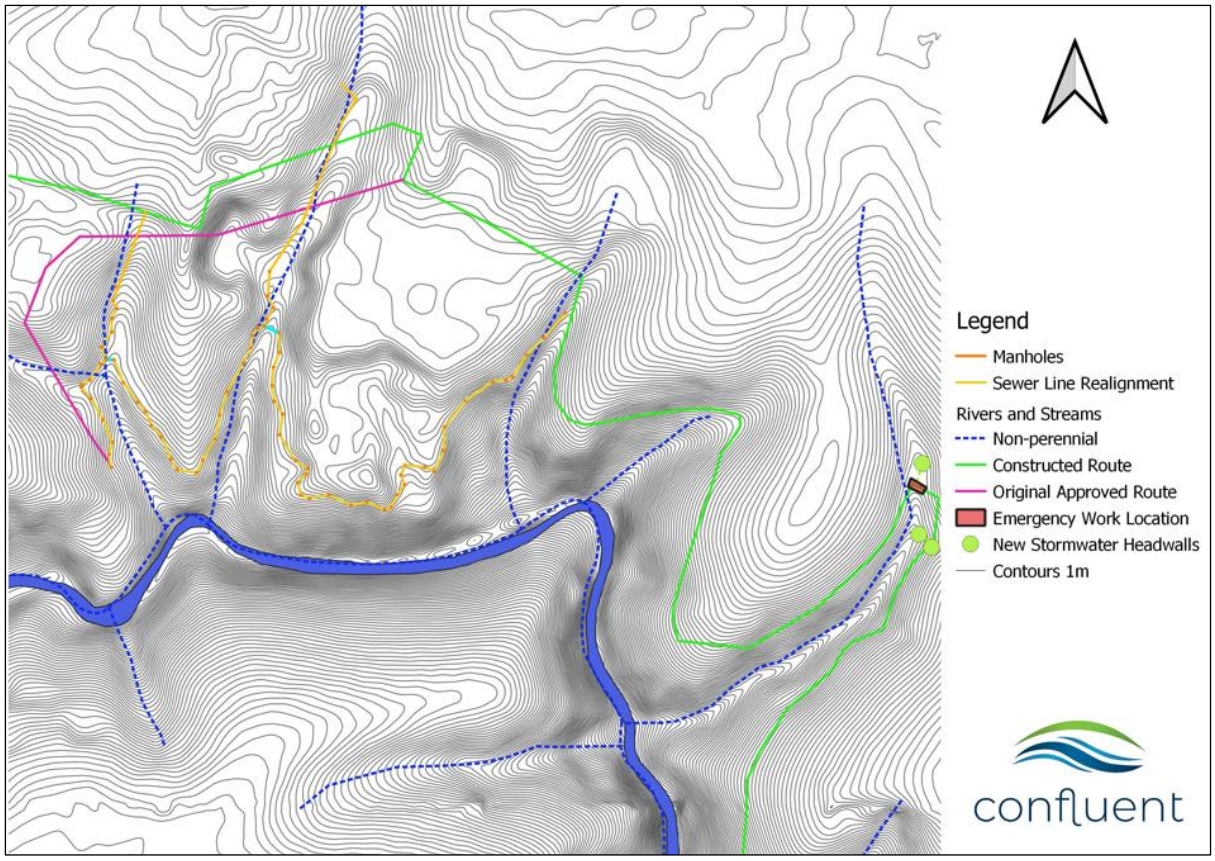


Figure 10. Mapped watercourses using the DWS 1:50 000 flow paths layer and the National Wetland Map 5 (NWM5).

2.6 Historical Assessment

The realigned pipeline traverses the steep edge of land that was previously used as a quarry for brick-making. The quarry was active for approximately 2 decades appearing in the mid to late 1990s. Areas were alternately mined then rehabilitated, and the quarry was finally closed in around 2017. Following this, informal settlement of the area began which has progressed to high density settlement of the area in poorly suited areas including drainage lines and steep slopes (Figure 11). It is clear from the series of satellite images presented that the realigned pipeline traverses aeras of significant historical disturbance due to mass earthworks. More recent disturbances include sprawling informal settlement in close proximity to watercourses with associated informal waste disposal of solids and liquids.

Figure 11. Historical imagery of the proposed realignment of the Thembalethu sewer line.

3. SITE ASSESSMENT

The site was visited on 1 November 2023 and a section of each potentially affected watercourse was walked and inspected to determine the classification, current ecological condition and impacts (Figure 12). The assessment included the section of existing pipeline where emergency work was required to stabilize erosion as part of the Section 20 application for emergency maintenance work in terms of the National Water Act.

The weather was clear and warm, and although the spring rains were good, no rainfall had fallen in the preceding 48 hours. Water quality readings were taken from each of the affected watercourses using a hand-held HANNA multiparameter meter.

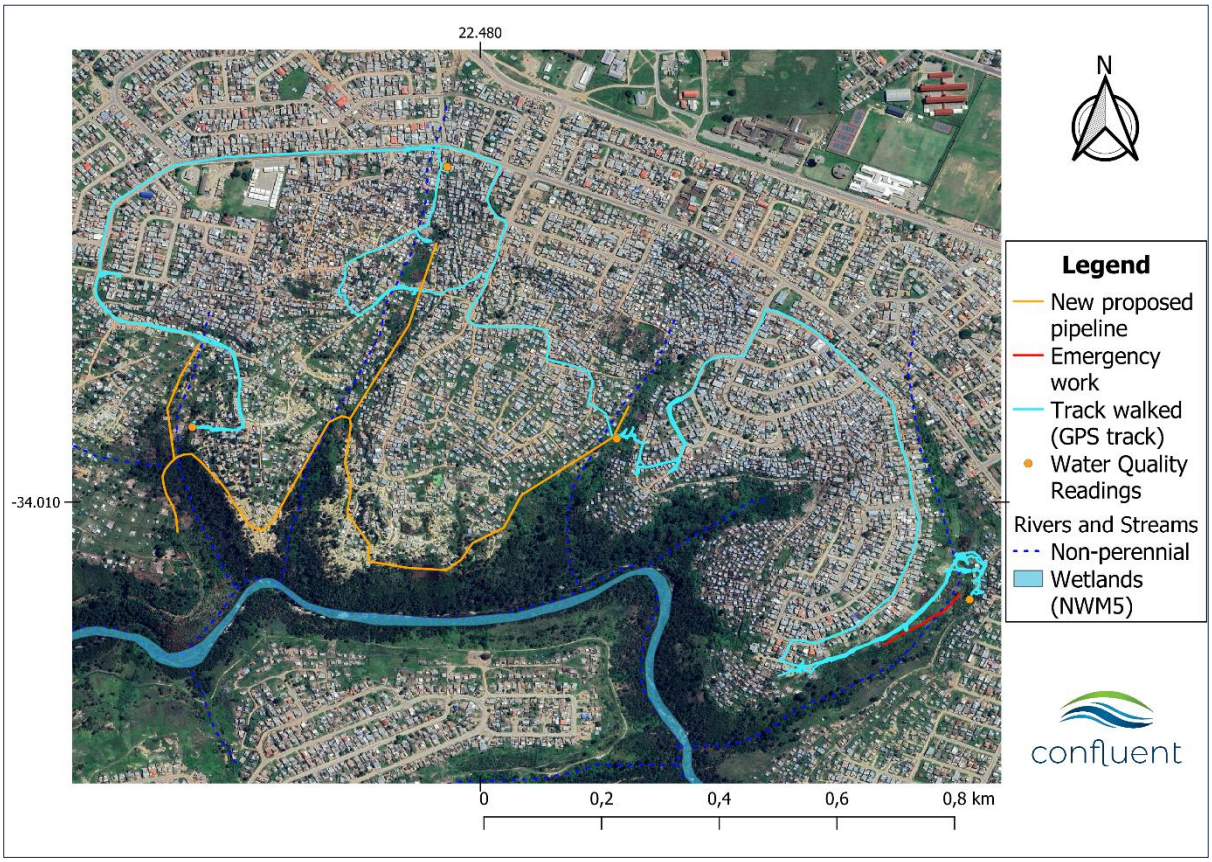


Figure 12. GPS track and points taken during the site assessment on 1 November 2024. The precise layout of the realigned pipeline has since been refined and readers should refer to Figure 2 for the final route.

3.1 Assumptions & Limitations

- Vehicle access to the affected watercourses was impossible given the non-existing road network in recently settled areas. Therefore, vehicles had to be left at the closest road access point, and extensive informal areas needed to be navigated on foot. This raised security concerns both for personal safety of the group as well as for the vehicles left behind. The extent of the area surveyed was limited to that shown in Figure 12 which still provided access to each watercourse affected by realignment of the pipeline and emergency work.

- The assessment of the site visit represents a brief temporal snapshot of conditions on the site. Changes in season or short-term changes in climatic conditions may possibly result in the formation of aquatic habitats (e.g. temporary or seasonal wetlands) under significantly wetter conditions. Despite this limitation the sensitivity of aquatic biodiversity on the site was determined with a high level of confidence.
- Given the high density of informal settlement in the area with very limited formal services, the state of the natural environment is under immense pressure from litter disposal, removal of vegetation, human waste disposal and construction of dwellings in watercourses. It is a rapidly changing landscape and this assessment therefore provides a brief snapshot of conditions at each site which are subject to change.

3.2 Representative Photos

A series of photos taken during the site visit of points representative of local conditions at most of the sites is presented in Figure 13. These show some of the typical impacts affecting streams in the area including dumping, discharge of untreated wastewater, vegetation clearing, alien invasive plant invasions, poorly conceived infrastructure, and precariously located dwellings.

Figure 13. Photos of various site aspects taken during the site visit on 1 November 2023.

3.3 Water Quality Data

Basic water quality readings were made using a handheld multiparameter meter (Hanna model). Given that surface water of a high quality usually has an Electrical Conductivity in the region of 80-120 uS/cm, the water in all streams could be considered polluted, most likely with a wide range of chemicals originating from wastewater and sullage (Table 4; domestic waste excluding sewage). Dissolved oxygen was at an acceptable level for most aquatic fauna, but the pH is more alkaline (elevated units) compared to reference conditions for the area. The pH of reference streams in fynbos is acidic ranging from as low as 4.0 to around 6.0. The elevated alkalinity is likely due to inputs of chemicals such as detergents and other household waste. Overall, water in all of the streams assessed is considered to be of poor quality.

Table 4. Water Quality Data collected from 3 points in the project area.

	Point 2 Crossing	Catchment stream (Fig. 12)	Point 4 (Emergency Work)
Electrical Conductivity (uS/cm)	3163	1222	1183
Dissolved Oxygen (%)	75	54	79.3
pH (units)	7.17	7.5	7.75
Temperature (°C)	16.8	21	18.65
Site Coordinates	S34° 00.517' E22° 28.482'	S34° 00.230' E22° 28.763'	S34° 00.673' E22° 29.333'

3.4 Eco Classification of Watercourses

3.4.1 Present Ecological State

All the watercourses in this assessment have been seriously modified from their original state by historical and ongoing activities. In the past, extensive earth-moving in and around watercourses for the brickwork quarry resulted in altered flow paths and ponding in areas which didn't occur naturally. Virtually every watercourse now has people living in or immediately adjacent to the watercourse, with the result that they are extensively littered with very poor water quality. While some of the watercourses may have originally been characteristic of wetlands (although there is no way of knowing this), little to no wetland habitat remains, and the watercourses were assessed as drainage lines in their current state. The Index of Habitat Integrity (IHI; Kleynhans, 1996) was applied to determine the PES of watercourses discussed in this report. The methodology is provided in Appendix 2 of this report.

The results indicate that the Present Ecological State of the watercourse at crossings 1 and 2 is a C, moderately modified. Ratings were lower at crossing point 3 and the emergency works crossing at point 4 because of more extensive development including road crossings, and a higher number of dwellings. The PES of the point 3 crossing is D, Largely Modified while the emergency work area at point 4 is D/E, Largely to Seriously Modified.

Table 5. Summary of scores used to determine the Index of Habitat Integrity (IHI) for affected watercourses.

Habitat Modification	Point 1 & 2 streams	Point 3 stream	Point 4 stream	Notes
INSTREAM HABITAT				
Water abstraction	0	0	0	None at present
Flow	5	10	10	Obstructed by crossings & enhanced by stormwater
Bed	10	15	15	Erosion, incision, deposition.
Channel	5	10	15	Road crossings and erosion
Physico-chemistry	20	20	20	Suspended sediment & untreated wastewater
Inundation	0	10	15	Upstream of road crossings
Alien macrophytes	0	0	0	None observed

Introduced aquatic fauna	0	0	0	None observed
Rubbish dumping	10	25	20	Prevalent to a large extent
	C Moderately Modified	**D Largely Modified**	**D Largely Modified**	
RIPARIAN HABITAT				
Vegetation removal	10	15	18	Combined removal and grazing by livestock
Exotic vegetation	15	15	15	Extensive areas of invasion *
Bank erosion	8	8	20	Uncontrolled stormwater
Channel modification	5	5	5	Other impacts more important
Water abstraction	0	0	0	None at present
Inundation	5	5	5	Minor inundation upstream of road crossings
Flow modification	0	5	5	Minor affecting riparian zone
Physico-chemistry	0	0	0	Not affecting riparian zone
	C Moderately Modified	**D Largely Modified**	**E Seriously Modified**	

* Alien invasive plants dominated by Bugweed (*Solanum mauritianum*); Castor oil plant (*Ricinus communis*); Pampas grass (*Cortaderia selloana*); and Black wattle (*Acacia mearnsii*).

3.4.2 Ecological Importance and Sensitivity

Methods used to determine the EIS are provided in Appendix 4. The watercourses were assessed collectively for their EIS as they are located at similar positions within the landscape and subject to similar existing modifications. Their importance relative to the Skaapkop River would also be considered similar in terms of the quality of water delivered to the larger valley-bottom river system.

The EIS was determined to be **Low / Marginal** for the drainage lines assessed. An explanation of scores is provided in Table 6.

Table 6. Ecological Importance and Sensitivity scored collectively for drainage lines in the area assessed.

Determinant	Drainage lines assessed collectively
Presence of Rare & Endangered Species	**0** – No species/taxon judged as rare or endangered at a local scale.
Populations of Unique Species	**0 –** No population (or taxon) judged to be unique at any scale.
Intolerant Biota	**1** - A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
Species/Taxon Richness	**1** – Not significant at any scale

Determinant	Drainage lines assessed collectively
Diversity of Habitat Types or Features	**1 -** Not significant at any scale
Refuge value of habitat types	**1** – Not significant at any scale. The presence of free-roaming domestic animals (cats and dogs) as well as minimal vegetation cover render this function very low as they will hunt any animals making use of this habitat.
Sensitivity of habitat to flow changes	**1** – Streams are naturally non-perennial with intermittent flows. The taxa present are therefore well adapted with low sensitivity to this aspect.
Sensitivity to flow related water quality changes	**1** – Smaller streams are more sensitive to changes in water quality, but the water quality is currently poor resulting in low sensitivity to this aspect in the current state.
Migration route for instream and riparian biota	**1** – The stream delineation is a marginally/low important link in terms of connectivity for the survival of biota upstream and downstream and has a marginal sensitivity to modification
Protection Status	**1** – The stream delineation is present within an area important for the conservation of ecological diversity on a local scale. All stream lead to the Skaapkop River which although heavily polluted represents a significant river that flows through George.
EIS Score	**1 – LOW/MARGINAL**

4. SCREENING TOOL OUTCOME

The sensitivity of the site is confirmed as **Very High** in spite of the Low / Marginal EIS and relatively degraded state of the watercourses affected. This is because the watercourses will be physically crossed by the pipeline entailing work within and adjacent to the watercourse which could result in further degradation during both the construction and operational phase of the project.

Given the original project was approved by a Water Use License, the risk of the proposed construction and operation of the sewer line to affected watercourses is inherently High. However, as the bulk of the sewer line has already been authorized in terms of both NEMA and the NWA it may be possible that an amendment to both authorisations for the work proposed be acceptable. Regardless of the process, an impact assessment for the proposed work is provided in the following section.

5. IMPACT ASSESSMENT

Methods for the impact assessment are provided in Appendix 5. The layout of the sewer line was not reconsidered because the alignment was historically approved, and the new alignment is completely dictated by the footprint of informal settlement. Any aspects of the engineering designs that could create negative impacts during the operational phase are addressed as such. The assessment is therefore focussed on the construction and operational phase of the sewer line realignment, and the emergency work as well as associated stormwater infrastructure.

5.1 Pipeline Realignment

5.1.1 Construction Phase

Impact: Excessive disturbance to soil and plants in the watercourse and riparian areas.

The proposed methods for constructing the watercourse crossings for the pipeline entail work with heavy machinery in the watercourse and on the banks where the crossing will take place. This work is unavoidable, but the footprint of disturbance should be kept to a minimum following the mitigation measures recommended in Table 7. Although a degree of mitigation can be achieved, this impact is rated as a **Moderate Negative** impact both with and without mitigation.

Table 7. Construction Impact: Excessive Disturbance Footprint.

Project phase	**Construction**			
Impact	**Excessive disturbance to soil and plants in the watercourse and riparian areas**			
Description of impact	**Vehicles, workers and materials active on the bed, banks and adjacent steep slopes.**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Prior to consttruction, the minimum footprint of disturbance must be delineated and should include vehicle access points, material stockpile areas, refuelling areas and actual work areas. A No-Go aera must be delineated 2 m beyond the disturbance footprint. The delineated No-Go area must be indicated using construction mesh attached to wooden droppers or similar materials. Altenratively, danger tape 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 the bed and banks.** **• 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 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.**			
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	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	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	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**		**Minor - 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 the bed and banks of the watercourse.			
Cumulative impacts	Not applicable			

Impact: Stormwater runoff from disturbed areas

Given the steeply sloping landscape where the pipeline needs to be installed, this impact and associated mitigation measures should be applied throughout the site in addition to

watercourse crossing points. All slopes end in a watercourse so avoiding the loss of soil downslope is critical to preventing unnecessary sedimentation. Adaptive management principles should continually be applied with the primary objective being to *ensure silt-laden water does not leave the work site.* Provided the mitigation measures are followed, or any other steps taken that achieve the same outcome without compromising the environment, the impact is determined to be a **Negligible Negative**.

Table 8. Construction Impact: 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 or slopes**			
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. • When construction commences in the watercourse, erect an instream silt fence using sand bags to hold down shade netting (90%) which should aim to intercept very low base flows of water and trap any silt. Excess silt must be removed from the trap to retain its effective use. • 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. Alternatively, small sections of trenching must be undertaken at a time 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 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			

Impact: Materials and Vehicle Management

Undertaking benching and trenching necessary for installation of the pipeline will create large quantities of soil that will need to be stockpiled for reuse (e.g. topsoil) or removed from the site

and dumped at an appropriate facility. Following the mitigation measures indicated in Table 9 the impact if mitigated is rated as a **Negligible Negative** (Table 9).

Table 9. Construction Impact: Materials and Vehicle Management.

Project phase	**Construction**			
Impact	**Materials and vehicle management**			
Description of impact	**Pollution of the watercourse**			
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 possible. • Materials to be removed must be taken away without delay to reduce the risk of spilling or washing down slopes, and limiting space in the work area. • 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 or unstable areas. • Vehicle refuelling areas must be located as far from the watercourse 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	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a
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	Mitigation measures should be applied through the length of the pipeline installation to ensure cumulative impacts are managed.			

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. With mitigation, this impact is rated as a **Negligible Negative** (Table 10).

Table 10. Construction Impact: 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 is established. • Ensure any litter from construction works or personnel is removed from the site. No litter, food scraps, or wate 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.			

5.1.2 Operational Phase

Impact: Rubbish dumping due to new access routes

Although rubbish dumping is an existing impact, the creation of additional vehicle access via benching for the pipeline creates an opportunity for greater amounts of dumping. Restricting access via gates or fencing is unlikely to be successful. However, installation of two or three lockable bollards (e.g. www.sabollards.co.za) could restrict vehicle access to municipal maintenance teams only. Without mitigation this impact could be quite serious as seen in other informal settlements where new access roads are located adjacent to watercourses. Mitigation will result in this impact being a **Minor Negative**, as dumping to a degree is still expected to occur (Table 11).

Table 11. Operational Phase Impact: Rubbish dumping due to new access routes.

Project phase	**Operation**			
Impact	**Additional rubbish dumping in the watercourse due to improved access along benching**			
Description of impact	**Further pollution of watercourses with litter and solid waste**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Create a barrier across the road restricting access to municipal personnel working on the pipeline for maintenance only. The barrier would need to be lockable, and made of a material that can't be stolen or tampered with. A lockable bollard could achieve this, and could at least restrict vehicle access.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Long term	Impact will last between 10 and 15 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	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	**Moderate - negative**		**Minor - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

Impact: Pipeline blockages and sewages spills into watercourses

The isolated location of the pipeline means that leaking sewage due to blockages may continue on a chronic basis, causing pollution, for extended time periods without response. Sewage leaks can have multiple causes and while these cannot be entirely eliminated, they can be mitigated to an extent and are rated as a **Minor Negative** impact in Table 12.

Table 12. Operational Phase: Pipeline blockages and sewage spill

Project phase	**Operation**			
Impact	**Pipeline blockages and sewage spills**			
Description of impact	**Pollution and eurtophication of receiving watercourses including health hazards**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Add signage to manholes and pipelines informing passersby of the manhole ID and telephone number to call and report leaks. Thse should ideally be in English, Afrikaans and isiXhosa and can be spray painted onto infrastructure to prevent loss of signs.** **• Ensure manhole lids are tamper-proof to prevent them from being easily removed for the purpose of dumping in drains.** **• Minimise the number of pipe joints directly over watercourse crossings.**			
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	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	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**		**Minor - negative**	
Comment on significance				
Cumulative impacts	The Skaapkop River is already heavily contaminated with sewage, improving the monitoring and response to sewer leaks is imperative to reducing this impact, but is somewhat beyond the scope of this assessment.			

Impact: Channel incision or erosion due to altered bed and channel features

Alterations to the bed and channel of a watercourse such as those proposed at crossing points 2 and 3 could result in altered flow paths leading to erosion. Ideally monitoring for such issues should be undertaken on an ongoing basis especially after very heavy rainfall events. The minimum mitigation measures recommended in Table 13 result in a **Negligible Negative** impact.

Table 13. Operational Phase: Channel incision or erosion due to altered bed and channel.

Project phase	**Operation**			
Impact	**Channel incision or erosion due to changes in bed and channel characteristics at crossings**			
Description of impact	**Degradation of habitat, reduced water quality, and ongoing maintenance**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• The full length of the newly installed pipeline and watercourse crossing points must be inspected 6- and 12-months following completion of project by the site engineer. The purpose is to identify any areas of erosion, undercutting, instability or structural failure. • If channel incision is occurring due to high velocity inflows, this could jeopardise concrete bridge supports of the sewer line and must therefore be controlled. One possibility is to install a series of small gabion check dams along the stream bed upstream and downstream which are aimed at reducing flows and encouraging sedimentation, building up the stream bed.**			
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	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	Probable	The impact has occurred here or elsewhere and could therefore 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	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	No applicable			

5.2 Emergency Work and Erosion Management

This section of the impact assessment focuses on the emergency work undertaken and proposed erosion control through formalised stormwater protection at Point 4 of the constructed pipeline (Figure 2). All the impacts considered in the construction and operational phase are directly comparable with those assessed for the realignment of the pipeline in the previous section. In this instance the activities are cross-referenced to prevent duplicating this information.

For the majority of construction and operational phase impacts, the mitigation measures provided in the previous section are applicable, and the same pre-and post-mitigation significance is relevant.

The design and layout of the two proposed reno mattresses and stormwater outlets is well considered and aims to mitigate erosion and stabilise the sewer line. Both are essential aims given the site environmental constraints and serious maintenance that has already been necessary due to erosion.

5.2.1 Construction phase

Impact: Stormwater runoff from disturbed areas

The mitigation measures provided in Table 7 are applicable along with pre- and post-mitigation significance values. It is, however, necessary to emphasise the importance of an instream check dam immediately downstream of the works to encourage the filtration of sediment for the duration of construction works. The use of hay bales which can biodegrade over time would be preferable for this purpose and typical methods of installation are provided in Figure 14. The check dam must be continually monitored for build up of sediment on the upstream side, which indicates it is fulfilling its function. This sediment should be removed by hand (spades) to retain the function of the structure.

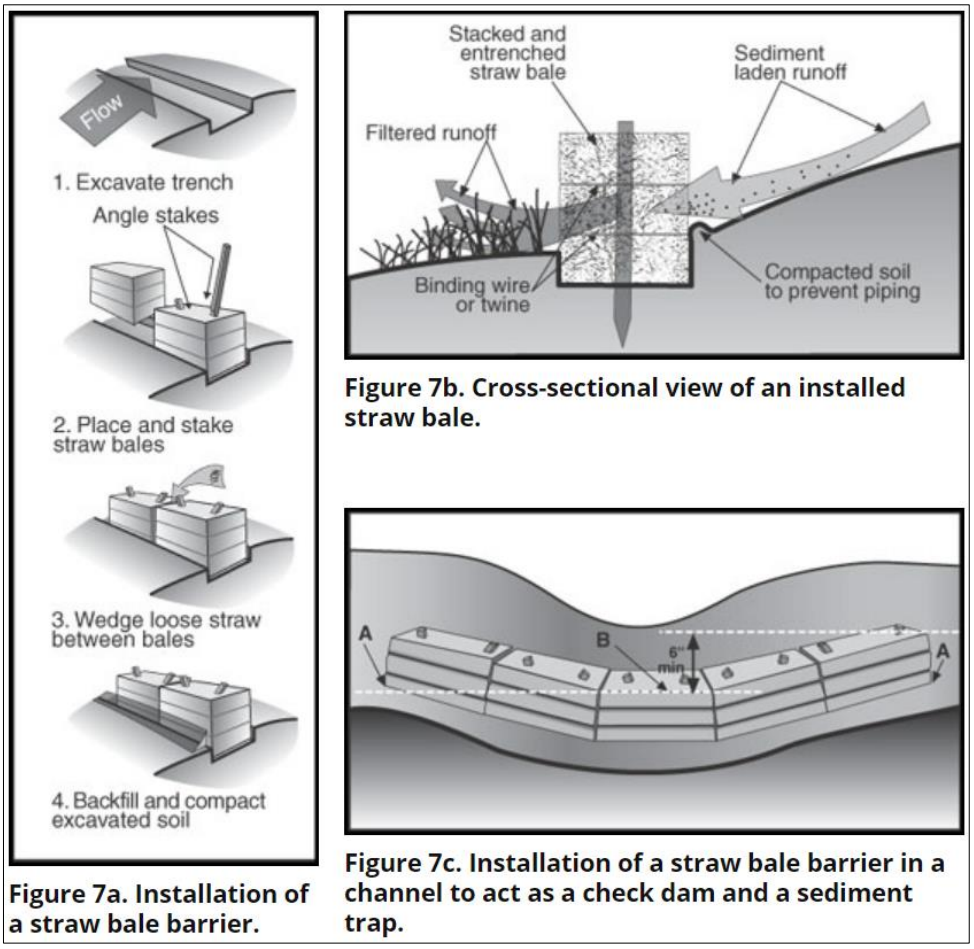


Figure 7a. Installation of a straw bale barrier.

Figure 7b. Cross-sectional view of an installed straw bale.

Figure 7c. Installation of a straw bale barrier in a channel to act as a check dam and a sediment trap.

Figure 14. Correct installation features of a biodegradable hay-bale check dam recommended downstream of works at Point 4 (University of Missouri, 2017).

6. CONCLUSIONS

Realignment of the sewer line is not in an ideal location but options for an alternative layout are non-existent given the extent of informal settlement that has occurred along the previously approved route.

Further, if the approved route were somehow cleared and the pipeline installed, all residents located below the pipeline would be excluded from a sewer connection should the area be formalised in the future.

The realignment of the sewer line includes the same number of crossings of the same watercourses as the approved route, just further downstream. For this reason, an amendment as opposed to a new application seems justified.

Watercourses affected by the proposed sewer line realignment as well as emergency work to the constructed sewer line are all in relatively poor conditions with PES ranging between C and E. Mitigation measures through the construction and operational phase of the pipeline are recommended to maintain the PES in its current state and ensure no further decline.

The proposed work assessed in this report is all supported by findings from the desktop and fieldwork assessment provided the mitigation measures recommended are fully implemented. The sewer line is a vital basic service to the residents of Thembalethu, as well as critical to reducing flows of untreated sewage and sullage into natural watercourses. It is recommended that this work be approved and expedited given the benefits to society and the environment.

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8. APPENDICES

8.1 Original Approved Sewerline

8.2 Methods for Index of Habitat Integrity (IHI)

Drainage lines are natural channels in which water flows intermittently following rainfall. These are assessed using the Index of Habitat Integrity (IHI; Kleynhans, 1996) which measures the impact of human disturbance on riparian and instream habitats. The IHI is a rapid assessment of the severity of impacts affecting habitat integrity within a defined segment of a watercourse. The method can be applied to both perennial and non-perennial watercourses. The instream impacts considered both before and after the excavation were: water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; and rubbish dumping. The riparian impacts assessed were: vegetation removal; exotic vegetation; bank erosion; channel modification; water abstraction; inundation; flow modification; physico-chemistry. Each of the impacts were given a score based on their degree of modification (1-25; Table 14), along with a confidence rating based on the level of confidence in the score.

Table 14. Descriptive classes for assessment of habitat modifications (Kleynhans, 1996)

Impact Class	Description	Score
None	No discernible impact or the modification is located in a way that has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not affected.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

An IHI class is then determined based on the resulting score which is shown in Table 15. These results provide an indication of the site-specific PES which can be compared to that determined in the desktop PES&EIS (DWS, 2014).

Table 15. Index of habitat integrity (IHI) classes and descriptions

Integrity Class	Description	IHI Score (%)
A	Natural	> 90
B	Largely Natural	80 – 90
C	Moderately Modified	60 – 79
D	Largely Modified	40 – 59
E	Seriously Modified	20 – 39
F	Critically Modified	0 – 19

8.3 Methods for Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) for watercourses was derived using the methods developed by Department of Water Affairs and Forestry (DWAF; 1999). Ecological Importance of a system is defined as the expression of its importance to the maintenance of ecological diversity and functioning on local as well as broader scales. Ecological sensitivity relates to the system's resilience to disturbance, or its ability to recover from disturbance that has occurred. For the assessment both biotic and abiotic factors are considered as follows:

- The presence of rare, endangered or unique aquatic species. This includes species of conservation concern, endemic or isolated species populations, intolerant species and overall species richness;
- Diversity and refuge value of habitat types;
- Sensitivity of the system to changes in flow and related water quality changes;
- Importance of providing functional connectivity between related systems;
- Biological connectivity in the form of migration routes / corridors instream and along riparian zones;
- Protection level of the area where the system is located (e.g. National Park).

These parameters are scored individually and the median score of all variables is calculated to derive an EI and ES category as defined in (Table 16).

Table 16. Ecological Importance and Sensitivity Categories

Ecological Importance and Sensitivity Categories	General Description
Very High	Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use
High	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/Marginal	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

8.4 Impact Assessment Methodology

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 17) 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 17. 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
Probability	**1**	**Highly unlikely / None**	Expected never to happen
	2	**Rare / improbable**	Conceivable, but only in extreme circumstances, and/or might occur for this 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 18, Table 19, & Table 20), respectively.

Table 18. 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 19. 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 20. 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