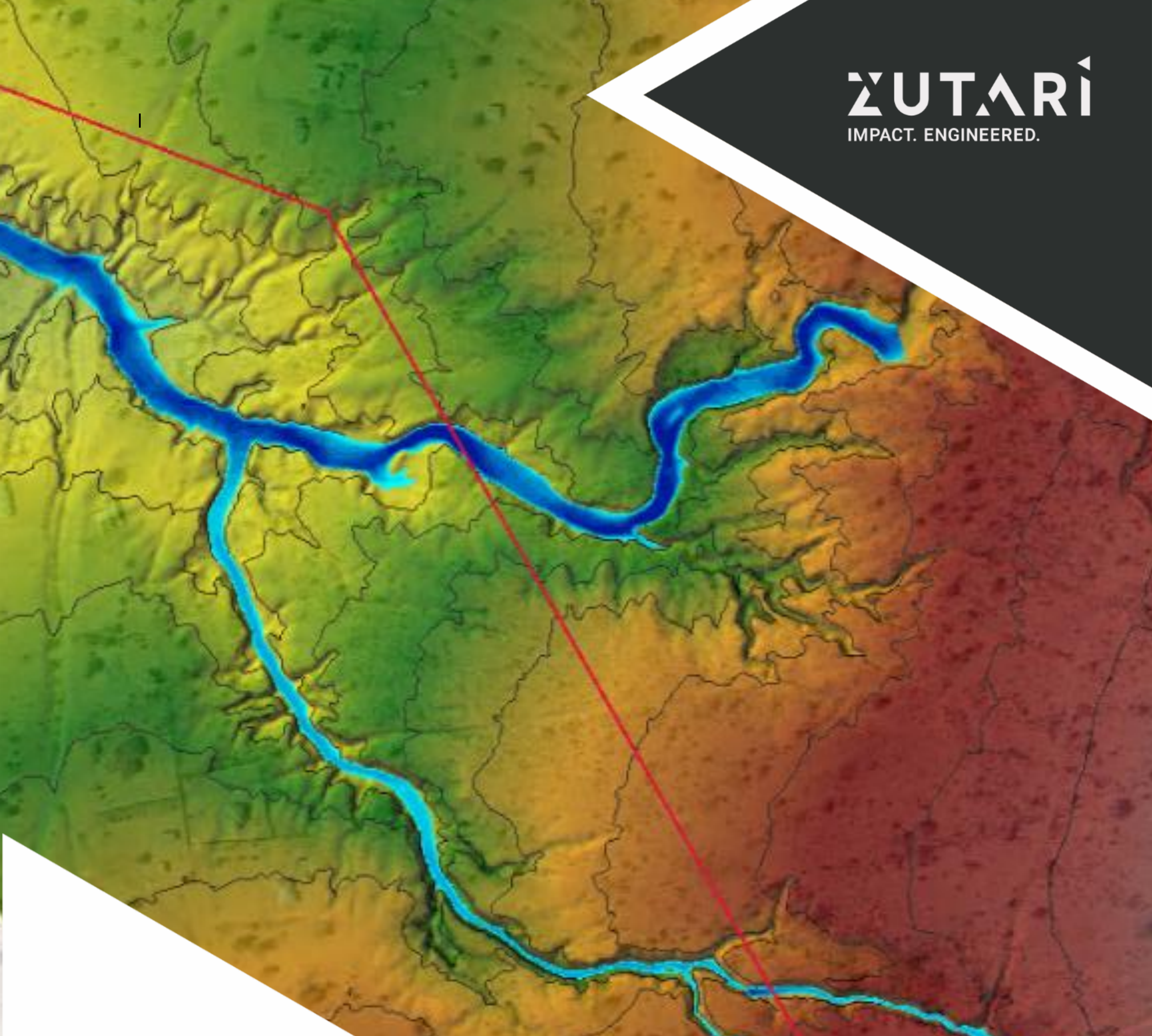

Hydrological
Impact Assessment

Olifants Management Model Programme Bulk Raw Water Study Phase

Phase 2F

Lebalelo Water User Association (LWUA)

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Abbreviations:

Acronym	Description
2D	Two-Dimensional
BA	Basic Assessment
BPR	Break Pressure Reservoir
CDNGI	Chief Directorate National Geo-spatial Information
CN	Curve Number
DEA	Department of Environmental Affairs
DEM	Digital Elevation Model
DFFE	Department of Forestry, Fisheries & the Environment
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
GIS	Geographic Information System
GN	General Notice
HEC-HMS	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' Hydrologic Modelling System
HEC-RAS	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' River Analysis System
HIA	Hydrological Impact Assessment
km	Kilometre
LiDAR	Light Detection and Ranging
LWUA	Lebalelo Water User Association
MAP	Mean Annual precipitation
NEC	New Engineering Contract
NEMA	National Environmental Management, 1998 (Act No. 107 of 1998)
NWA	National Water Act, 1998 (Act No. 36 of 1998)
OMMP–BRWSP	Olifants Management Model Programme Bulk Raw Water Study Phase
ORWRDP-2	Olifants River Water Resources Development Project – Phase 2
SANLC	South African Land Cover
SCS-SA	Soil Conservation Service method for South Africa
TCTA	Trans-Caledon Tunnel Authority
USACE	United States Army Corps of Engineers
WTW	Water Treatment Works
WULA	Water Use Licence Application
ZNJV	Zutari Ndodana Joint Venture

Definitions

Term	Definition
Infiltration	Transfer of water from the surface to the sub surface location, the rate of infiltration depends on soil and land use characteristics
Catchment	Area contributing to run-off at certain point via surface and sub-surface flow.
Flow path	Location where enough water has accumulated in the catchment area to form a concentrated stream
Run-off	Measurement of the amount of water that is produced from a specific catchment area.
Hydrology	Hydrology is the study of precipitation and water, especially its movement, in relation to the land. It represents the amount of water (run-off) that comes from a catchment. It deals with the circulation of water through the hydrological cycle and the quantification of run-off caused by rainfall. In land development, hydrology usually refers to the rate of precipitation, the volume of water, the velocity of surface run-off and the time of arrival at a particular point (the project site)
Hydraulics	Hydraulics is the science of transporting water through pipes and channels (streams, rivers, lakes, etc.). In land development, hydraulic analysis is used after the hydrological reporting process to design stormwater drainage networks or to assess the flow characteristics of natural channels.
Regulated area of Watercourse	With reference to the National Water Act (NWA) of 1998, section 21 (c) and (i), this term 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 100 m 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 NWA); or (c) 500m from the boundary of the delineated boundary of a wetland or pan.

1 Introduction

1.1 Background

The Zutari Ndodana Joint Venture (ZNJV) was previously appointed by the Trans-Caledon Tunnel Authority (TCTA), on behalf of the Department of Water and Sanitation (DWS) for the provision of professional services for the Olifants River Water Resources Development Project – Phase 2 (ORWRDP-2).

The ORWRDP-2 has since been reconstituted to become the Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP–BRWSP) in recent years, with the Lebalelo Water User Association (LWUA) acting as the implementing agent. One of the projects within this appointment is Phase 2F, that comprises 60 km of pipeline intended to convey water to the Olifantspoort Water Treatment Works (WTW), thereby augmenting the water supply to Polokwane and surrounding rural areas.

The pipeline route is situated within the Olifants Water Management Area, within quaternary region B71E (Matadi, Moopetsi, Motse Catchment group), B52E (Monametsi Catchment Group), B52G (Olifants Catchment Group) and B52E (Pelangwe Catchment group). The Catchment and the locality of the main scope elements can be seen in Figure 1-1.

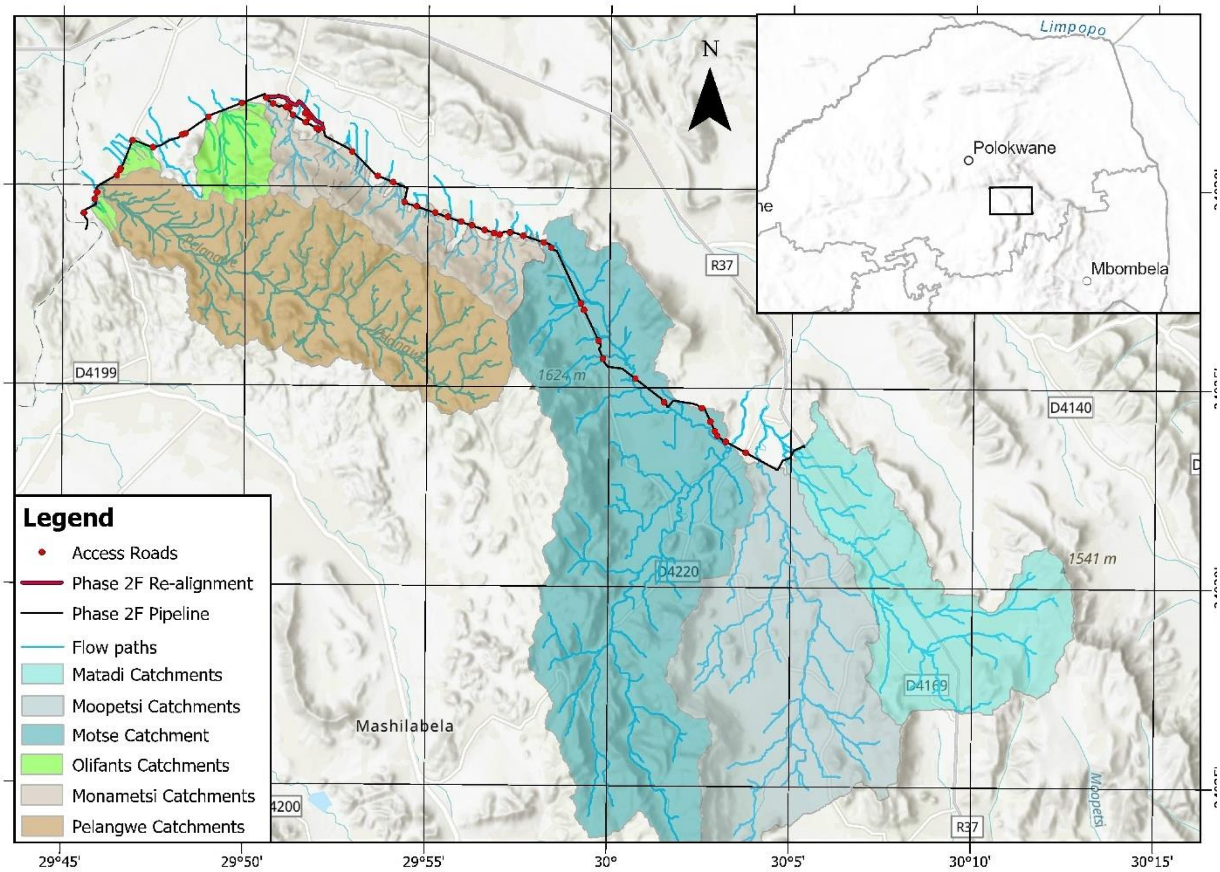

Figure 1-1: Locality Map

1.2 Scope

The projects require authorisation through a basic assessment (BA) process in accordance with Regulations 19 - 20 of the Environmental Impact Assessment (EIA) Regulations of 2014 (GN R982 of 2014). Zutari (Pty) Ltd was appointed to conduct the Hydrological Impact Assessment (HIA) in support of the BA for the authorisation of the proposed scope changes within Phase 2F. The original route was authorised in 2016 (old alignment), while the revised alignment was proposed in 2024 (refer to design report – 1002569-00-00-RP-ZZ-00005). Accordingly, this assessment only addresses areas that have been amended since the 2016 authorisation.

An overview of the entire pipeline route, highlighting sections that were realigned, are shown in Figure 1-2:

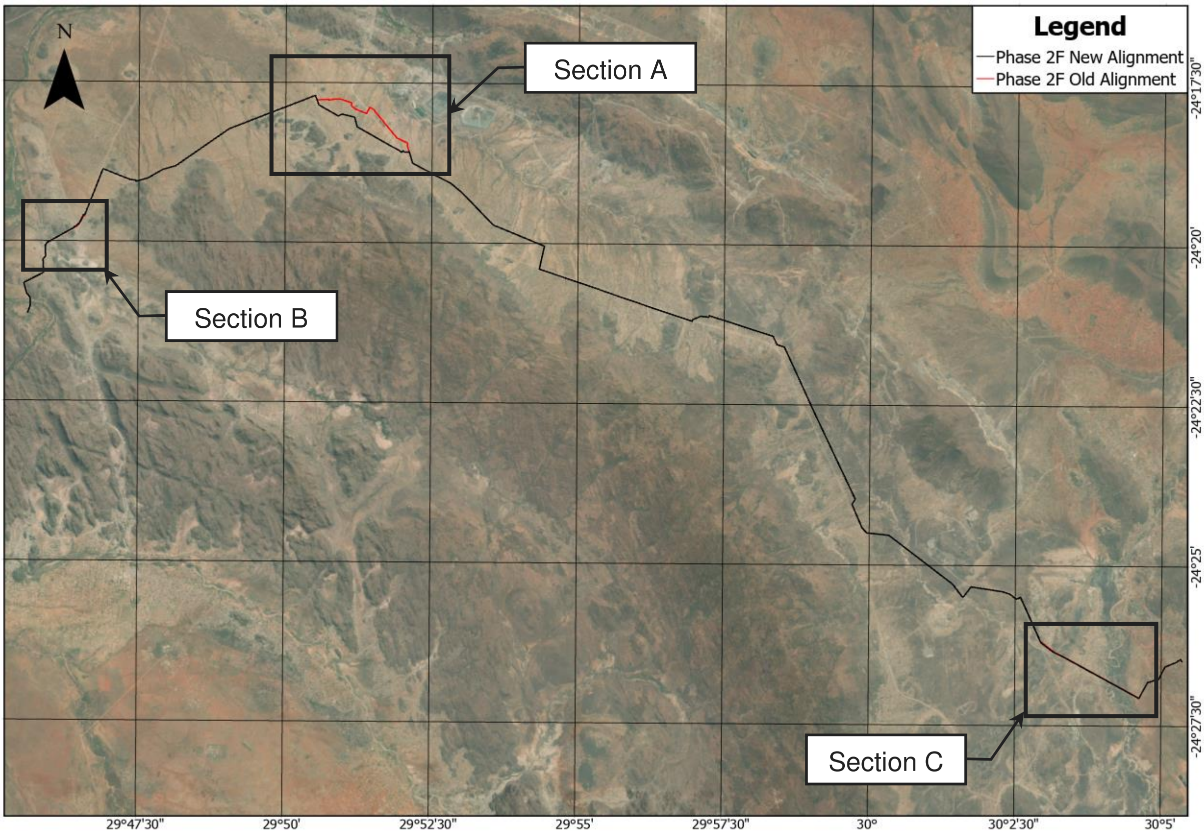

Figure 1-2: Overview of realigned sections of pipeline

The amendments to the pipeline within Section A were classified as major amendments and triggered listed activities under the National Environmental Management Act (NEMA) EIA Regulations of 2014 (GN R982 of 2014). The amendments include the following:

- Realignment of a 3.35 km portion of the 44 km of pipeline (Section A in Figure 1-2); and
- Development and widening of access roads along entire pipeline route.

Other minor deviations along the pipeline alignment which do not trigger listed activities are:

- Realignment of a portion of pipeline along the D4190, close to the settlement of Malogeng (Section B in Figure 1-2).
- Realignment of a portion of pipeline southwest of the Ditobeleng settlement (Section C in Figure 1-2).

Although the realigned portions of Section B and Section C do not trigger any listed activities under the NEMA EIA Regulations of 2014 (GN R982 of 2014), their inclusion in this report was specifically requested to ensure a comprehensive understanding of the potential hydrological impacts associated with the realigned sections of the Phase 2F pipeline.

An overview of Section A, B and C is provided in Figure 1-3 to Figure 1-5.

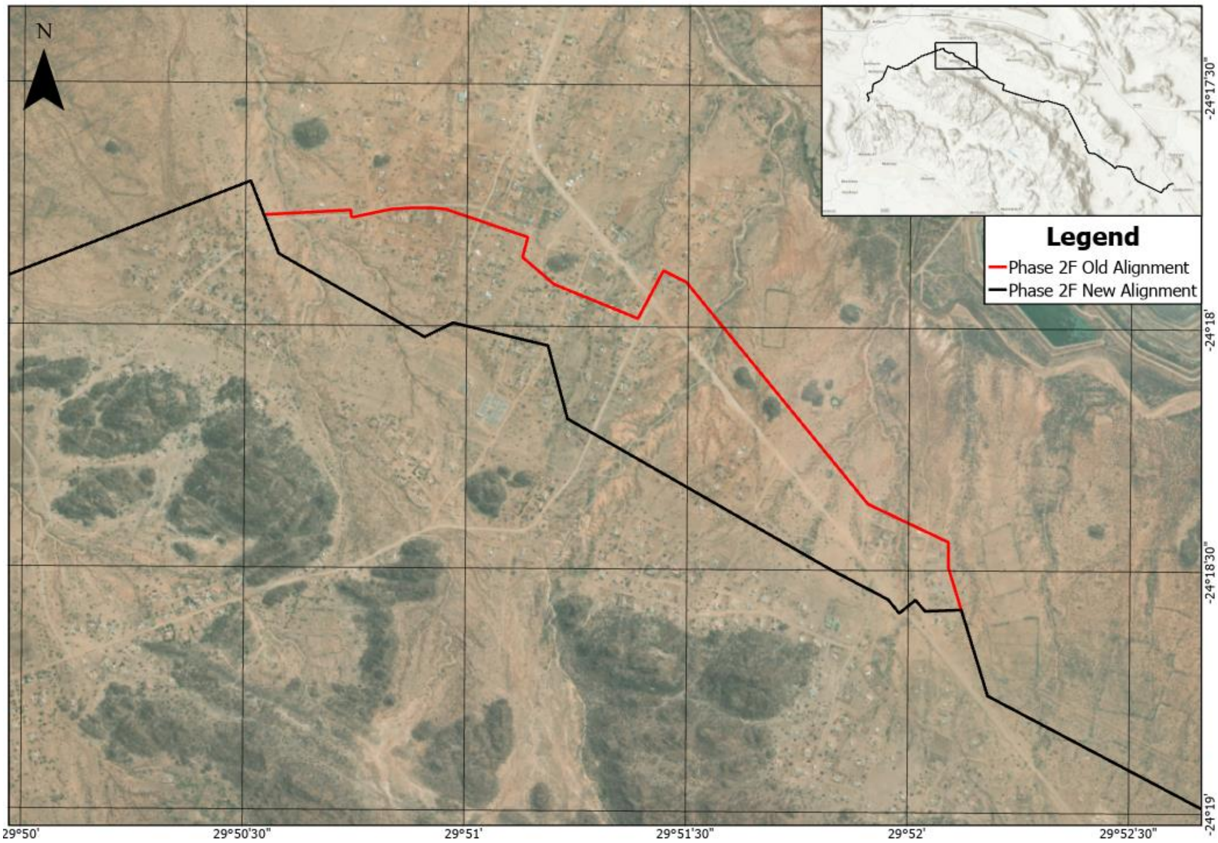

Figure 1-3: Phase 2F – Realigned Section A

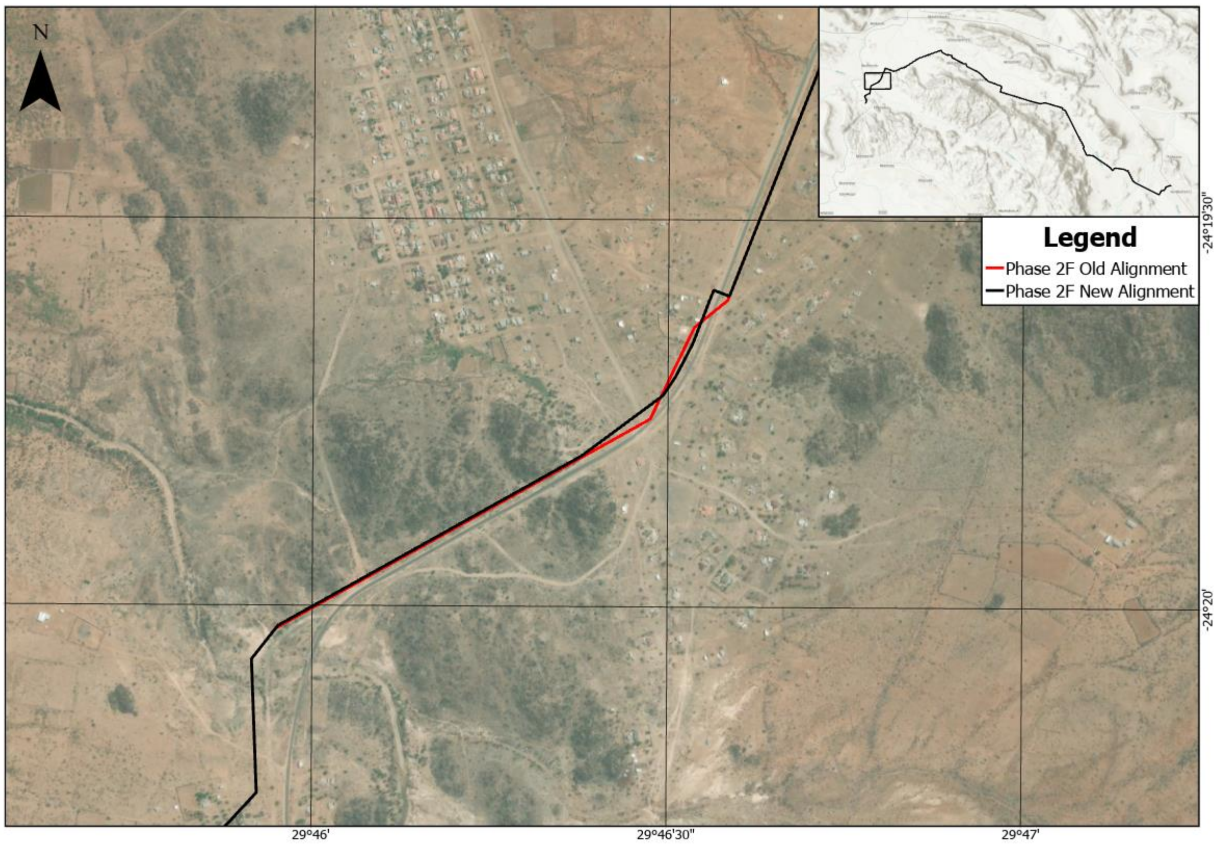

Figure 1-4: Phase 2F - Realigned Section B

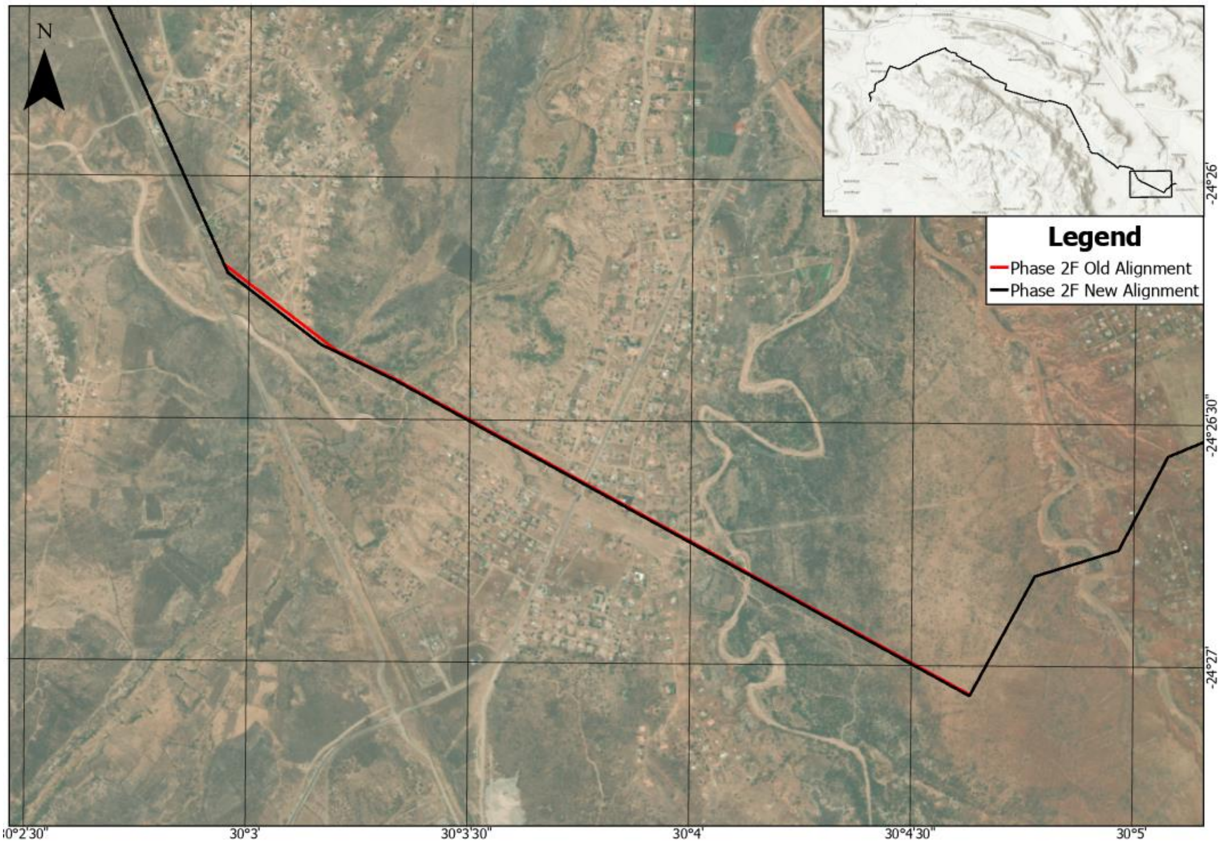

Figure 1-5: Phase 2F - Realigned Section C

The main objective of this study is as follows:

- Determine the risks associated with the proposed realignment of pipeline for Sections A, B and C and the development of access roads corresponding to the full pipeline alignment.
- Determine the 1 in 100-year run-off floodlines at pipe crossings; and
- Proposal of appropriate mitigation measures where required.

The hydrological impact is evaluated by assessing how new developments alter the existing surface water flow in the area, any effect that the Phase 2D development will have on the existing flow regimes will be the primary focus of this report.

The battery limits of this assessment are limited to the spatial extents of the 1 in 100-year floodlines, with hydrological impacts of the Phase 2F development being assessed within these extents (i.e., the assessment is limited to the footprint of the 1 in 100-year floodlines). The assessment excludes the delineation and assessment of wetlands, riparian habitats or the associated regulated areas of a watercourse.

It should be noted that the design for Phase 2F has been completed to a reference design level as per the New Engineering Contract (NEC) Design and Construct contract. Detail design information is not available for incorporation into this assessment. As a result, it is possible that the final construction designs may evolve beyond the context presented in this report. Accordingly, this assessment captures the hydrological status quo in the area and puts forward mitigation measures to minimise anticipated hydrological impacts of the development. It must still be ensured that the final detail design sufficiently mitigates the anticipated hydrological impacts outlined in this assessment as defined by applicable legislation and engineering best practice.

2 Methodology

2.1 Quantifying Risk

The risk that hydrological elements can pose is often expressed as the arithmetic product of hazard, exposure and vulnerability. The definitions and applicable examples of each of these terms are given below.

- **Hazard**: The potentially destructive event, which constitutes the 1 in 100-year flood with regard to hydrological impact and applicable legislation.
- **Exposure**: The people, property and infrastructure that will be influenced by the hazard by means of being located within the 1 in 100-year floodline.
- **Vulnerability**: The people, property and infrastructure susceptible to damage that can be quantified by financial damage incurred, or social cost and impact. Level of vulnerability can also vary, with informal settlements being more vulnerable than a sports field for example.

2.2 Floodline Delineation for Pipeline Crossings

A certified floodline is required by the National Water Act, 1998 (Act 36 of 1998) (NWA) as a basis for new development. The floodline should be certified by professionals and based on the best available information and practise. This study has been prepared based on the best available information and practise as described in this section and are certified by a specialist according to the specialist declaration attached in Appendix A.

2.2.1 Inputs and Methods

The methods, software and data sources used for both the hydrology and hydraulic design are summarised in Table 2-1 and Table 2-2.

Table 2-1: Methodology software and basis

Design Item	Method	Software	Basis for attributes
Catchment delineation	Auto delineation	ArcGIS Pro	Digital Elevation Model (DEM)
Hydrology	Rational Method Alternative 3	Spreadsheet	Rainfall information, DEM, Landcover database, Soil type database
	Soil Conservation Service for South Africa (SCS-SA) Method	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' Hydrologic Modelling System (HEC-HMS), Spreadsheet.	
	Unit Hydrograph Method (UHM)	Spreadsheet	
Hydraulics	Two-dimensional (2D) floodline modelling	United States Army Corps of Engineers Hydrologic Engineering Centre – River Analysis System (HEC-RAS)	DEM, Landcover database, Hydraulic structures

Table 2-2: Base information

Base information	Extent of information used	Reference
DEM	The route of the pipe has been surveyed with light detection and ranging (LiDAR) systems (dated 2016). Beyond the extent of the lidar survey boundaries, topographical information from the Chief Directorate: National Geo-spatial Information (CDNGI) was used.	(Department: Agriculture, Land Reform and Rural Development, 2024)
Pipeline design criteria	Pipeline alignment and applicable attributes based on the OMMP-BRWSP Phase 2D, 2H and 2F Design Report	Report 1002569-00-00-RP-ZZ-00005
Rainfall information	The Design Rainfall Software was exclusively used	(Smithers & Schulze, 2002)
Landcover database	The landcover database was use as basis and adjusted manually with information from site visits, arial imagery and web imagery.	(GeoterraImage Pty Ltd (GTI) for the Department of Environmental Affairs (DEA), 2016)
Soil type database	The soil type database was used exclusively.	(Schulze, 2012) (Conic North Consulting Engineers , 2013)
Hydraulic structures	Based on site measurements and assumptions were areas not accessible	

2.2.2 Rainfall Analysis

The rainfall data for the catchment area was extracted using the Design Rainfall Estimation Tool for South Africa (Smithers & Schulze, 2002). The software contains rainfall data for a 1'x1' latitude and longitude grid over South Africa and the information per grid point is calculated from the 6 nearest rainfall stations. The location of the rainfall stations is shown in Figure 2-1.

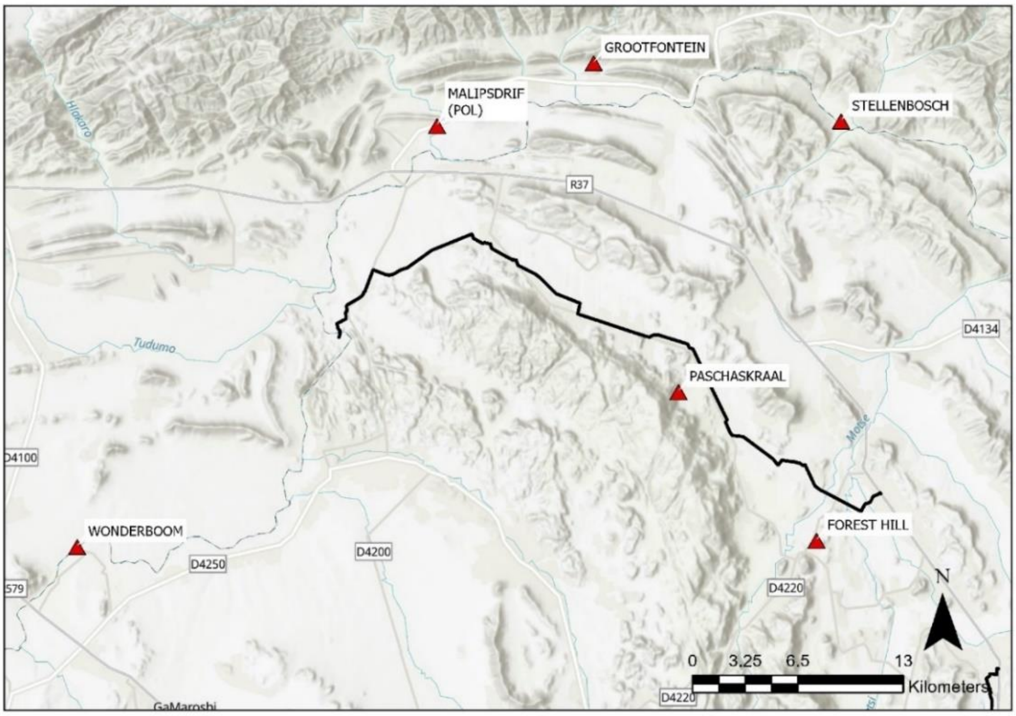

Figure 2-1: Rainfall station

Based on the locations of the catchments along the pipeline alignment it was necessary to develop gridded rainfall data for each catchment group. The results from the gridded rainfall analysis, specifically the rainfall depth corresponding to the 1 in 100-year return period, was used to determine the design floods for the different sections.

The gridded rainfall information for Section A, B and C is shown in Table 2-3 to Table 2-5:

Table 2-3: Section A – Point rainfall results

Duration	Rainfall depth per Return Period (years)						
	2	5	10	20	50	100	200
2 hours	37	51	61	71	84	96	107
12 hours	52	71	84	98	117	132	149
24 hours	59	80	95	111	133	150	169
1 day	49	66	79	92	110	125	140

Table 2-4: Section B - Point rainfall results

Duration	Rainfall depth per Return Period (years)						
	2	5	10	20	50	100	200
2 hours	40	54	65	76	91	103	116
12 hours	56	77	91	107	128	145	163
24 hours	64	87	104	121	146	165	185
1 day	53	73	87	101	122	138	155

Table 2-5: Section C - Point rainfall results

Duration	Rainfall depth per Return Period (years)						
	2	5	10	20	50	100	200
2 hours	39	53	64	74	89	101	114
12 hours	55	75	90	105	127	144	162
24 hours	63	86	103	121	145	165	185
1 day	52	72	86	101	121	137	154

2.2.3 Crossing points and catchment delineation

Floodlines were delineated for points at which the realigned pipeline crosses a watercourse for Section A, B and C. The delineated catchments and longest flow paths for Section A, B and C is shown in Figure 2-2 to Figure 2-4. The flow paths and catchments were delineated using steepest upslope algorithms within ArcGIS, using the DEM as an input.

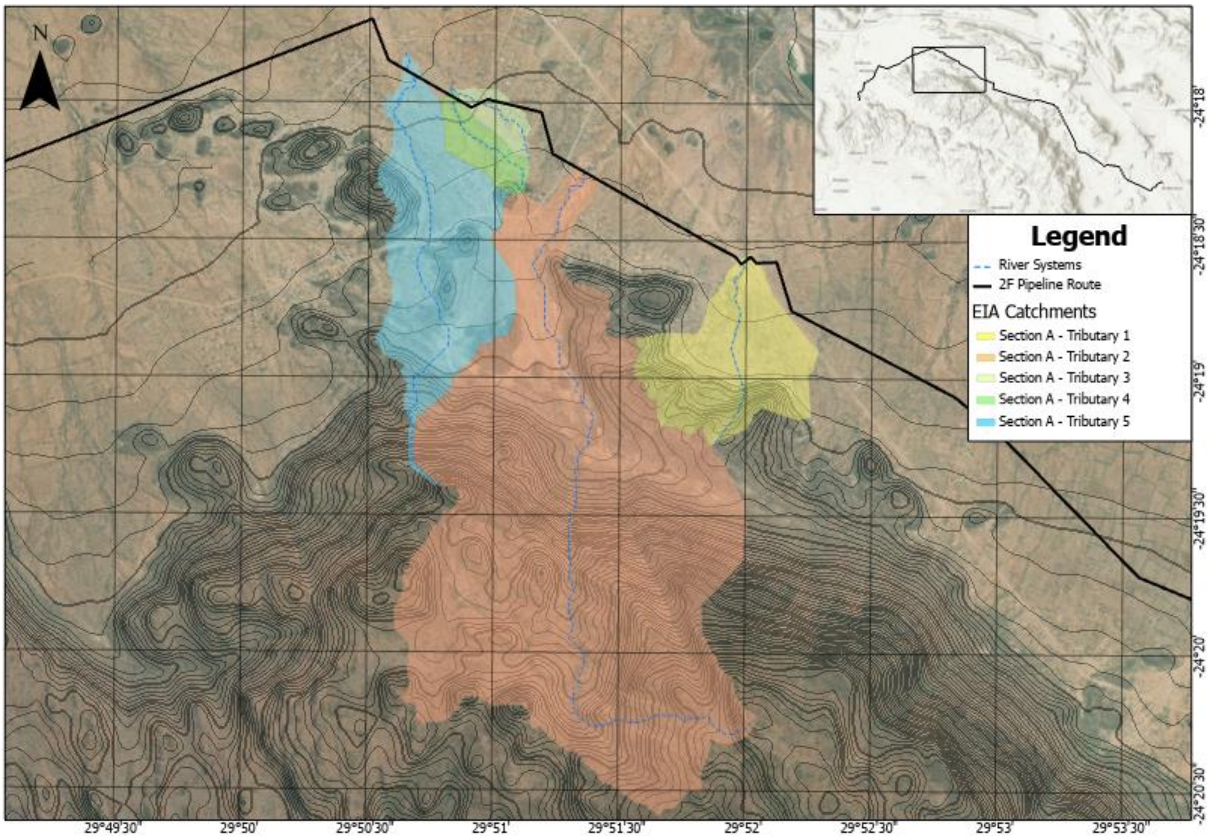

Figure 2-2: Section A – Catchment delineation and longest flow path

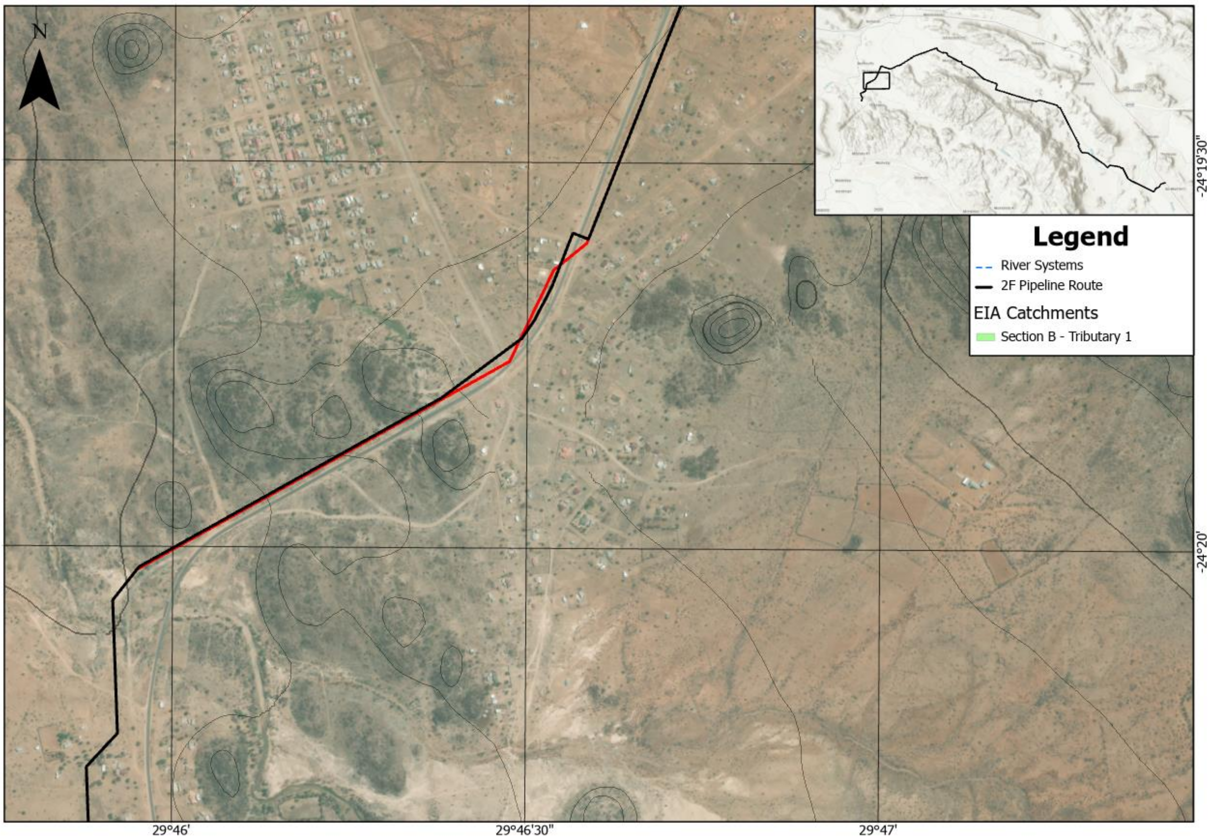

Figure 2-3: Section B - Catchment delineation and longest flow path

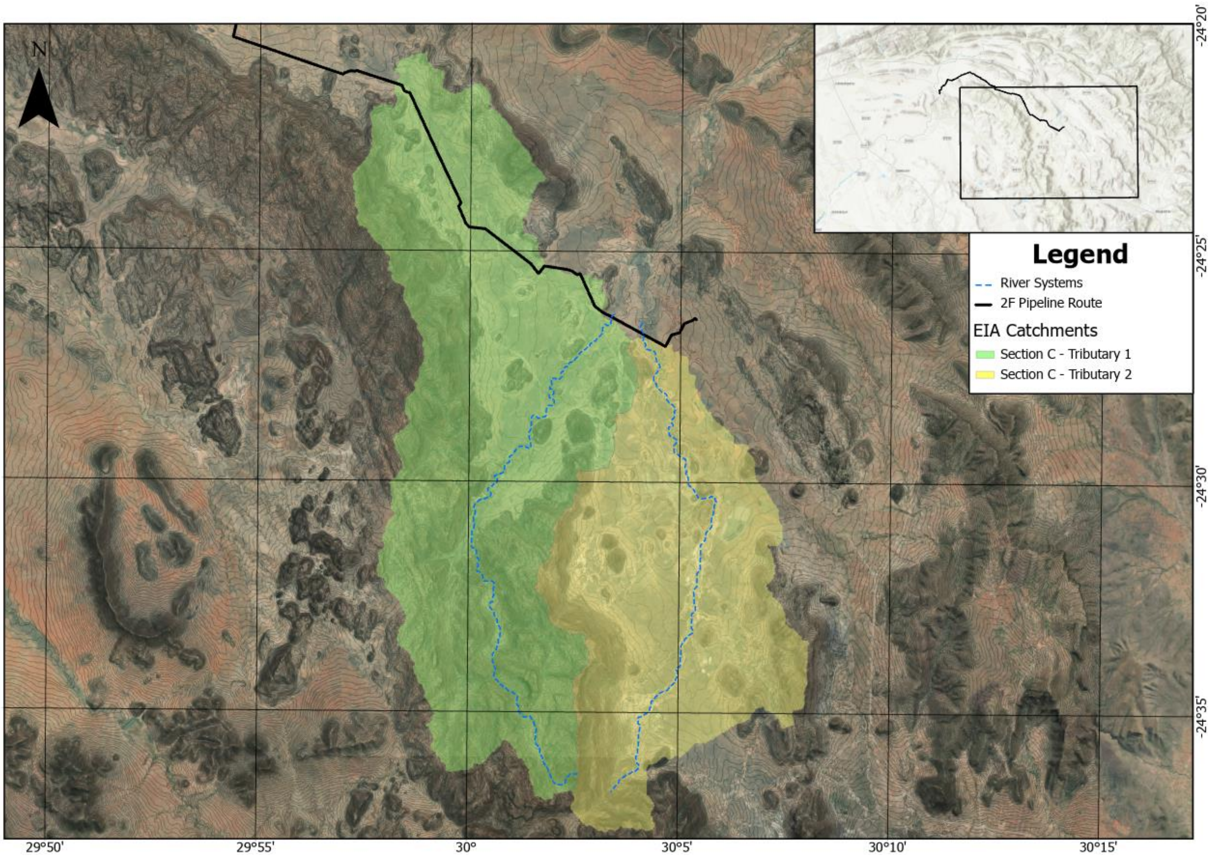

Figure 2-4: Section C - Catchment delineation and longest flow path

The longest flow path refers to the maximum distance for water to travel from the most remote point to the outlet – it is not to be confused with a drainage path or watercourse which are collectors of run-off. The catchment characteristics are summarised in Table 2-6 and were used to determine the design flood peaks for the 1 in 100-year event.

Table 2-6: Physical catchment characteristics

Catchment	Area (km^2)	Longest flow path (km)	10-85 Slope (m/m)
Section A – Tributary 1	0.9	1.48	0.09
Section A – Tributary 2	5.9	5.68	0.12
Section A – Tributary 3	0.1	0.81	0.02
Section A – Tributary 4	0.2	1.03	0.03
Section A – Tributary 5	1.4	3.50	0.06
Section B – Tributary 1	0.2	0.72	0.01
Section C – Tributary 1	129.2	30.10	0.03
Section C – Tributary 2	123.3	28.93	0.01

2.2.4 Design Flood

The SCS-SA, Rational Method alternative 3 and the UHM were used for the design flood determination. A summary is provided in Table 2-7 of the main inputs as well as applicable catchment size for each of the flood estimation methods according to the SANRAL Drainage Manual (SANRAL, 2013).

Table 2-7: Applicable flood estimation methods

Flood estimation method	Input Information	Maximum Catchment Size (km^2)
Rational method alternative 3	Catchment area, watercourse length, average slope, catchment characteristics, design rainfall depth	<15
SCS-SA method	Design rainfall depth, catchment area, Curve Number, catchment lag	<30
UHM	Design rainfall depth, catchment area, watercourse length, length catchment centroid, mean annual rainfall, veld type and synthetic regional unit hydrograph	15 to 5000

The rational method uses a run-off coefficient (C-factor) to gauge the flow that would be generated by a catchment, also considering the soil permeability, land use and catchment slope. The rainfall is accounted for by calculating the time of concentration of the catchment and selecting the associated intensity.

The unit hydrograph concept helps define the distinct physical characteristics of a catchment in the form of a hydrograph. Its size and duration are influenced by the intensity and length of rainfall. A unit hydrograph represents the run-off response of a specific catchment and is metrically defined as the hydrograph generated by one millimetre of run-off resulting from a uniform rainfall of a specific duration. The duration of the hydrograph corresponds to the rainfall duration, while its volume is directly related to the rainfall intensity.

The specific unit hydrograph to be used is dependent on the veld type of the catchment and using Figure 2-5 below the veld type was assumed to be region 8.

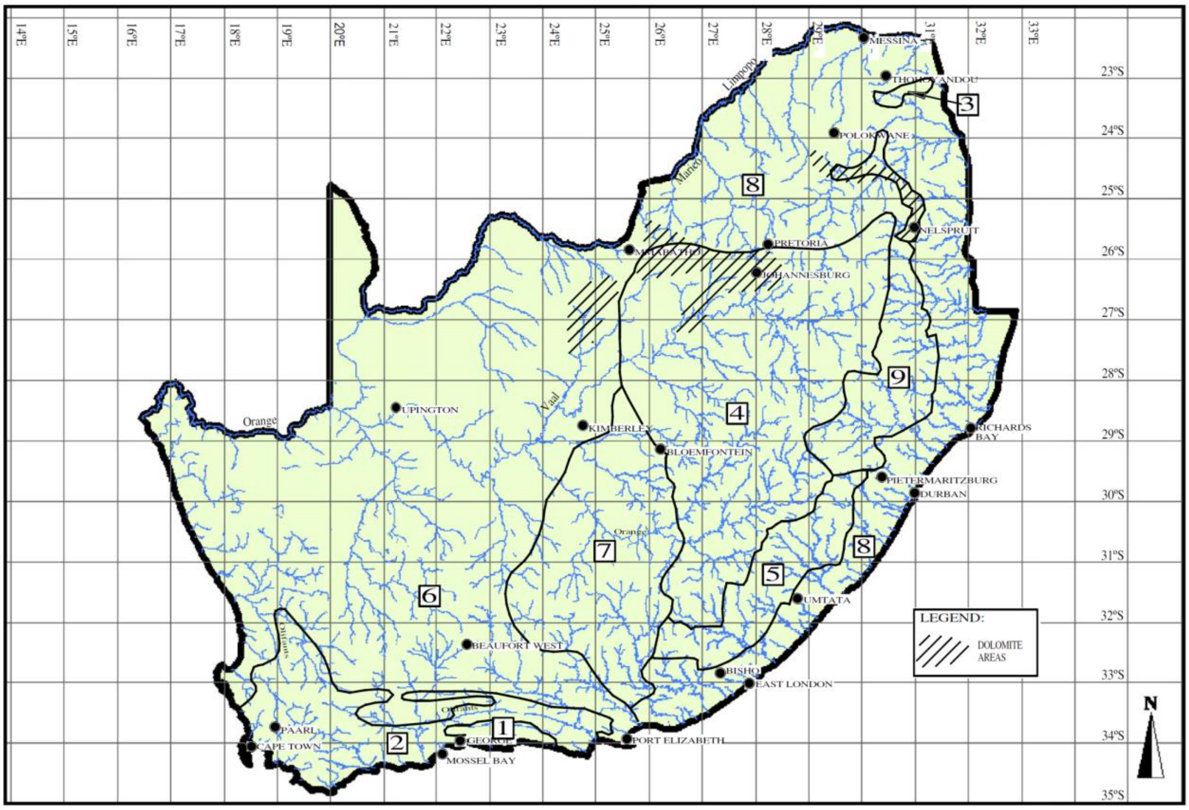

Figure 2-5: Regions with generalised veld types (SANRAL, 2013)

The SCS method and Rational method inputs are put forward in Table 2-8 and Table 2-9 respectively.

Table 2-8: SCS method inputs

Catchment	Main SCS Soil Type	Curve Number	Initial Abstraction (mm)	Lag Time (min)
Section A – Tributary 1	D	81	5.8	27
Section A – Tributary 2	D	81	5.7	45
Section A – Tributary 3	D	78	6.9	24
Section A – Tributary 4	D	80	6.8	23
Section A – Tributary 5	D	84	4.6	36
Section B – Tributary 1	C	84	4.6	23
Section C – Tributary 1	D	84	4.7	145
Section C – Tributary 2	D	87	3.8	161

Table 2-9: Rational method inputs

Catchment	C-value	Time of Concentration (hours)	Associate rainfall intensity (mm/hr)
Section A – Tributary 1	0.31	0.23	182.3
Section A – Tributary 2	0.41	0.57	108.5
Section A – Tributary 3	0.32	0.24	179.7
Section A – Tributary 4	0.34	0.27	167.8
Section A – Tributary 5	0.37	0.51	115.4
Section B – Tributary 1	0.35	0.28	164.6
Section C – Tributary 1	0.36	3.49	32.1
Section C – Tributary 2	0.35	4.97	24.2

Table 2-10: Catchment flood peaks

Catchment name	Area (km^2)	1 in 100-year Peak flow (m^3/s)		
		SCS	Rational Alt 3	UHM
Section A – Tributary 1	0.9	18	14	
Section A – Tributary 2	5.9	84	73	
Section A – Tributary 3	0.1	2	2	
Section A – Tributary 4	0.2	4	3	
Section A – Tributary 5	1.4	24	16	
Section B – Tributary 1	0.2	12	3	
Section C – Tributary 1	129.2	755	415	392
Section C – Tributary 2	123.3	725	290	240

The design flood estimation was carried out using three methods: the SCS-SA, Rational, and UHM. For smaller catchments, the SCS-SA method was selected, while the UHM was applied to larger catchments. The Rational Method served as a verification tool to ensure the reliability of the results. It was determined that the flood peaks from the SCS-SA method would be used for catchments smaller than 15 km², whereas the UHM was applied to catchments larger than 30 km².

A key advantage of both the SCS-SA and UHM methods is that they generate a hydrograph as part of their outputs, which can be directly used in the hydraulic analysis. In cases where both methods were applicable, the most conservative assumption was adopted to ensure a robust and reliable flood estimation.

2.2.5 Floodline delineation

A 2D hydraulic model was configured along the pipe route survey extent. HEC-RAS Version 6.6, was used to model the hydraulics for this area. The following data was used to configure and calibrate the HEC-RAS 2D hydraulic model:

- The topography, represented by a DEM;
- Flood hydrographs; and
- Manning's roughness coefficients determined using recommendations from literature.

LiDAR data is typically processed to remove vegetation and buildings, creating a topographical model of the ground surface. The available LiDAR dataset covers the pipeline route with a buffer zone of approximately 300 m on either side. Figure 2-6 shows the full coverage of the 2016 LiDAR.

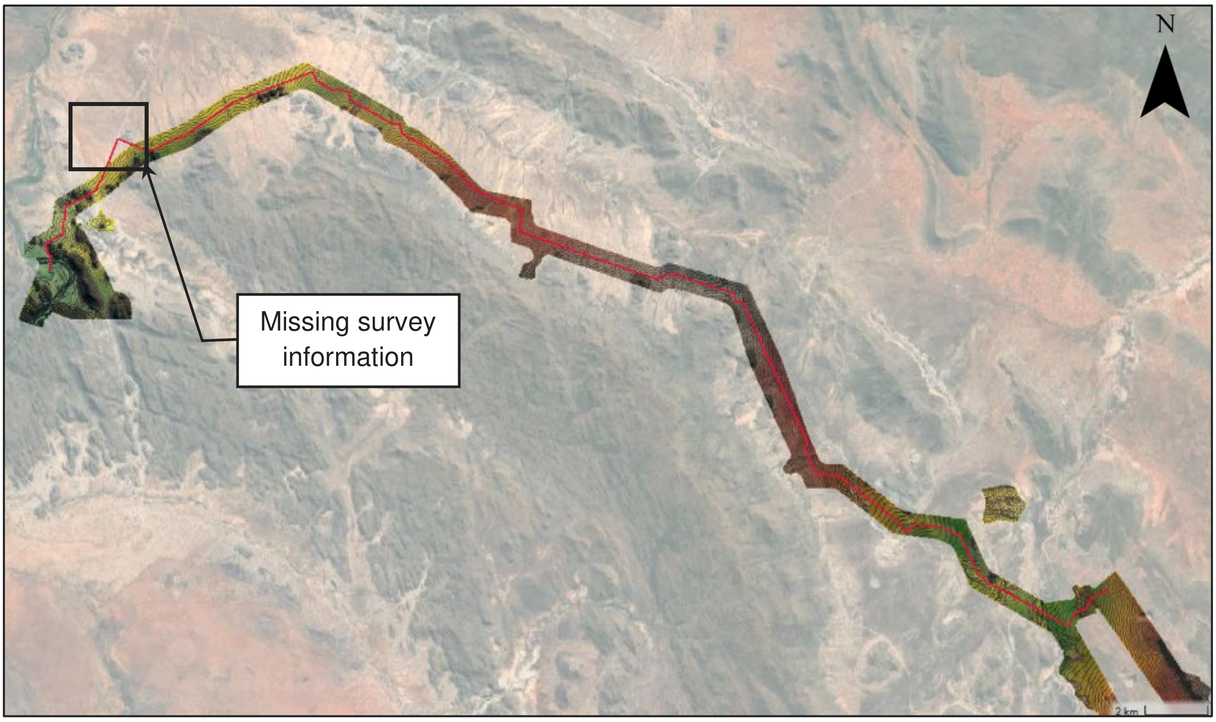

Figure 2-6: LiDAR survey extent

It should be noted that a portion of the pipeline deviates from the LiDAR survey at chainage 20 400 m. However, the realigned portions of the pipeline are not affected by this area. Additionally, due to the age of the LiDAR survey (2016), various upgrades to the D4190 have not been captured, with the available LiDAR information still reflecting the old road alignment and levels. This mainly affects the catchments of the realigned portion Section B.

However, given the relatively low magnitude of the 1 in 100-year flood calculated for Section B–Tributary 1 and its small catchment size, it was not deemed necessary for any additional intervention measures and the hydrological impacts in this area was determined using the available information.

The 2D model operates with a computational mesh. The mesh was generated at an initial resolution of 10 m and was refined in numerous areas to allow accurate modelling of the hydraulics. The computational mesh perimeter and refinement regions can be seen in Figure 2-7.

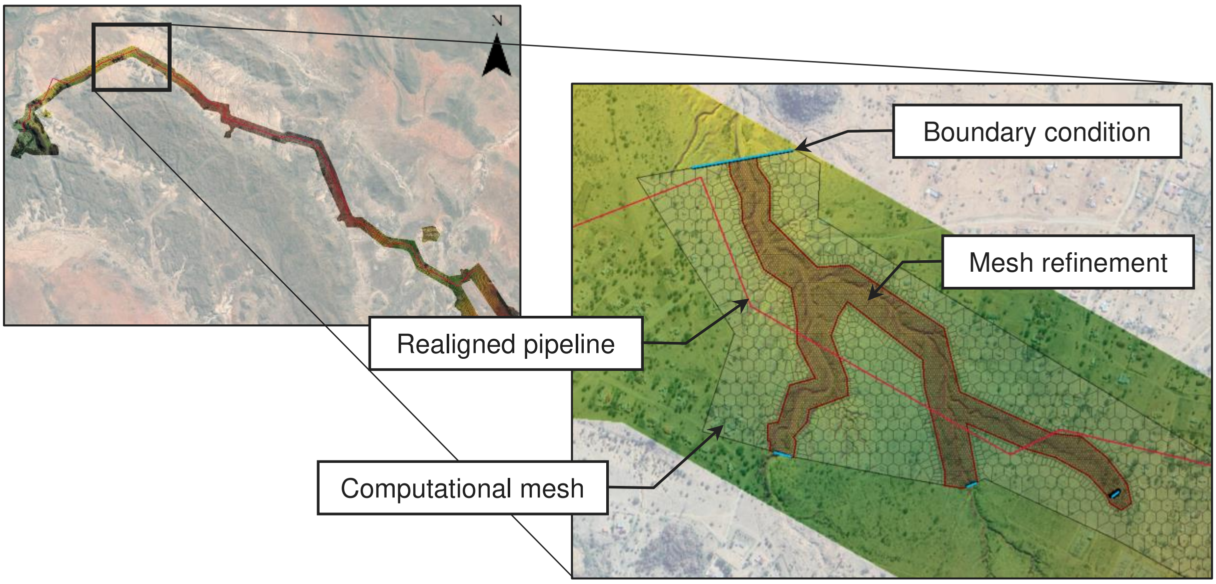

Figure 2-7: Computational mesh and refinement

Possible hydraulic structures such as culverts and bridges were identified using aerial imagery and the LiDAR information. These structures were included in the model and the dimensions of these structures were based on site measurements.

Hydraulic resistance to flow is represented using Manning's roughness values in HEC-RAS. Since each land cover category tends to be reasonably uniform from a hydraulic resistance perspective, land cover is often used as a proxy for hydraulic resistance.

The South African National Land Cover (SANLC) 2022 database (GeoterraImage Pty Ltd (GTI) for the Department of Environmental Affairs (DEA), 2016) was assessed for applicability but it was found that the scattered trees in the area was often classified individually but the pixel size of the classification is bigger than the tree girth, this would cause very high manning's values scattered along the river area. Due to the inaccuracy of this information, a roughness value representing the combination of grassland and scattered bush (n = 0.05) was found to better represent the area and therefore adopted in the model. Furthermore, the low-flow stream width is very narrow and defining this separate from the overbanks would have a major effect on the results. The results from the floodline delineation are shown in Section 3.1.

2.3 General Assessment of Access Points and Road

A 15 m permanent pipeline servitude and a 25 m temporary servitude have been allowed to accommodate the proposed pipeline and facilitate construction activities. The permanent servitude extends along the entire length of the pipeline, while the temporary servitude is included in areas without spatial constraints. In locations where spatial restrictions exist, it is assumed that construction activities will be confined to the permanent servitude.

The pipeline servitude generally runs parallel to an existing road and associated road reserve. These existing roads will therefore be used to facilitate construction and maintenance activities. In areas where the servitude does not run parallel to a road, the servitude generally crosses existing roads which will also be utilised for access to the pipeline. Accordingly, a minimal amount of new access roads will need to be constructed to serve the access points to the servitude of the Phase 2F alignment. Access points and the associated roads therefore are expected to have minimal impact on the prevailing hydrological conditions within the study area. An overview of the access road locations along the Phase 2F pipeline are provided in Figure 2-8:

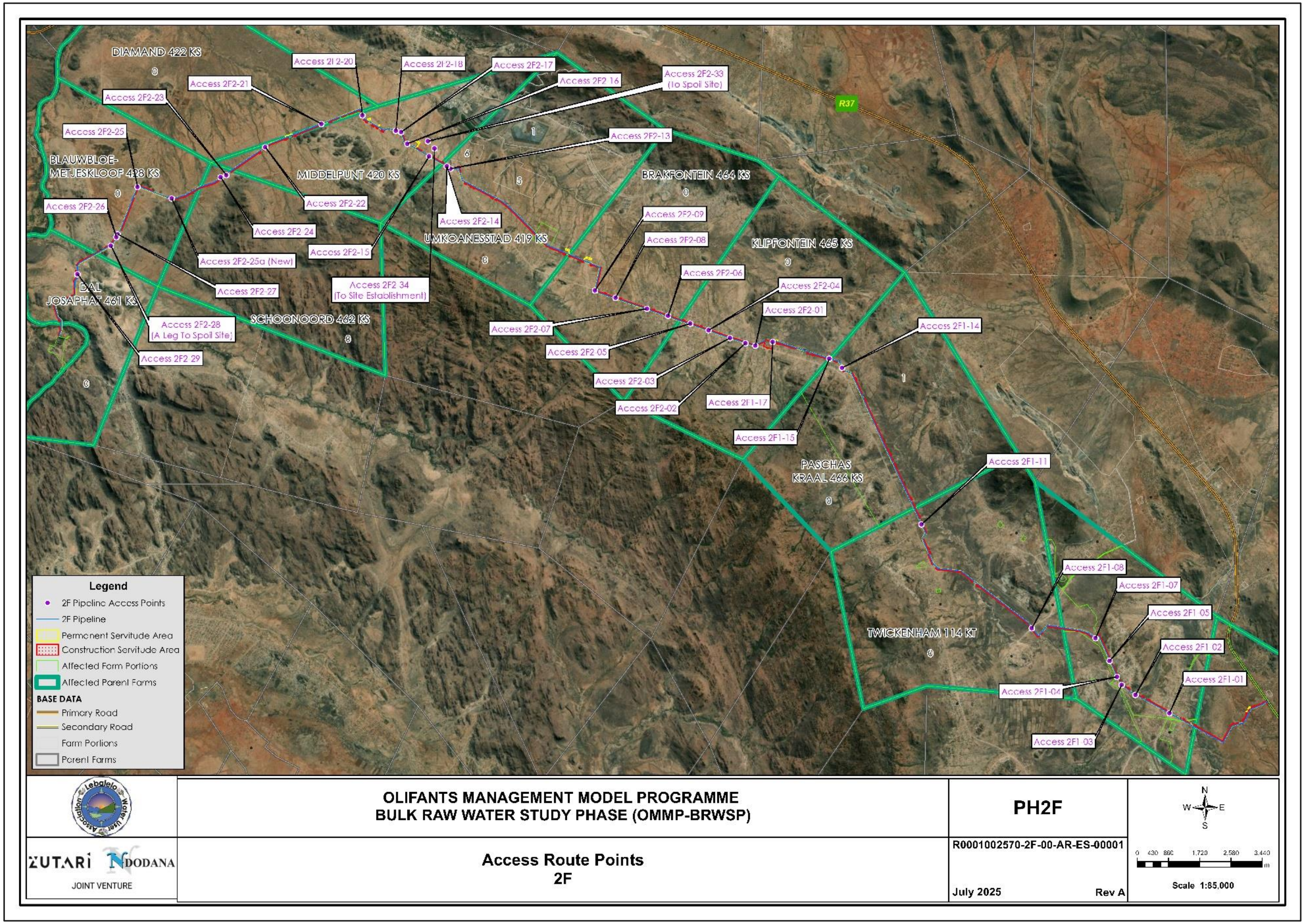

Figure 2-8: Layout of access points

The assessment methodology for this impact is summarised in Table 2-11. Access roads were mainly classified as either being new or existing based on available aerial imagery.

Table 2-11: Access road classification

Status	Type	Assumed Upgrades	Additional Hydrological Impacts to be Mitigated
Existing	Paved Road	None	None
	Unpaved Road		
New	Informal Tyre Tracks or Footpath	Grading, followed by the placement of gravel surfacing.	Local erosion due to increased stormwater run-off volumes and the concentration of this run-off. Downstream siltation due to migration of fine material in stormwater run-off.
	New Road	Clearing and grubbing, followed by grading, followed by the placement of gravel surfacing.	

Figure 2-9 and Figure 2-10 illustrate examples of an existing and a new proposed access road, respectively. In these figures, the permanent servitude is indicated by green lines, the temporary servitude by red lines, and the pipeline alignment is shown in blue.

Examples of an existing and a new access road are shown in Figure 2-9 and Figure 2-10 respectively.

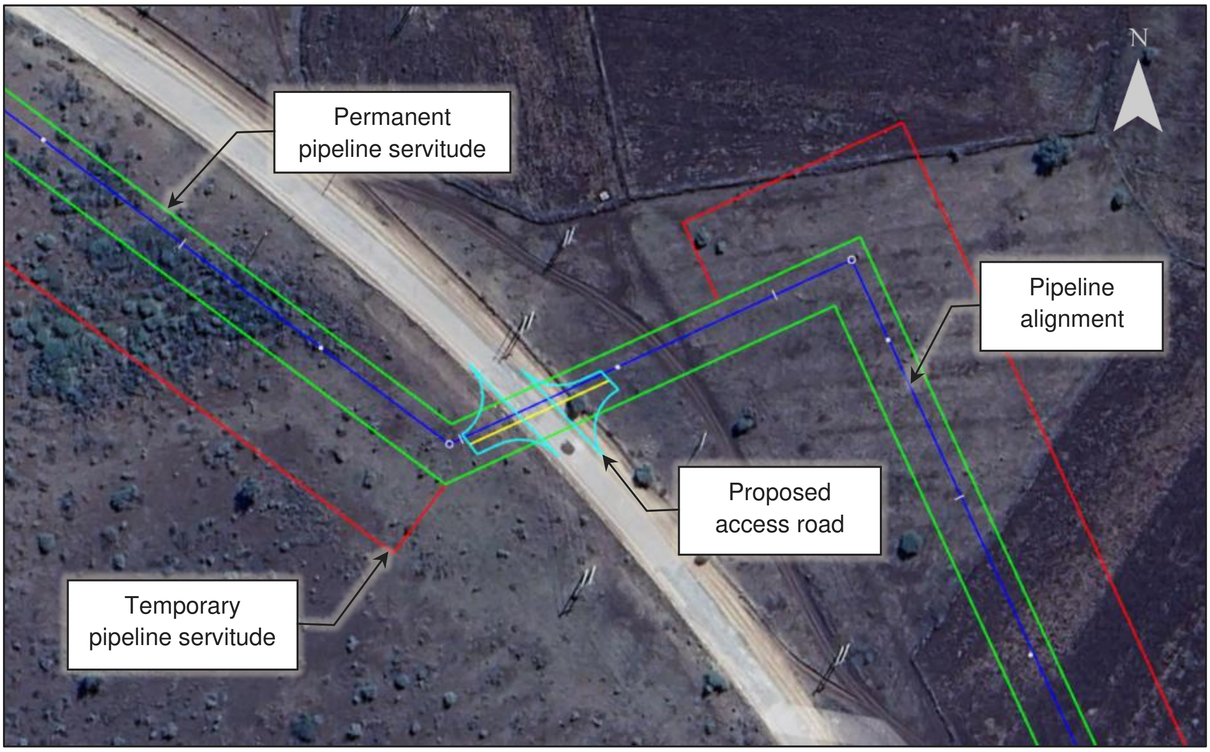

Figure 2-9: Example of an access point running off an existing paved road

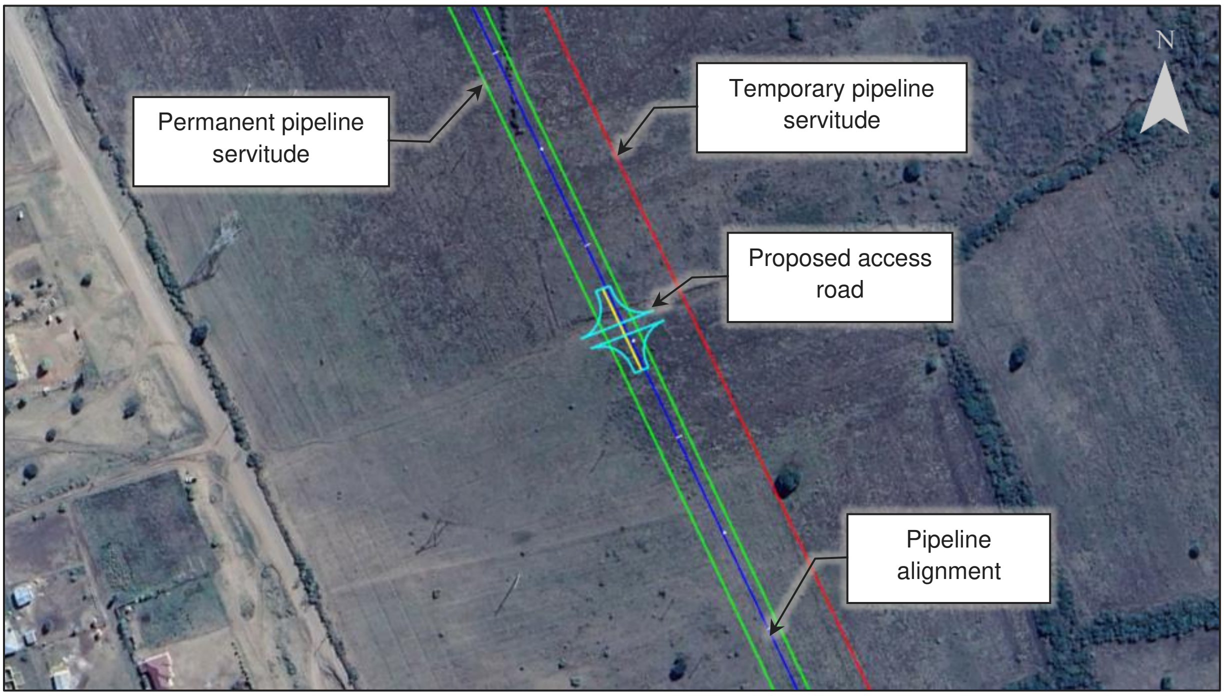

Figure 2-10: Example of an access point that will require the development of a new access road

Certain access roads include bell mouth entrances that diverge from existing roads and extend only a few meters into the pipeline servitude. Figure 2-11 illustrates a typical example of such an access point originating from an existing paved road.

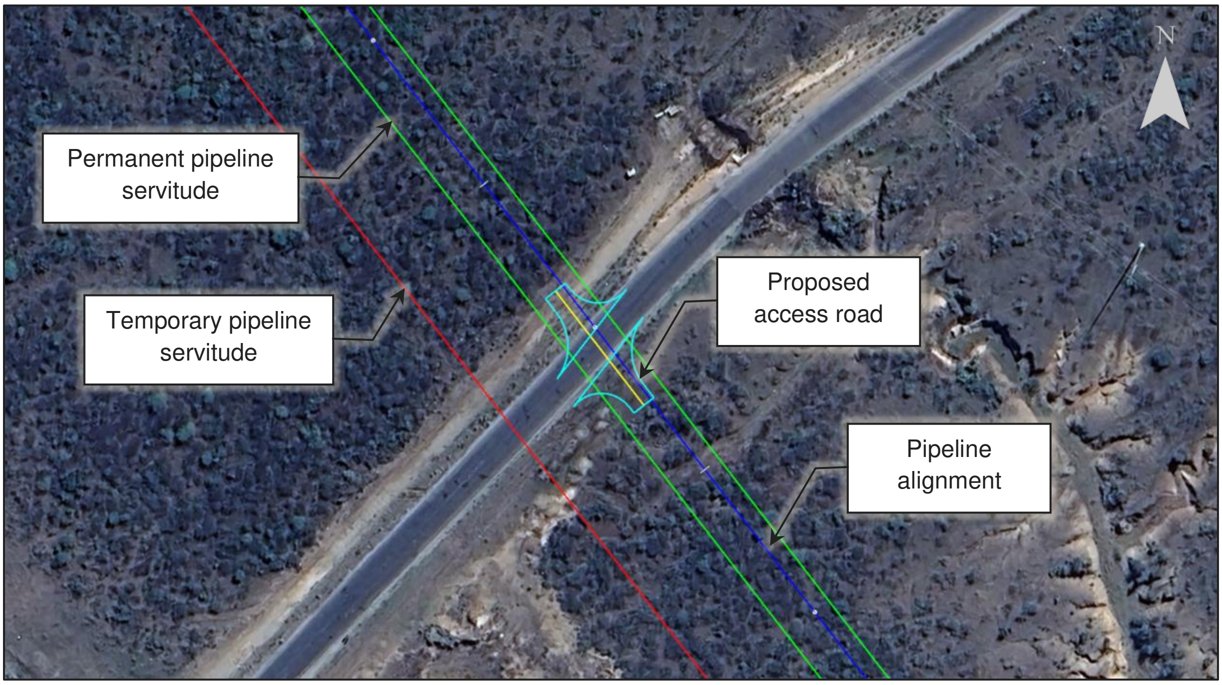

Figure 2-11: Example of a bell mouth access point to the pipeline servitude

For access roads utilising existing roads, no modifications are expected other than that associated with an increased rate of wear due to a potential increase in traffic. In the case of new access roads, the proximity thereof to a delineated watercourse was qualitatively assessed using a visual review of aerial imagery to determine whether there was a reasonable potential for a road to fall within a 1 in 100-year floodline. If so, an appropriate mitigation measure was put forward which considered the potential relocation of the access road. Informal tyre tracks and footpaths were designated as new access roads, as they are likely to undergo minor alterations for construction activities (i.e. widening, grading, compaction etc.).

If the visual assessment indicated that the access road was likely to fall outside of the 1 in 100-year floodline, then it was assumed that the access road could be retained and that minor upgrades could potentially be made to the access road footprint as described in Table 2-11, including mitigation measures related to the aforementioned minor upgrades. The results based on this methodology are put forward in Section 3.2.

2.4 Site Visit

A site visit was conducted to assist with building an understanding of the prevailing hydrological conditions in the area to inform hydrological calculations, and to gather information on relevant hydraulic structures for incorporation into hydraulic modelling.

An important observation during the site visit was the high erosion potential in the area. This was evident at two pipeline watercourse crossings for an existing pipeline located within close proximity of the Phase 2F alignment (although not within the realigned portion). Figure 2-12 shows an example of this existing pipeline being undermined due to erosion at a location within ±40 m of the downstream of a planned crossing for the Phase 2F alignment. Figure 2-13 shows another eroded and undermined existing crossing located ±200 m downstream of the Phase 2F alignment to which retrofitted erosion control measures have had to be applied.

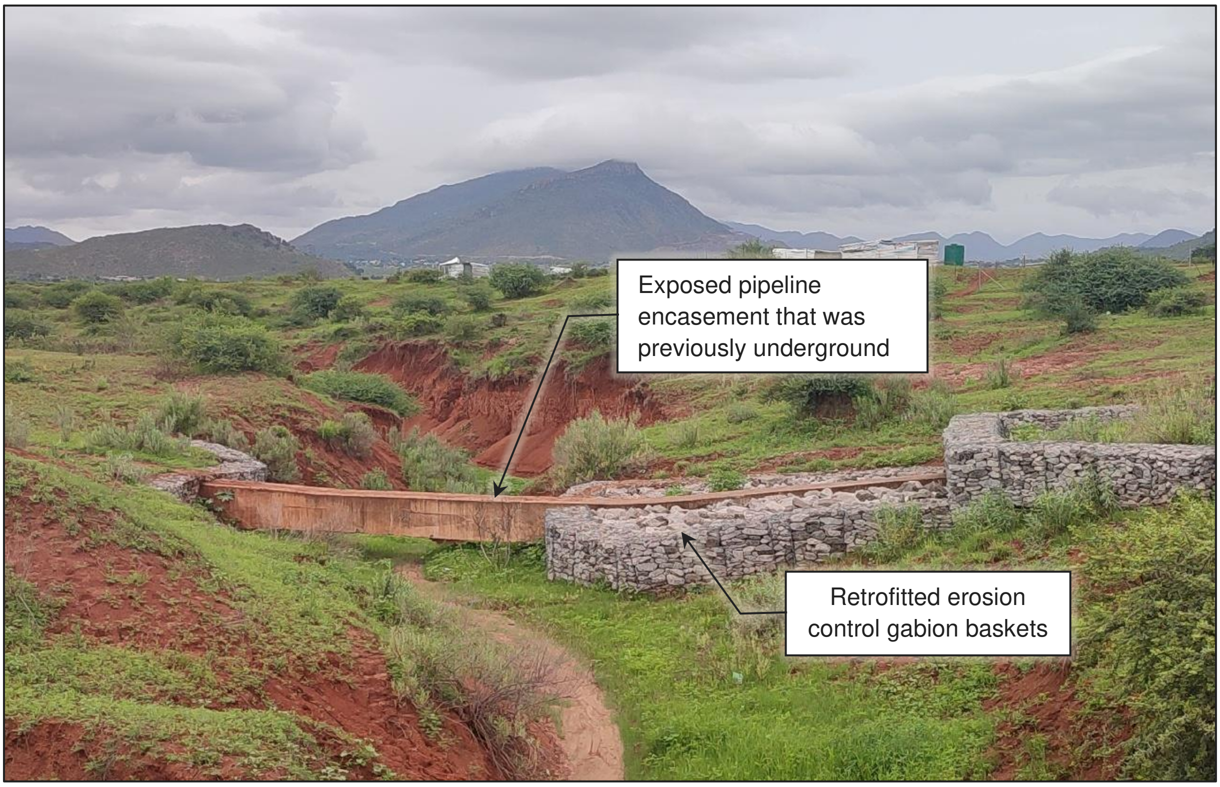

Figure 2-12: Example of an eroded and undermined pipeline crossing

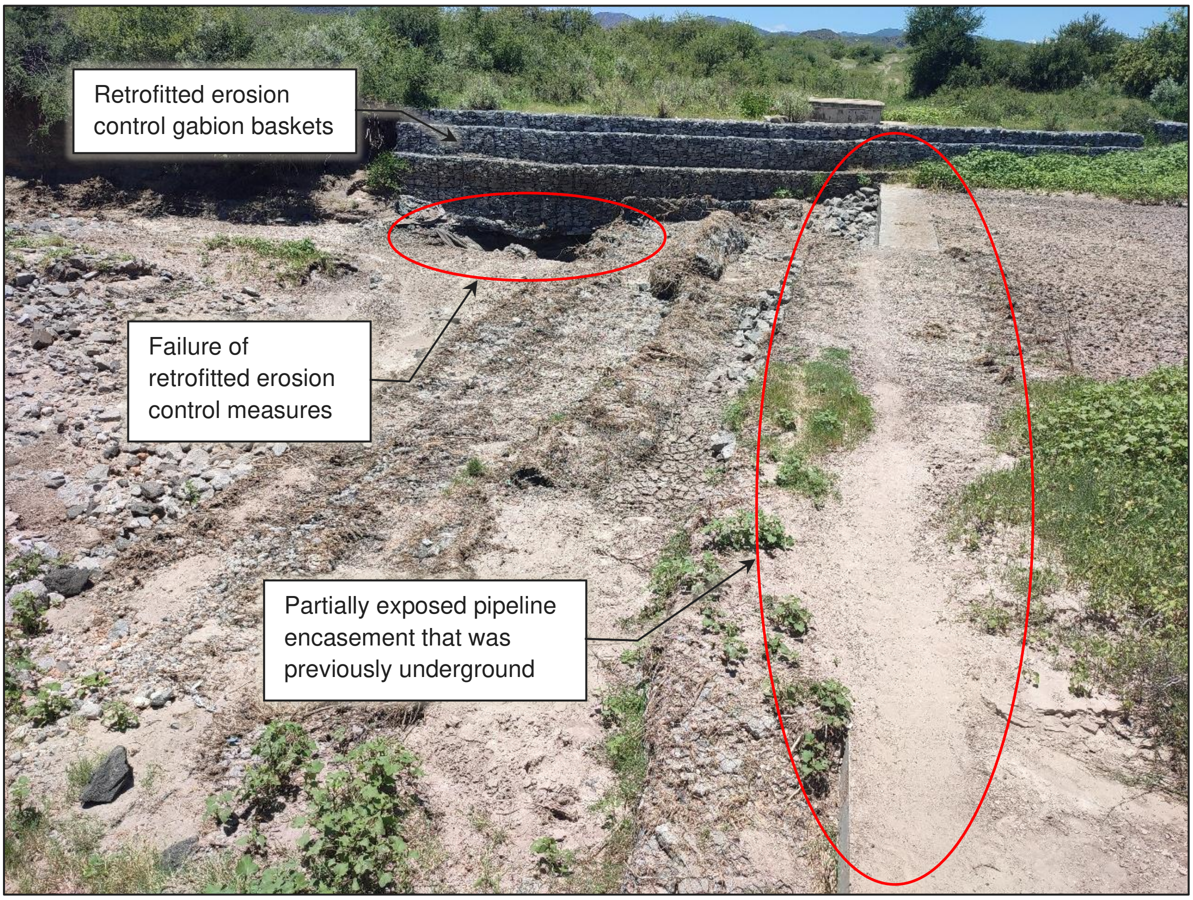

Figure 2-13: Retrofitted erosion protection measures for an underground pipeline

Figure 2-14 shows an aerial view of the pipeline crossing shown in Figure 2-13 above dated January 2007, showing minimal signs of erosion. Figure 2-15 provides the same view from December 2012, showing the encased pipeline being exposed by natural erosion of the watercourse. Figure 2-16 shows the same crossing from June 2023, which provides additional insight of the extent of remedial measures that had to be taken in this area to protect both the pipeline and the riverbed.

Figure 2-14: Aerial view of a nearby underground pipeline crossing from January 2007

Figure 2-15: Underground pipeline crossing (December 2012), showing the exposed encasement

Figure 2-16: Underground pipeline crossing (June 2023), with the erosion control measures

3 Results

3.1 Floodlines and Pipeline Crossings

3.1.1 Section A – Tributary 1

The 1 in 100-year status quo floodline for Section A – tributary 1 is shown in Figure 3-1. The Phase 2F pipeline interacts with the floodline for a linear distance of 76 m as shown in Figure 3-2. A maximum of 1,800 m² of the permanent pipeline servitude falls within the 1 in 100-year floodline. The floodlines do not interact with the temporary pipeline servitude in this area.

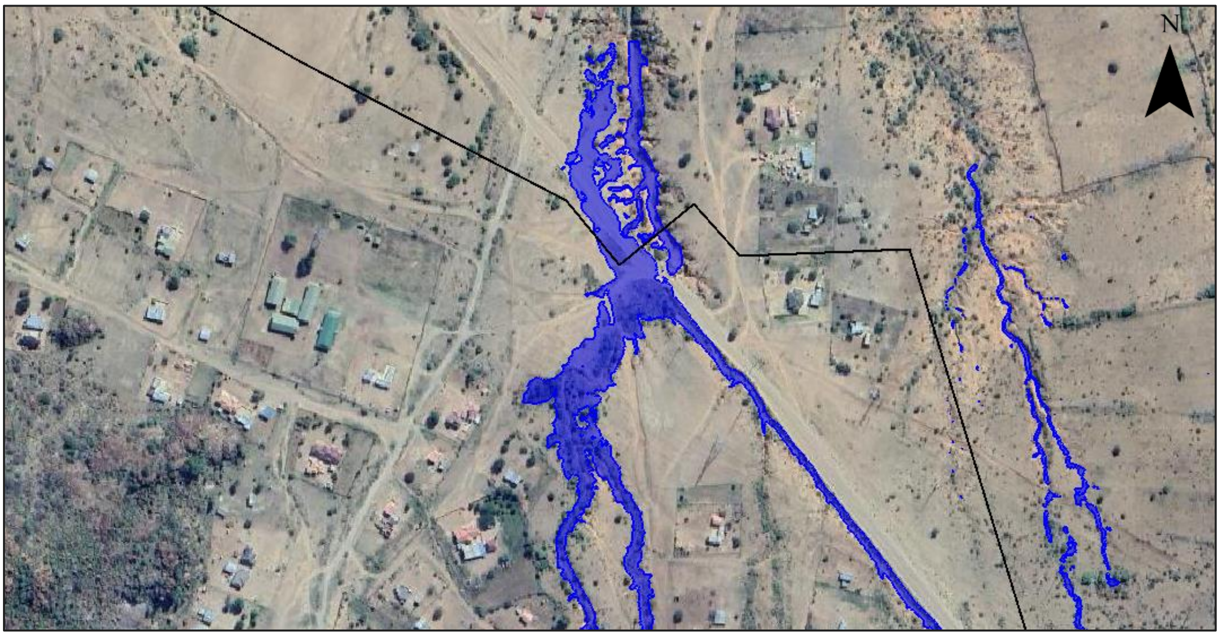

Figure 3-1: 1 in 100-year floodline for Section A – Tributary 1

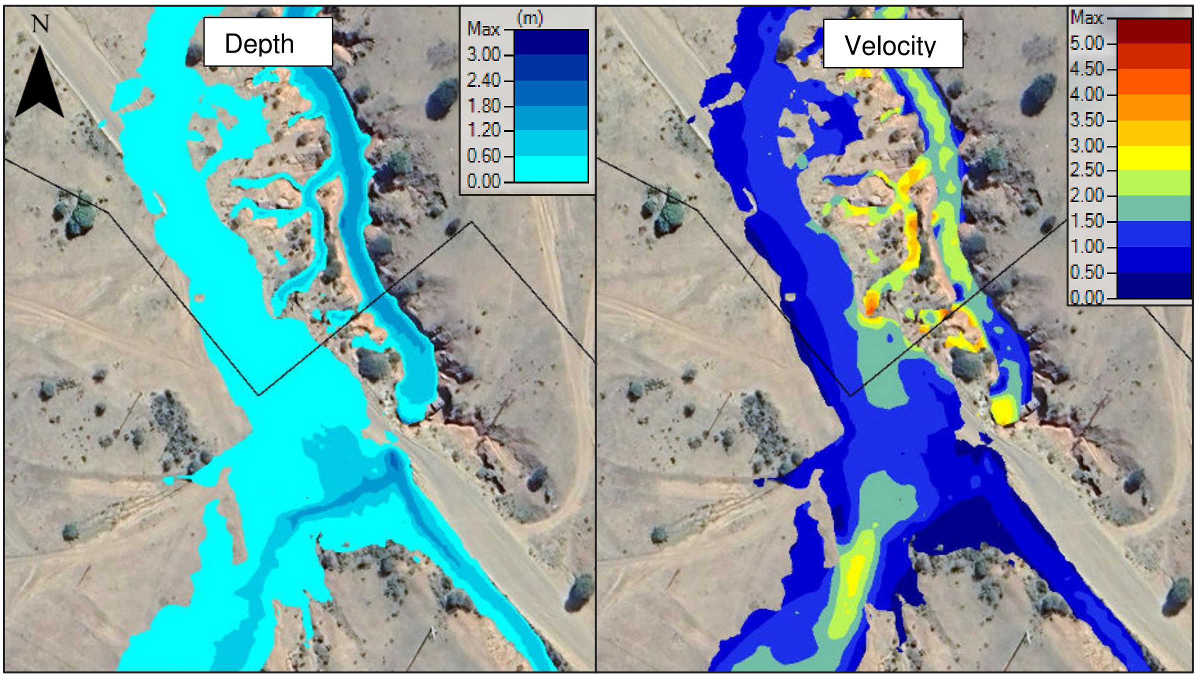

Figure 3-2: Interaction between the pipeline alignment and Section A – Tributary 1

3.1.2 Section A – Tributary 2

The 1 in 100-year status quo floodline for Section A – Tributary 2 is shown in Figure 3-3. The Phase 2F pipeline interacts with the floodline for a linear distance of 40 m is shown in Figure 3-4. A total of 680 m² of the permanent pipeline servitude falls within the 1 in 100-year floodline. The floodlines do not interact with the temporary pipeline servitude in this area.

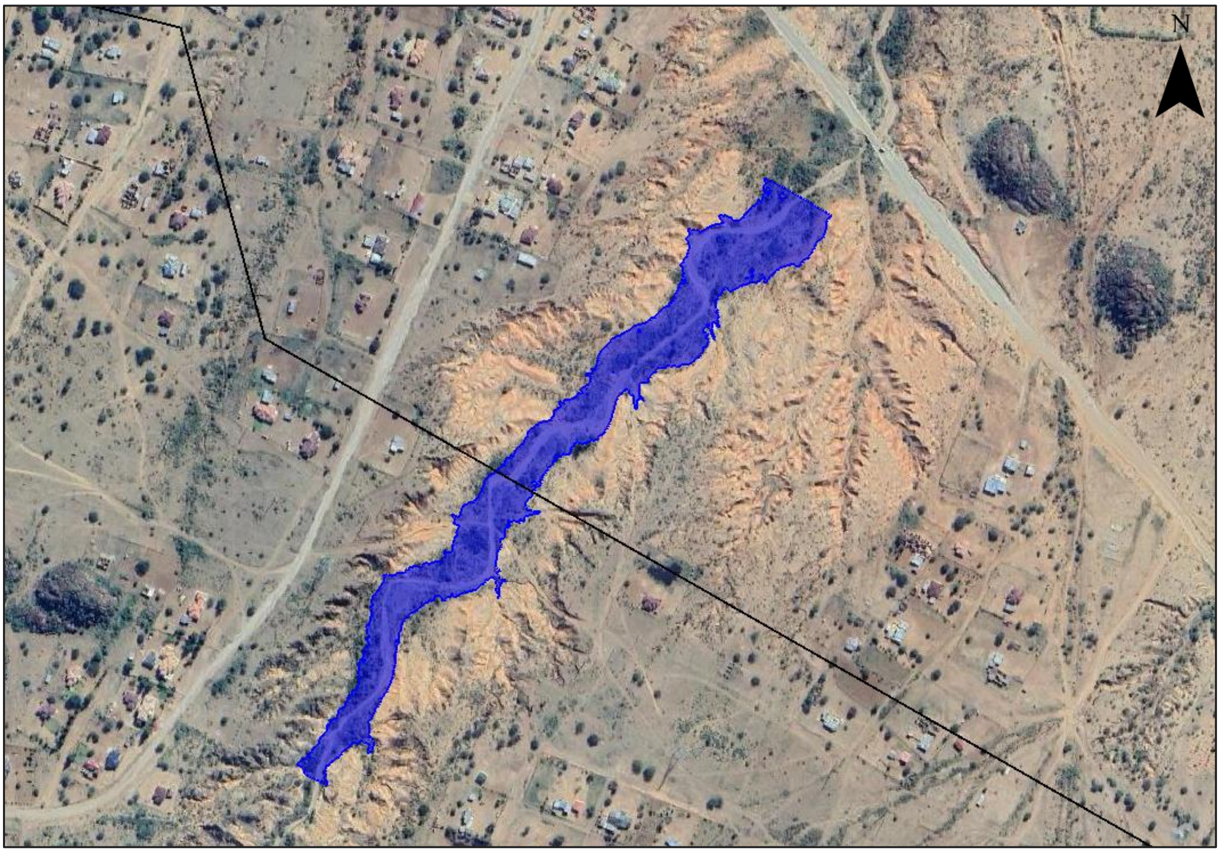

Figure 3-3: 1 in 100-year floodline for Section A – Tributary 2

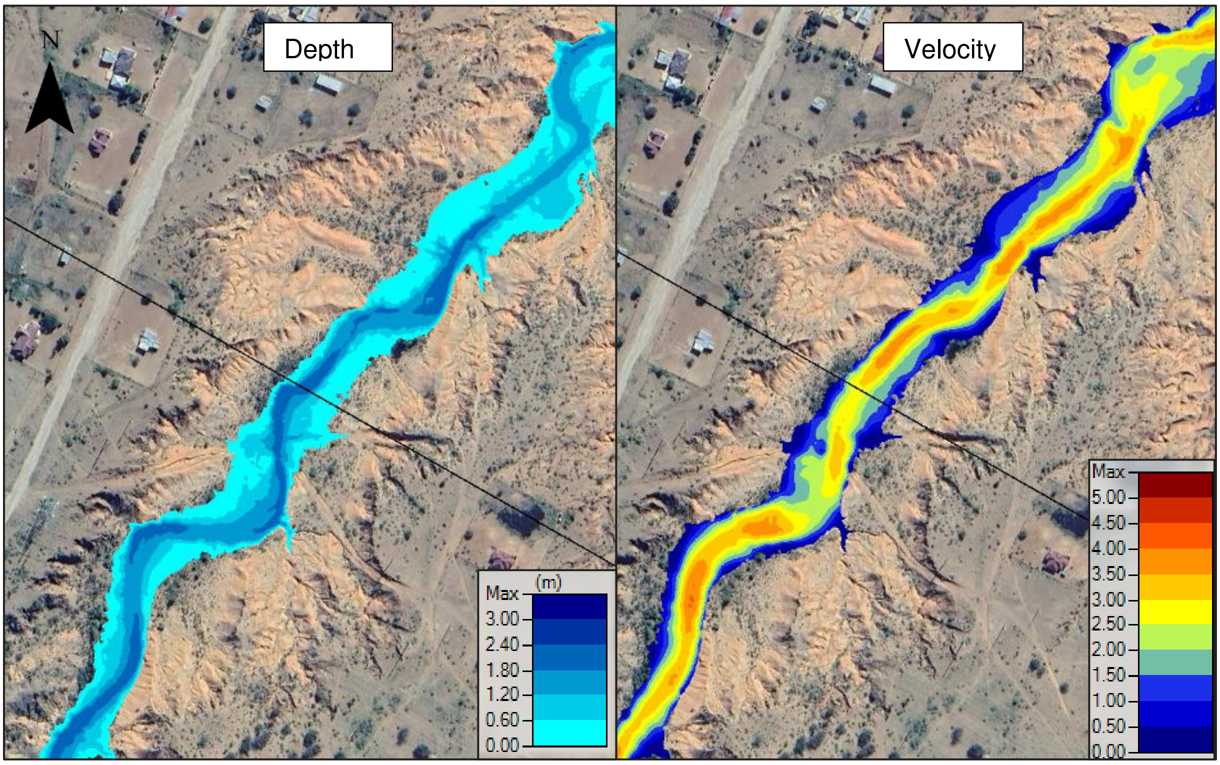

Figure 3-4: Interaction between the pipeline alignment and Section A – Tributary 2

3.1.3 Section A – Tributary 3, 4 and 5

The 1 in 100-year status quo floodline for Section A - Tributary 3, 4 and 5 is shown in Figure 3-5. The Phase 2F pipeline interacts with the status quo floodline for linear distances of 6 m, 5 m and 30 m for tributary 3, 4 and 5 respectively as shown in Figure 3-6. 160 m², 420 m² and 1,410 m² of the permanent pipeline servitude for tributaries 3, 4 and 5 falls within the 1 in 100-year floodline respectively. The floodlines do not interact with the temporary pipeline servitude in this area.

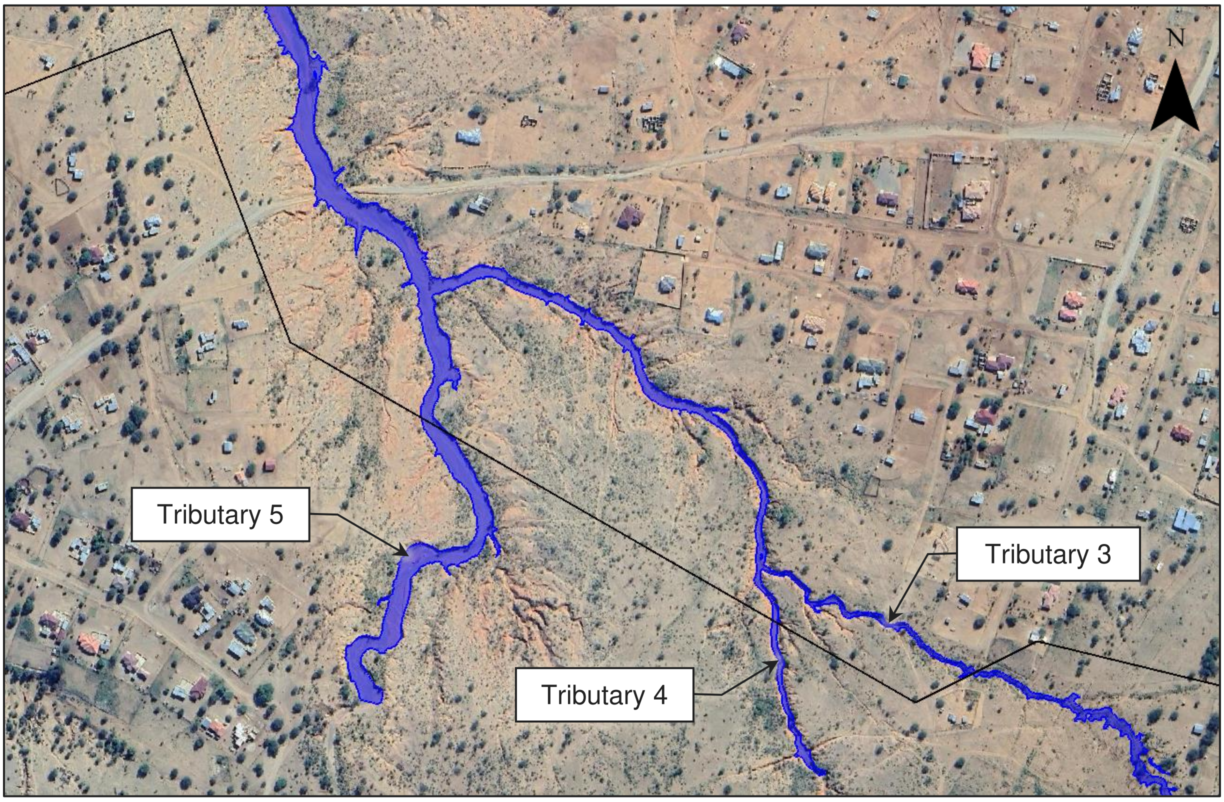

Figure 3-5: 1 in 100-year floodline for tributaries 3, 4 and 5 of Section A

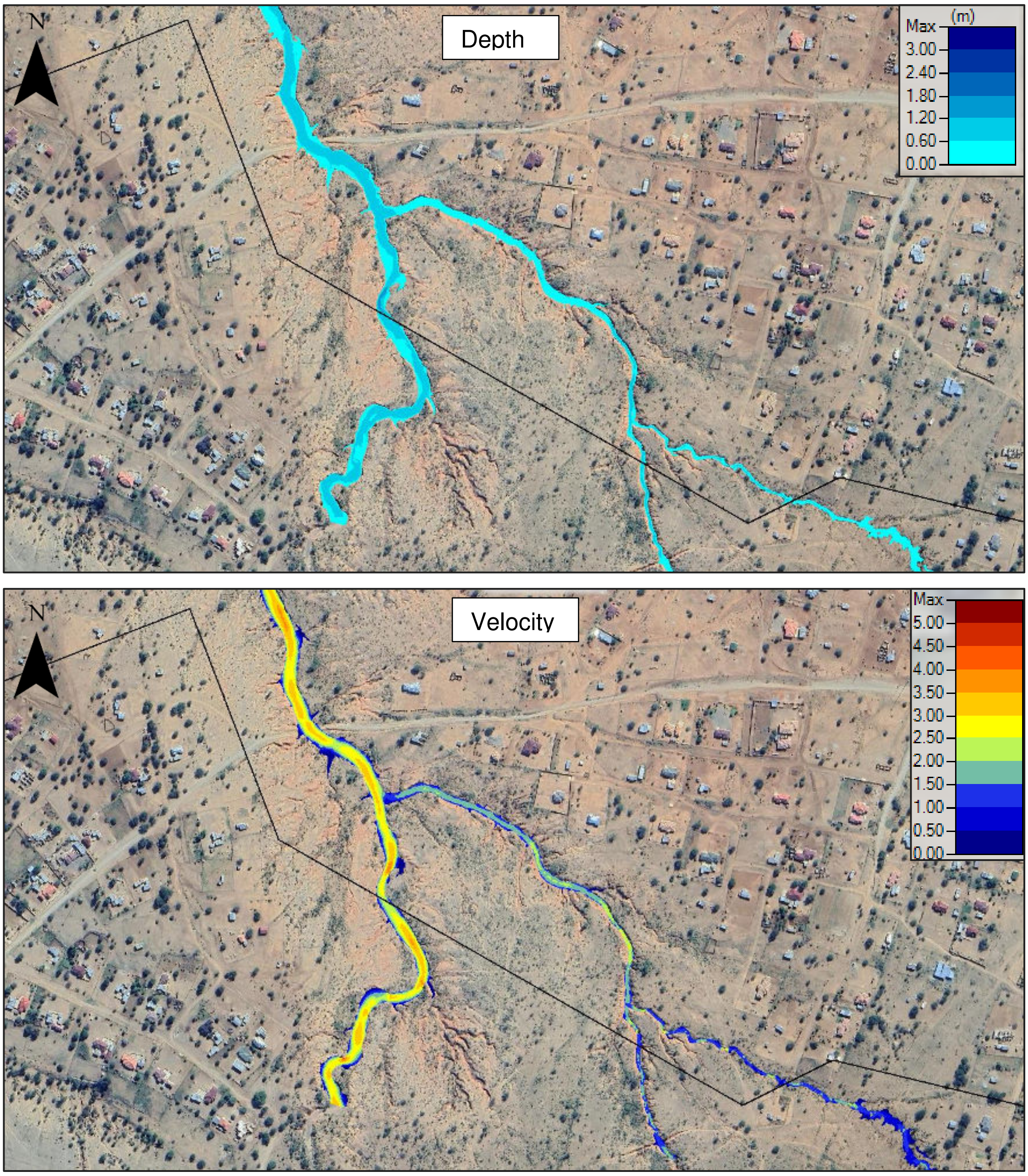

Figure 3-6: Interaction between the pipeline alignment and tributaries 3, 4 and 5 for Section A

3.1.4 Section B – Tributary 1

The 1 in 100-year status quo floodline for Section B – Tributary 1 is shown in Figure 3-7. The Phase 2F pipeline interacts with the floodline for a linear distance of 45 m as shown in Figure 3-8. 680 m^2 of the permanent pipeline servitude and 970 m^2 of the temporary servitude falls within the 1 in 100-year floodline.

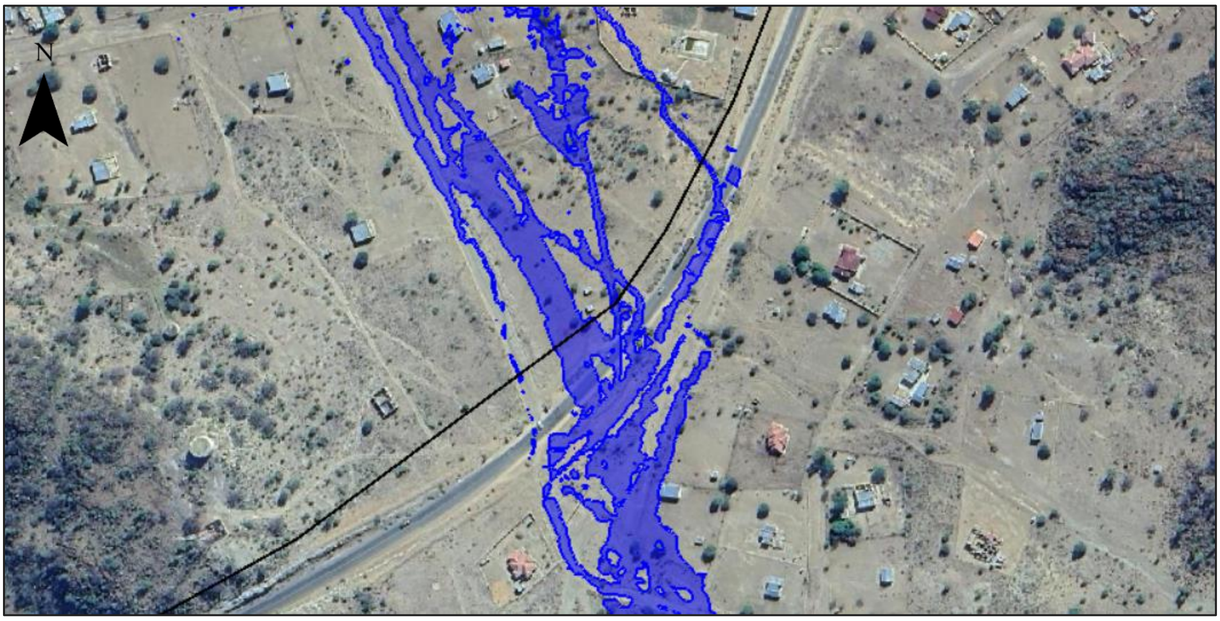

Figure 3-7: 1 in 100-year floodline for Section B – Tributary 1

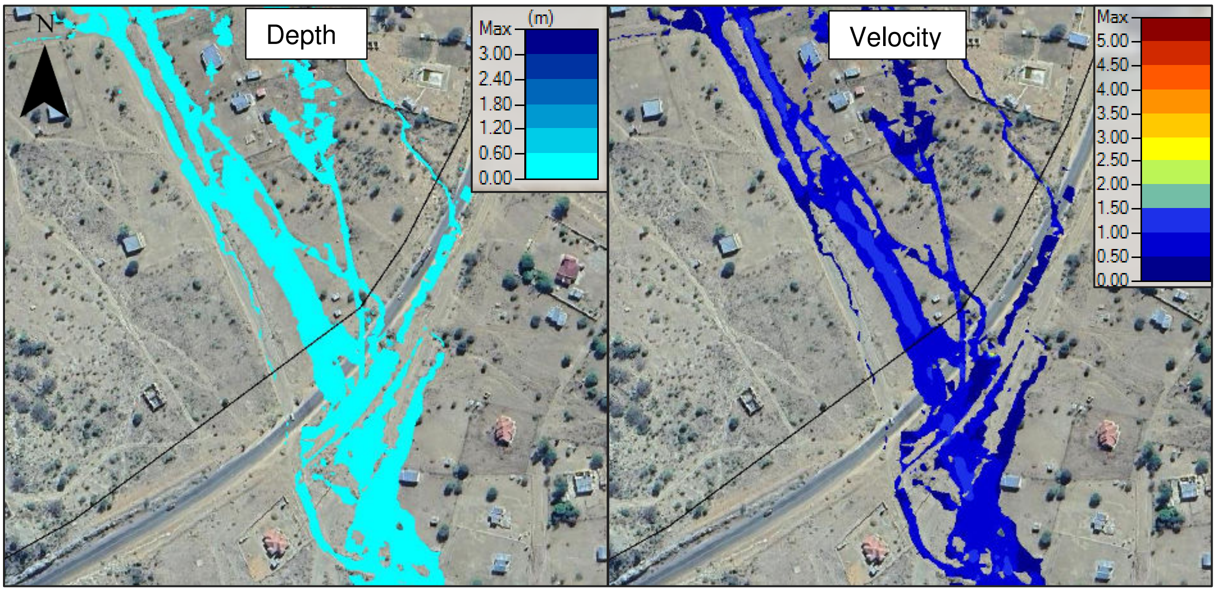

Figure 3-8: Interaction between the pipeline alignment and Section B – Tributary 1

3.1.5 Section C – Tributary 1

The 1 in 100-year status quo floodline for Section C – Tributary 1 is shown in Figure 3-9. The Phase 2F pipeline interacts with the floodline for a linear distance of 350 m as shown in Figure 3-10. 5,670 m² of the permanent servitude and 8,500 m² of the temporary pipeline servitude falls within the 1 in 100-year floodline.

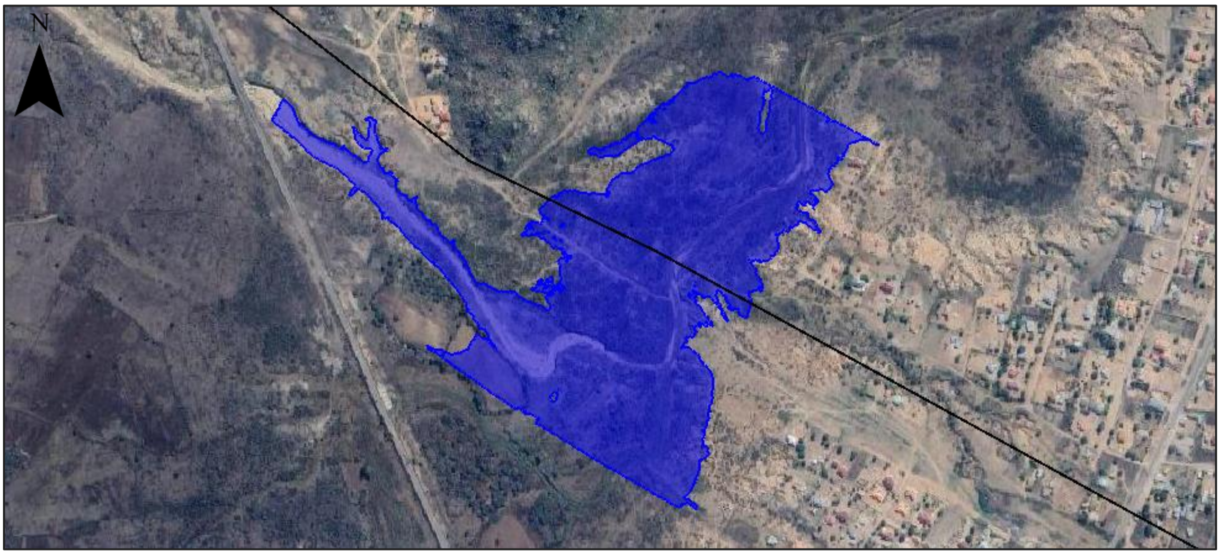

Figure 3-9: 1 in 100-year floodine for Section C – Tributary 1

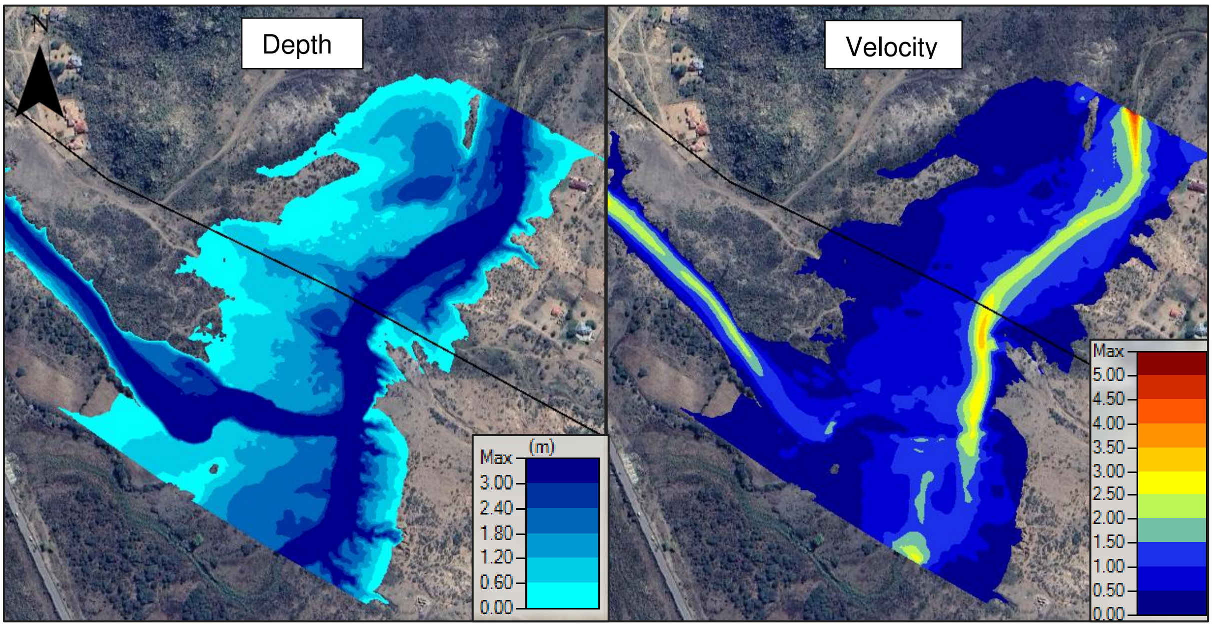

Figure 3-10: Interaction between the pipeline alignment and Section C – Tributary 1

3.1.6 Section C – Tributary 2

The 1 in 100-year status quo floodline for Section C – Tributary 2 is shown in Figure 3-11. The Phase 2F pipeline interacts with the floodline for a linear distance of 215 m as shown in Figure 3-12. 2,900 m^2 of the permanent servitude and 2,200 m^2 of the temporary pipeline servitude falls within the 1 in 100-year floodline.

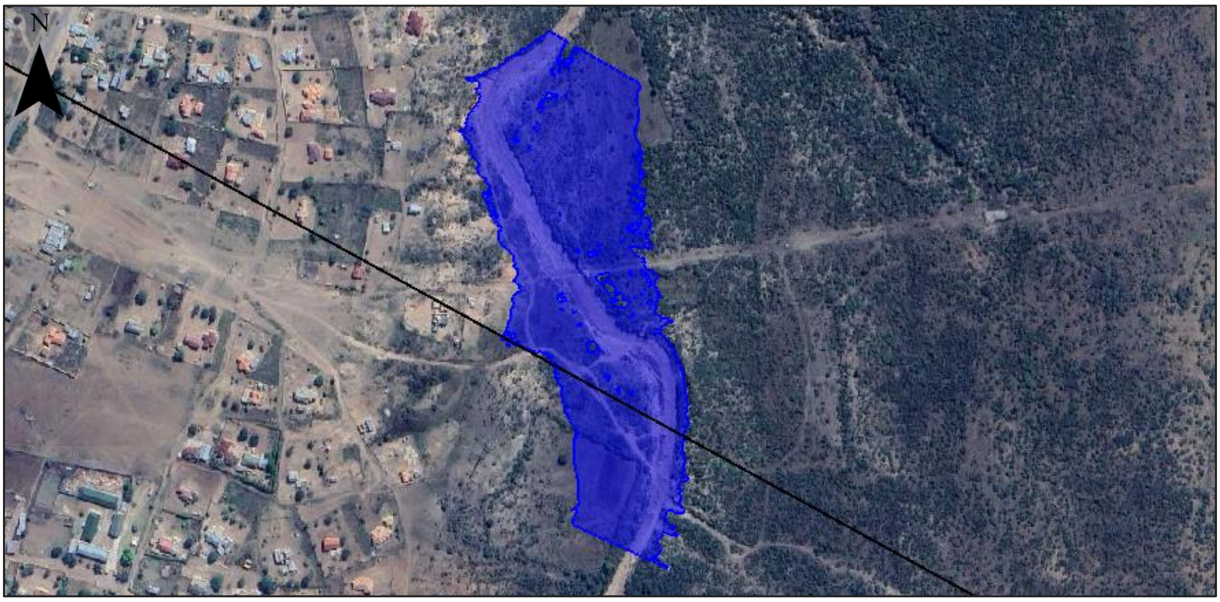

Figure 3-11: 1 in 100-year floodine for Section C – Tributary 2

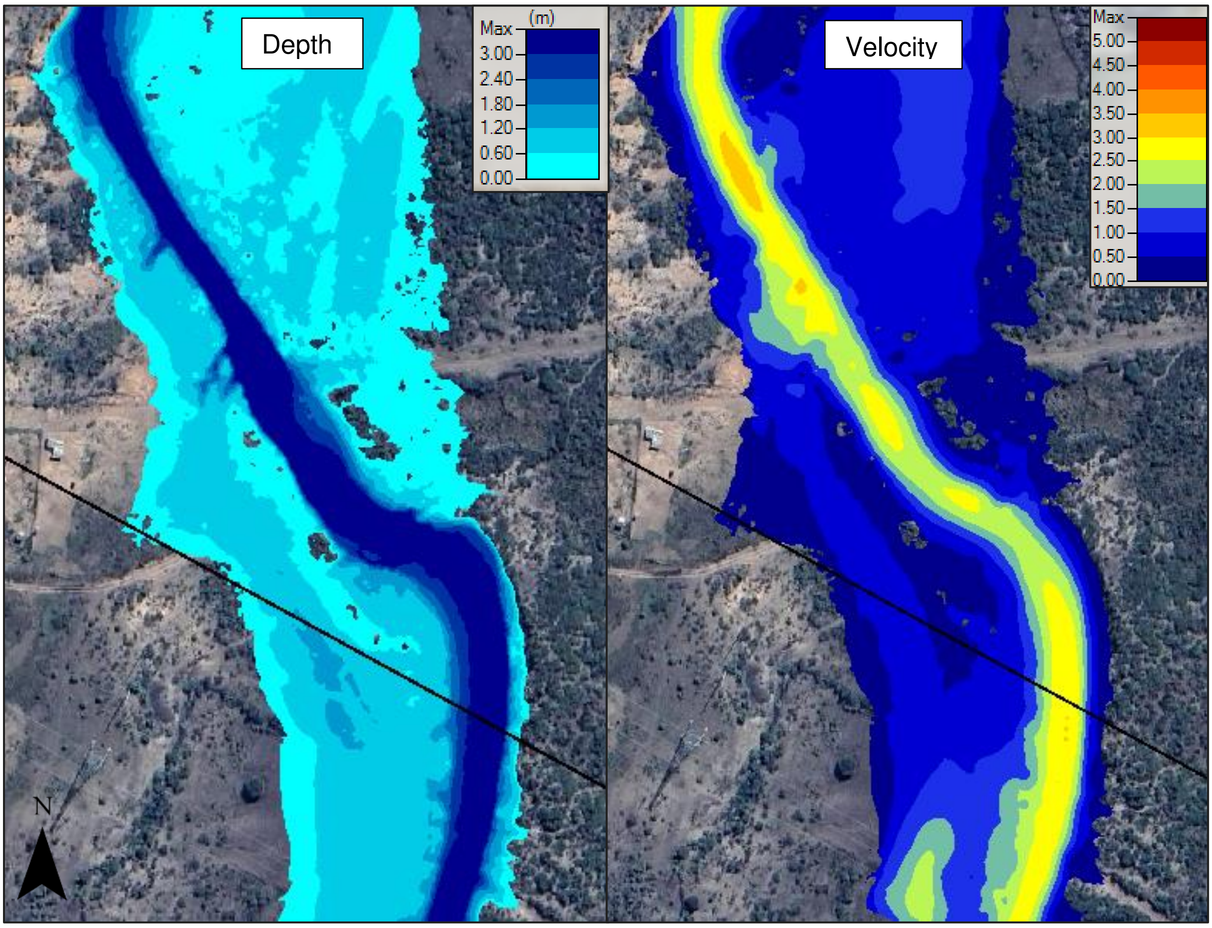

Figure 3-12: Interaction between the pipeline alignment and Section C – Tributary 2

3.2 Access Roads

3.2.1 Classifications and Mitigations

Access roads were classified as per the methodology put forward in Section 2.2.1 above. Table 3-1 puts forward a summary of the number of access roads by type. Table 3-2 provides detailed classification per access road including appropriate mitigation measures in keeping with the principles set forward in Section 2.2.1 above. Section 3.2.2 below provides additional information on certain new access roads for which additional context was deemed necessary and Section 3.2.3 provides general mitigation measures which could be implemented for the other access roads.

Table 3-1: Numerical summary of access roads by type

Status	Type	Total Number
Existing	Formal Paved Road	6
	Formal Gravel / Unpaved Road	28
New	Informal Tyre Tracks or Footpath	2
	New Road	3

Table 3-2: Detailed classification of access roads

Access Number	Status	Road Type	Proposed Mitigation Measures
2F1-01	Existing	Paved Road	—
2F1-02	Existing	Unpaved Road	Erosion and siltation management.
2F1-03	Existing	Unpaved Road	—
2F1-04	Existing	Unpaved Road	—
2F1-05	Existing	Unpaved Road	—
2F1-07	Existing	Paved Road	—
2F1-08	Existing	Paved Road	—
2F1-11	Existing	Gravel Road	—
2F1-14	Existing	Unpaved Road	—
2F1-15	Existing	Unpaved Road	—
2F1-17	New	New Road	Erosion and siltation management.
2F2-01	Existing	Unpaved Road	—
2F2-02	Existing	Unpaved Road	—
2F2-03	Existing	Unpaved Road	—
2F2-04	Existing	Unpaved Road	—
2F2-05	Existing	Unpaved Road	—
2F2-06	Existing	Unpaved Road	—
2F2-07	Existing	Unpaved Road	—
2F2-08	Existing	Unpaved Road	—
2F2-09	Existing	Unpaved Road	—
2F2-13	Existing	Unpaved Road	—

Access Number	Status	Road Type	Proposed Mitigation Measures
2F2-14	Existing	Unpaved Road	—
2F2-15	Existing	Unpaved Road	—
2F2-16	Existing	Unpaved Road	—
2F2-17	Existing	Unpaved Road	—
2F2-18	Existing	Unpaved Road	—
2F2-20	Existing	Unpaved Road	—
2F2-21	New	Informal Tyre Tracks	Erosion and siltation management.
2F2-22	New	Informal Tyre Tracks	Erosion and siltation management.
2F2-23	Existing	Unpaved Road	—
2F2-24	Existing	Unpaved Road	—
2F2-25	Existing	Unpaved Road	—
2F2-25a	Existing	Unpaved Road	—
2F2-26	Existing	Paved Road	—
2F2-27	Existing	Paved Road	—
2F2-28	Existing	Paved Road	—
2F2-29	Existing	Unpaved Road	—
2F2-33	New	New Road	See Section 3.2.2.1
2F2-34	New	New Road	See Section 3.2.2.2

3.2.2 Detailed Mitigations

3.2.2.1 Access 2F2-33

It is understood that access 2F2-33 provides access to a spoil area as shown in Figure 3-13. It is recommended that the existing unpaved road indicated in Figure 3-13 be used instead of developing a new road which will have an influence on drainage lines and will be sensitive to erosion. Provisions will need to be made for erosion and siltation management. Review of the hydrological impacts of the spoil area itself does not form part of the scope of this assessment.

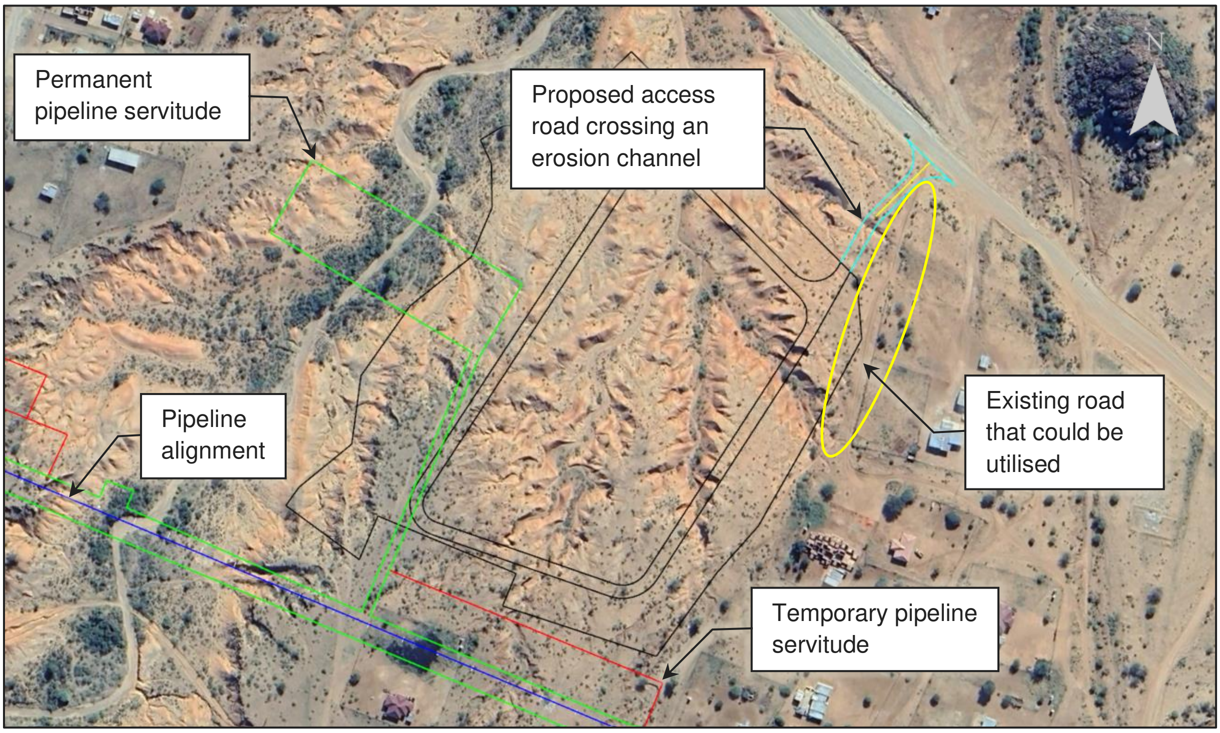

Figure 3-13: Access 2F2-33

3.2.2.2 Access 2F2-34

It is understood that access 2F2-34 provides access to a site establishment area as per Figure 3-14. It is advisable to position this access road further north as shown on Figure 3-14 to increase its distance from the watercourse. Review of the hydrological impacts of the site establishment area itself does not form part of the scope of this assessment.

Figure 3-14: Access 2F2-34

3.2.3 General Mitigations

To minimise erosion and ensure long-term functionality of access roads, particularly where they interact with natural or man-made drainage paths, the following general mitigation measures are recommended:

- Install drifts or culverts at locations where access roads intersect with natural watercourses to facilitate uninterrupted flow and reduce the risk of overtopping.
- Construct side drains along the upstream side of access roads to collect and safely convey stormwater along the road alignment, preventing water accumulation and surface erosion.
- Protect road embankments against erosion by lining the toe with semi-flexible materials such as Reno mattresses or stone pitching.
- Erosion protection should also be provided at culvert inlets and outlets using durable materials such as stone pitching, reno mattresses, or Armorflex to prevent scour and undermining.
- At junctions where access roads meet paved roads with existing drainage infrastructure, ensure that surface drainage patterns are preserved, if possible, and that flow continuity is maintained.

4 Conclusion and Recommendations

This report assesses the hydrological impact of changes to the scope and extent of the Phase 2F pipeline alignment since it was authorised in 2017. The assessment includes conducting a floodline analyses for three sections of alignment deviation and assessing the impact of various planned access roads. Any recommendations provided aims to mitigate identified hydrological risks associated with the planned infrastructure.

4.1 Flood Risk for Pipe Re-alignment

The flow paths crossing the pipeline were determined and the design floods were established based on current best practice. Watercourse hydraulics for the 1 in 100-year flood event was modelled based on hydrological calculations in HEC-RAS 2D resulting in delineated floodlines. The interactions between the realigned pipeline and these floodlines were then captured.

The aim of the mitigation measures was to address the hydrological impacts where the pipelines are affected by a watercourse. For this reason, the proposed mitigation measures can be divided into two main options:

(a) Placing the pipeline below ground at these areas
(b) Provide a pipe bridge to span the watercourse where feasible

These options are discussed in further detail below:

Mitigation measures (a):

It is understood that the current design intent is to place the pipeline underground which significantly mitigates the overall hydrological impacts of the pipeline when compared to an above ground pipeline. It is therefore anticipated that only structures protruding from the natural ground level may cause adverse hydrological impacts. If these structures are located within the 1 in 100-year floodline boundaries, they may locally alter the natural flow regime which may induce erosion. These structures will mainly include scour valve chambers which are generally located at low points along the alignment of the pipeline.

To mitigate the hydrological impacts of these structures, the following measures can be applied:

- Ensure that structures near watercourses and within floodlines do not impede/obstruct flow.
- Ensure that erosion control measures are implemented so that the protrusions do not exacerbate localised erosion in the area.
- Should the structure be situated in an area which is already subject to significant erosion, soil conservation measures (gabion baskets, silt fences, etc.) should be implemented in an attempt to stabilise the area.
- The hydrological impact during construction should be managed and must consider both downstream and upstream effects.

Additionally, due to the high erosion potential observed during the site visit conducted in January 2025 (refer to Section 2.4), it is essential that additional precautions be taken at pipeline crossings over watercourses. Over time, ground cover above the pipeline may erode, potentially exposing the pipeline and increasing the risk of hydrological impacts. These may need to be managed in future, similar to the retrofitted erosion protection measures observed in the area. This natural variability should be accounted for during the detailed design phase, and it is therefore recommended that the following considerations be incorporated into the detailed design:

- Cover and backfill requirements:
    - This may be informed by sediment transport and erodibility assessments coupled with flow velocity determinations.
- Maximum undermined pipeline span (should excessive erosion be experienced):

- An undermined pipeline will be subject to gravitational forces, as well as significant drag forces imparted by the flow of water. These forces have the potential to damage the pipeline, which may in turn cause significant downstream damage in the event of sudden pipeline failure. The potential for, and consequences of, such a sudden failure should be assessed.

► Erosion protection and soil conservation structures:

  - Construct erosion protection measures at all pipeline-watercourse crossings. These structures should be designed based on local flow velocities, flow depths, and soil erosivity conditions.
  - Construct soil conservation structures in erosion prone areas, such as dongas and gullies near the pipeline, to mitigate the progression of head-cuts in these areas.
  - Both structures should aim to reduce the flow velocity upstream of the structure, effectively promoting sedimentation.
  - Allowance should also be made for a key wall on the downstream side to intercept any potential head-cuts from progressing upstream which will allow the downstream reach to reach equilibrium in terms of sediment transport.

It is anticipated that by implementing the recommendations mentioned above, an overall improvement to risk of erosion in the area can be achieved. The mitigation measures will improve the stability of the watercourses and promote sedimentation in the upstream of the control structures essentially improving the overall hydrological impacts in the area. Ongoing maintenance and the surveying of donga growth should be monitored annually post construction.

Mitigation measures (b):

Alternatively, another approach that may be considered is to place the pipeline above the 1 in 100-year floodline by means of a pipe bridge in areas where excessive velocities and erosion is anticipated. The following may be considered:

► Ensure that portions of the pipeline that spans across the floodline boundary are above the water surface elevation of the 1 in 100-year flood.
► Locate the pipe supports outside the regulated boundaries where possible.
► Should pipe supports be required within the 1 in 100-year floodline boundary, appropriate erosion protection measures should be incorporated to reduce the risk of erosion compromising the supports.

Although this may reduce the immediate need of large erosion control measures and soil conservation structures at crossings, this does not prevent the propagation of head-cuts and there may be an increased risk for a local point failure at bridge supports. Consequently, erosion protection measures at the footing locations must be managed accordingly. In areas where long spans and multiple footings within the floodline are required, pipe bridges are not suggested due to the risk of failure.

As this assessment was prepared to reference design level as per NEC, revised post-construction floodlines should be delineated as part of the final design and the detail design must ensure that the impact of these post-construction floodlines is fully mitigated, including the risk of inundation of property and infrastructure, and the risk of the exacerbation of erosion and sedimentation.

4.2 Access Roads

The access roads were assessed based on the criteria set out in Section 2.3 and stormwater management interventions are proposed to mitigate the impact of new access roads on the current hydrological conditions. The primary objective of these interventions is to preserve natural or man-made flow paths and to minimise erosion resulting from the construction of the new access roads. The proposed mitigations measures are listed below:

- Drift or culverts should be installed where access roads cross natural flow paths to allow for uninterrupted water movement.
- Side drains should be constructed along the upstream side of the road to collect and convey stormwater water along the road alignment.
- Erosion protection should be implemented by lining the toe of the road embankments with semi-flexible materials such as reno mattresses or stone pitching.
- Culvert inlets and outlets should be protected against erosion using durable materials like stone pitching, reno mattresses or Armorflex.
- Where access roads connect to paved roads where side drainage is present, the relevant surface drainage should be maintained by the access road.

5 References

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Appendix A
Specialist Declaration

forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

Private Bag X447, Pretoria, 0001, Environment House, 473 Steve Biko Road, Pretoria, 0002 Tel: +27 12 399 9000, Fax: +27 86 625 1042

SPECIALIST DECLARATION FORM – AUGUST 2023

Specialist Declaration form for assessments undertaken for application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

REPORT TITLE

OLIFANTS MANAGEMENT MODEL PROGRAMME BULK RAW WATER STUDY PHASE (OMMP-BRWSP): PROPOSED PHASE 2F PIPELINE RE-ALIGNMENT AND ASSOCIATED INFRASTRUCTURE, IN THE FETAKGOMO TUBATSE AND LEPELLE NKUMPI LOCAL MUNICIPALITIES, WITHIN THE CAPRICORN AND GREATER SEKHUKHUNE DISTRICT MUNICIPALITIES, IN THE LIMPOPO PROVINCE.

Kindly note the following:

1. This form must always be used for assessment that are in support of applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting, where this Department is the Competent Authority.
2. This form is current as of August 2023. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.dffe.gov.za/documents/forms.
3. An electronic copy of the signed declaration form must be appended to all Draft and Final Reports submitted to the department for consideration.
4. The specialist must be aware of and comply with '*the 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 act, when applying for environmental authorisation - GN 320/2020)*', where applicable.

1. SPECIALIST INFORMATION

Title of Specialist Assessment	Hydrological Impact Assessment
Specialist Company Name	Zutari (Pty) Ltd
Specialist Name	Ivan Jenkins
Specialist Identity Number	8810295012086
Specialist Qualifications:	B.Eng
Professional affiliation/registration:	Pr. Eng
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E-mail	Ivan.Jenkins@zutari.com

2. DECLARATION BY THE SPECIALIST

I, Ivan Jenkins declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements 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 (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. "the Protocols") and in Government Notice No. 1150 of 30 October 2020.
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing –
    - any decision to be taken with respect to the application by the competent authority; and;
    - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the NEMA Act.

Signature of the Specialist

Zutari

Name of Company:

18 Jun 2025

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, _ Ivan Jenkins_________, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

Zutari

Name of Company

18 June 2025

Date

COMMISSIONER OF OATHS (RSA)
Fredah Nkuna
Designation: HR Professional | Reg Number: 9334
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Ashlea Gardens, Extension 6
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SABPP™
SA BOARD FOR PEOPLE PRACTICES
Setting HR standards

Signature of the Commissioner of Oaths

18 JUNE 2025

Date

In diversity there is beauty and there is strength.

MAYA ANGELOU

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