TRANS-CALEDON TUNNEL AUTHORITY

CONSULTING SERVICES FOR THE BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT No. TCTA 21-041

RISING MAIN CONCEPT DESIGN

26 NOVEMBER 2021

AMANZI ENTABA JOINT VENTURE

Report No: 1A-R-211-06 (Rev B)

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RISING MAIN CONCEPT DESIGN

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RISING MAIN CONCEPT DESIGN

ABBREVIATION AND ACRONYMS

AEJV	Amanzi Entaba Joint Venture
AI	Aggressiveness Index
BRVAS	Berg River Voëlvlei Augmentation Scheme
CCPP	Calcium Carbonate Precipitation Potential
CCT	City of Cape Town
dia	diameter
DN	Nominal Diameter
D/t	Diameter (D) divided by pipe wall thickness (t)
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EWRs	Environmental Water Requirements
GRP	Glass-fibre reinforced polyester
h	hours
HDPE	High-Density Polyethylene
JV	Joint Venture
km	kilometre
m	meter
m asl	meter above sea level
m^3/s	cubic meters per second
m/s	metre per second
M&E	Mechanical and Electrical
NDU	Natural Drainage Unit
NERSA	National Energy Regulator of South Africa
O&M	Operation and Maintenance
PV	Present Value
PDBC	Plant and Design Build Contract
RID	Record of Implementation Decision
TCTA	Trans-Caledon Tunnel Authority
WCWSS	Western Cape Water Supply System

1. INTRODUCTION

1.1. Scope

The Berg River Voëlvlei Augmentation Scheme (BRVAS) Inception Report (Report No. 1A - R - 2112 - 01 (Rev B) dated 22 April 2021 has reference. During the review of the available Feasibility Study and related documentation, a number of shortcomings and gaps in the feasibility designs were identified and recorded in the Inception Report. A proposal to develop the feasibility designs to a higher level of detail, to address shortcomings and gaps related to the Rising Main, was submitted to TCTA on 26 April 2021 (AEJV letter ref. 3177-00-00/1 (AEJV-TCTA-L033). TCTA accepted the proposal on 29 April 2021 (TCTA letter ref. AEJV 023-290421).

This report was compiled in line with the above proposal and addresses the following aspects:

a) Design capacities and system yields;

b) Pipeline routing, servitude details and wayleaves;

c) Pipeline materials, pipeline diameter optimisation and hydraulic assessments; and

d) Outlet at Voëlvlei Dam, structures related to the reverse flow application and valve chambers.

1.2. Background and BRVAS Description

The Berg River Voëlvlei Augmentation Scheme (BRVAS) involves the transfer of water from the Berg River to the existing Voëlvlei Dam during winter months. The BRVAS will entail the abstraction of surplus winter water (after provision for the Environmental Water Requirements (EWRs) and downstream users) from a proposed low level diversion weir across the Berg River and pumping of the water via a 6.3 km long Rising Main into the Voëlvlei Dam.

According to the Feasibility Study BRVAS consists of the following main components:

- Diversion Weir and Abstraction Works in the Berg River including a crump weir, a soil embankment on the right bank, a fishway, a canoe chute or portage facility and a Pumping Station;
- Water transfer system (i.e. Pumping Station and 6.3 km long Rising Main). The system must allow for releases in summer from the Voëlvlei Dam to the Berg River and downstream users, including West Coast District Municipality Water Treatment Works;
- Appurtenant works – roads, river, road and power line crossings, outlet at the Voëlvlei Dam, control and instrumentation, network infrastructure, network components, etc;
- Decommissioning of the existing canal that will be redundant due to the above. The canal can also only be decommissioned once it's been established how irrigators currently abstracting water from the canal based on their allocations will be serviced by the pipeline;
- Electricity supply and associated installations to energise the Pumping Station; and
- Implementation of measures to mitigate the impact of the project on the environment.

Refer to Figure 1 for a layout of the BRVAS infrastructure as defined during the Feasibility Study. Details of changes to the Diversion Weir and Abstraction Works are provided in the Hydraulic Model Study (draft final report dated 31 August 2021 prepared by the University of Stellenbosch).

The scheme operation has been planned on the basis of winter abstraction from the river whilst still being able to meet the downstream EWRs for the river and the estuary in both summer and winter. A 4 m^3/s stepped pumping rule and a 6 m^3/s abstraction by means of variable speed drive pumps were considered. However, from an ease of operation point of view and the available yield, the 4 m^3/s stepped abstraction was recommended during the Feasibility Study.

The discharge location into the Voëlvlei Dam would best be sited midway between the CCT intake works and that of the West Coast District Municipality (WCDM). This position would be optimum from a conveyance route and pumping perspective, as well as best for facilitating blending and mixing with the water in the dam to ensure that the best possible water quality conditions prevail at the intakes.

2. BRVAS INFRASTRUCTURE COMPONENTS ASSESSED IN THIS REPORT

The main BRVAS infrastructure components, as listed in Section 1.2 above and defined during the Feasibility Study, are reflected in Figure 1.

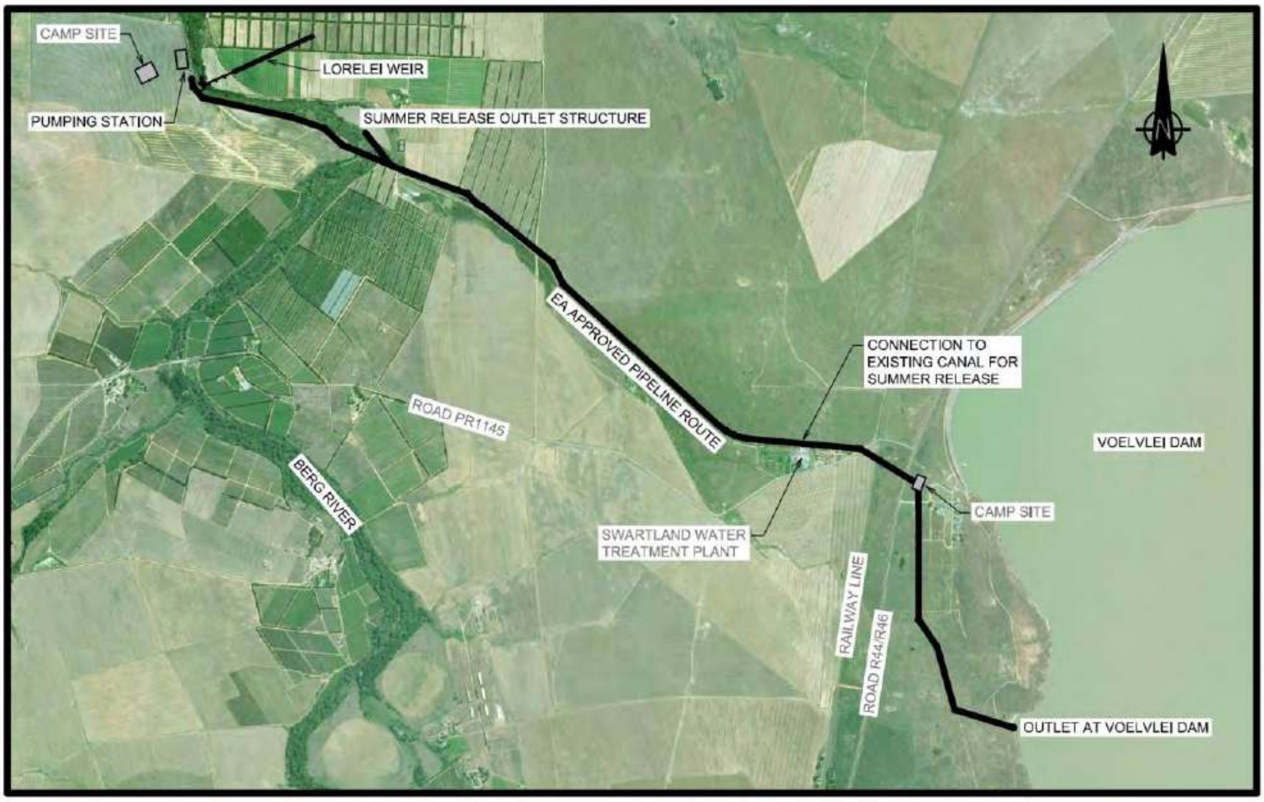


Figure 1: BRVAS Infrastructure Layout (Feasibility Study)

The focus of this report is to determine optimum pipeline diameter and materials. Hydraulic aspects and the associated pumping station requirements are therefore considered. Pipeline routing, servitude details, wayleaves and structures associated with outlet at the Voëlvlei Dam and related to the reverse flow application are also considered.

The selected pipeline diameter will not have an influence on the details and costs of the Lorelei Weir and Abstraction Works, roads and other appurtenant works. The details of these components are therefore not considered in this report.

3. BRVAS YIELD, DESIGN CAPACITY AND ADOPTED AVERAGE PUMPING RATE

Two BRVAS scheme options where considered during the Feasibility Study to supplement the Western Cape Water Supply System i.e.:

- Option 1: 4 m^3/s supply system with stepped pumping rule providing a 1:50 year incremental yield of 23 million m^3/a (operating rule allows for pumping in flow increment steps of 1 m^3/s up to the pumping station capacity of 4 m^3/s and a base flow of at least 1 m^3/s is allowed to pass the site at all times); and

- Option 2: 6 m^3/s supply system with variable speed pumping units providing a 1:50 year incremental yield of 20 million m^3/a (operating rule allows for the exact EWR requirement to pass the site at all times while the balance is abstracted up to the pumping station capacity).

It is assumed that the apparent anomaly, of the lower 4 m^3/s supply system providing the higher incremental yield of 23 million m^3/a, can be attributed to the difference in pumping rules and EWR releases that were adopted for modelling of the two options.

In line with the proposal submitted to TCTA on 26 April 2021, assessments in this report are based on Option 1 i.e. 4 m^3/s supply system with an incremental yield of 23 million m^3/a. Allowance was made for 15% redundancy to cater for climate change as required by TCTA (refer to TCTA letter ref. AEJV 037-020721), the peak capacity of the supply system is therefore 4.6 m^3/s. Variable speed pumping units were adopted in line with the Pumping Station – Pump Selection Report (Revision C) dated 8 October 2021 prepared by AEJV. Variable speed pumping units could potentially increase the BRVAS yield by also abstracting the excess flows between any two flow increments. Based on the Feasibility Study pumping rule of 1 m^3/s flow increment steps for Berg River, flows between for example 2 m^3/s and 2.99 m^3/s only 1 m^3/s can be abstracted and the rest of the flow must be allowed to pass the site at all times. Only at Berg River flows between 3 m^3/s and 3.99 m^3/s can the abstraction rate be increased to 2 m^3/s. With variable speed units, it will be possible to also abstract the flows between the step increments of 1 m^3/s. The increase in yield associated with the adoption of variable speed pumping units has not been quantified and is therefore not taken into consideration with assessments in this Report.

Option 1 modelling during the Feasibility Study was done for abstraction to occur during the months of June to October of each year. During an average year the yield of 23 million m^3/a will be abstracted during five months of the year which equates to an average continuous pumping rate of 1.75 m^3/s. An average pumping rate of 3.5 m^3/s and pumping at this rate for 50% of the time during the five month “yield” period is adopted as a good approximation for economic assessments in this report. Actual pumping rates will however vary from month to month and year to year.

As laid out above the flows adopted in this report are as follows:

- Design flow for the sizing of supply system components – 4.6 m^3/s; and
- Average flow (adopted for economic evaluation) - 3.5 m^3/s.

For the reverse flow application, to supply water from Voëlvlei Dam back to the Berg River during the summer months, the design capacity of 0.5 m^3/s indicated in the Feasibility Study Report is adopted.

4. OPTIMISATION PRINCIPLES, PARAMETERS AND CRITERIA

4.1. Conceptual Design Criteria for Purposes of Pipeline Diameter Optimisation

4.1.1. Pipeline Route and Vertical Alignment

The pipeline route adopted for conceptual design is that provided in the Environmental Impact Assessment (EIA) Report and approved in the Environmental Authorization (EA).

The Inception Report prepared by AEJV recommends that adjustments to the pipeline route be investigated. However, TCTA recently indicated that the adjustment to the pipeline route proposed in the Inception Report (to locate the pipeline on the eastern side of the Berg River) would require additional environmental approval processes to be followed and that due to time constraints and the risk of an appeal/s, the proposed adjustment to the pipeline route cannot be accommodated. Route adjustment assessments undertaken to identify a pipeline route on the eastern side of the Berg River has therefore been suspended.

Section 9 of this report deals with changes to the pipeline route and related matters.

4.1.2. Pipeline Material and Diameters for Optimisation

Glass-fibre reinforced polyester (GRP) pipeline material was recommended in the Feasibility Study. The RID however states that GRP pipes are not recommended by DWS and that the use of ductile iron or steel pipes should be optimised during detail design (with due consideration of practical implications, price and other factors).

Recent correspondence from TCTA indicate that steel pipelines will be required for BRVAS. Steel piping is a robust material, widely used in South Africa and worldwide as well as previous TCTA and DWS projects, available for all sizes and internal pressures and external loads and manufactured by four companies in South Africa. AEJV supports steel as pipeline material and the pipeline diameter optimisation in this Report is based on steel piping. “Standard” pipe outside diameter dimensions, required pipe wall thickness and 0.5 mm thick epoxy lining are adopted to determine pipe internal diameters for hydraulic design. Refer to Section 10 of this Report regarding CML as potential pipeline lining material.

A high-level comparison between the optimum steel pipeline diameter and ductile iron/HDPE piping with an equivalent internal diameter is provided in Section 7 of this Report.

4.1.3. Hydraulic Design

The Colebrook White formula is used for the calculation of friction losses. “Worst case” operating pressures or “old pipeline” conditions are simulated to ensure that the design flow can still be supplied at the end of a 45 year project life cycle and a pipeline roughness (k) value of 0,3 mm is therefore used with hydraulic calculations. Allowance is made for nominal secondary loss coefficients through pipe specials, valves, reducers, etc.

4.1.4. Structural Design of Pipelines

The required pipe wall thicknesses are determined taking static pressures, steady state working pressures and typical surge over pressures into account. Surge over pressure of 50 m has been allowed.

External loads have not been considered in detail for purposes of optimisation. To make allowance for external loads an additional safety factor was included in the wall thickness calculations for internal pressures.

Minimum wall thicknesses are based on maximum D/t ratios of 150.

4.2. Capital, Energy and Operation and Maintenance Costs

4.2.1. Capital Costs

Construction cost estimates includes for preliminary and general and design costs, an allowance for contractor’s risk and 10% for contingencies. The cost of field investigations, professional fees, the acquisition of servitudes, contract price adjustment and VAT are excluded from cost estimates.

The capital cost estimates for the Rising Main and Pumping Station are discussed in Sections 4.2.1.1 and 4.2.1.2 below.

The base date for cost estimates is July 2021.

4.2.1.1. Pipeline

Based on the required pipe wall thicknesses and pressure ratings established during the conceptual design, a basic schedule of quantities was prepared for each of the pipeline alternatives considered in this report. Rates for construction activities used in the cost estimates were based on escalated rates from recent contracts of similar nature. Cost estimates are based on the following:

i. Pipe supply and delivery rates that were adopted are the average of the rates provided by two South African steel pipe manufacturers. Piping prices were based on the ArcelorMittal steel base price of R17 000/ton for May 2021. Refer to Figure 2 and associated discussion below regarding steel price risk;

ii. The cost of road/rail crossings, river crossings, valve chambers and associated piping and valves are based on a preliminary assessment of the pipeline route and longitudinal section;

iii. 30% of the volume of excavations was assumed to be in rock with the remainder being soft (this is considered a conservative assumption and a better indication of the extent of rock in pipe trench excavations will become available on completion of the geotechnical investigations that are currently underway);

iv. 20% of pipe bedding could be sourced from the pipe trench with 60% of bedding to be sourced from borrow pits and 20% from commercial sources (this is considered a conservative assumption and a better indication of sources of pipe bedding material will become available on completion of the geotechnical investigation that are currently underway); and

v. Allowance has been made for the estimated cost of pipeline AC mitigation and cathodic protection systems.

The ArcelorMittal steel base price history is reflected in Figure 2 below.

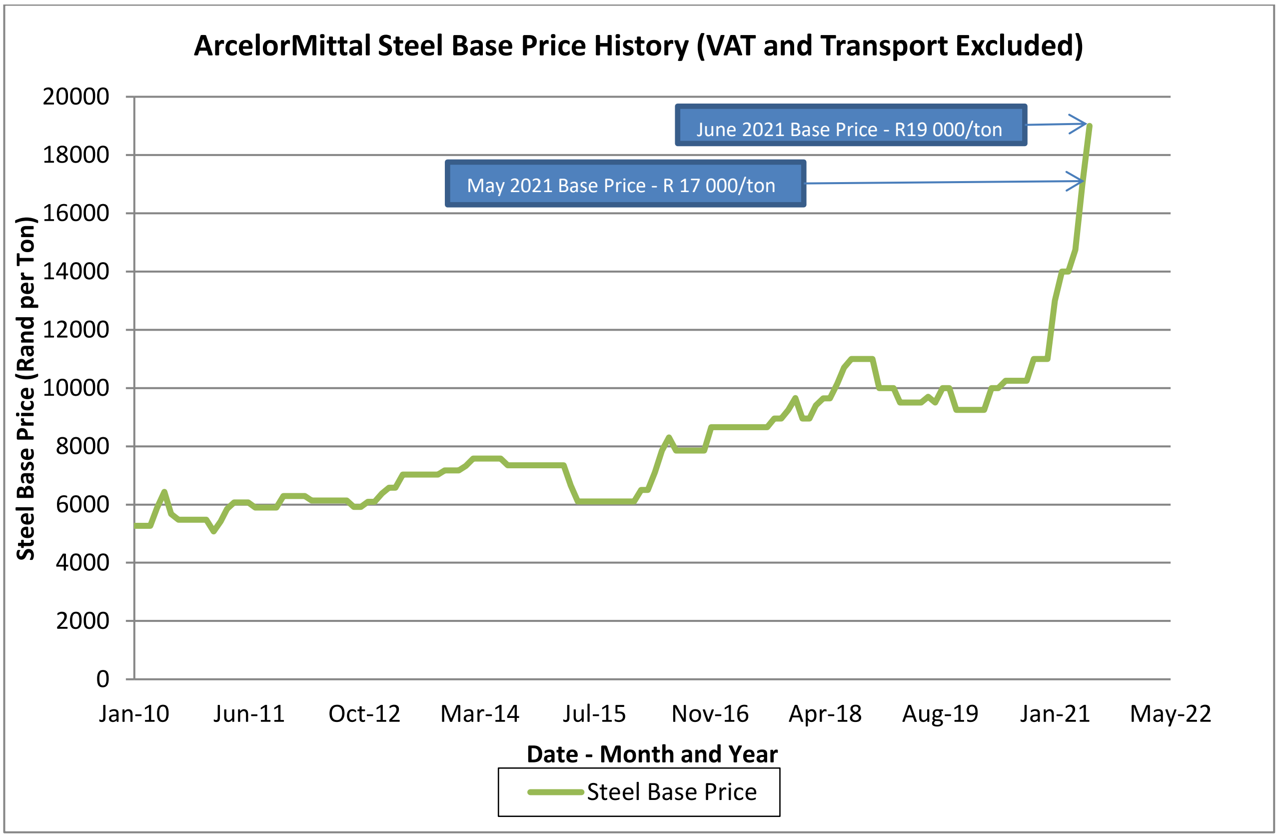


Figure 2: ArcelorMittal Steel Base Price History (VAT and Transport Excluded)

Figure 2Figure 3 reflects a dramatic increase in the ArcelorMittal steel base price since December 2020. The higher steel price may be attributed to the Covid-19 pandemic and international forces of supply and demand. The spike in steel prices is likely to be of a cyclical or temporary nature and is likely to drop in the foreseeable future – it should however be recorded as a cost risk and steel prices should be monitored.

4.2.1.2. Pumping Stations

Cost estimates for the pumping stations are based on recent tenders for similar infrastructure of a similar scale.

Cost estimates for the mechanical and electrical equipment of the pump stations is based on a rate of R 23 150 per kW installed capacity. This rate includes for variable speed drives that may be required due to potential technical constraints and for optimum operation of the system. The civil cost of pumping stations that have been adopted varies between R 55 000 000 and R 65 000 000 depending on the capacity of the pumping station.

4.2.2. Pumping Energy Costs

Pumping energy costs are based on the most appropriate Eskom tariffs i.e. "Megaflex" tariffs that have been adopted by DWS on previous projects.

During recent years energy cost has become a much more critical variable in life cycle costing and scheme optimisation due to substantial energy cost increases. During the past fourteen years, the National Energy Regulator of South Africa (NERSA) granted Eskom price increases as reflected in Table 1 below (information obtained from Eskom's website except as indicated in table notes 1 and 2).

Table 1: Average Eskom Tariff Adjustments (2008 to 2022)

Applicable Period	Average Tariff Adjustment (Nominal)	Consumer Price Index	Average Price Increase (Real)
1 April 2008 to 31 March 2009	27.5%	10.3%	17.2%
1 April 2009 to 31 March 2010	31.3%	6.16%	25.14%
1 April 2010 to 31 March 2011	24.8%	5.4%	19.4%
1 April 2011 to 31 March 2012	25.8%	4.5%	21.3%
1 April 2012 to 31 March 2013	16%	5.2%	10.8%
1 April 2013 to 31 March 2014	8%	6%	2%
1 April 2014 to 31 March 2015	8%	6%	2%
1 April 2015 to 31 March 2016	12.69%	5.7%	6.99%
1 April 2016 to 31 March 2017	9.4%	6.59%	2.81%
1 April 2017 to 31 March 2018	2.2%	5.3%	-3.1%
1 April 2018 to 31 March 2019	5.23%	4.5%	0.73%
1 April 2019 to 31 March 2020	13.87%	4.1%[Note 1]	9.77%
1 April 2020 to 31 March 2021	8.94%	3.3%[Note 1]	5.64%
1 April 2021 to 31 March 2022	15.06%	4.0%[Note 2]	11.06%
Cumulative increase (12 year period)	**673%**	**-**	**339%**

Note 1 – Statistics South Africa Data

Note 2 - Forecast

As reflected in Table 1 above, electricity price increases has been dramatic during the past fourteen years with the nominal price of electricity increasing by 673% (real increase of 339%). The average annual tariff increase has been 14.6% (real average annual tariff increase of 9.1%) over the fourteen year period. Real tariff increases at such a high rate is not considered sustainable into the future. For Present Value (PV) calculations in this report no real energy cost increases are assumed. The sensitivity of the optimum solutions to real energy cost increases is however investigated for the following two scenarios:

a) Real energy cost increases of 3% for the first five years of the project life cycle (2022 to 2026); and
b) Real energy cost increase of 6% for the first five years of the project life cycle (2022 to 2026).

4.2.3. Operation and Maintenance Costs

The economic analyses are based on annual allowances for operation and maintenance costs as laid out in Table 2 below.

Table 2: Allowances for Annual Operation and Maintenance Costs

Component	Percentage of Capital Cost
Civil Structures	0.25%
Mechanical and Electrical Components	4%
Pipelines	0.5%

The above allowances are based on DWS guidelines for cost assessments. The cost of replacing or refurbishing components during the project life cycle are covered with these allowances.

4.3. Economic Parameters

4.3.1. Life Cycle Length and Discount Rates

A life cycle length of 45 years was adopted with the calculation of Present Values (PV's). Discount rates of 4%, 6% and 8% were considered to reflect the sensitivity of the cost of capital. The adopted parameters are in line with DWS guidelines for economic analyses.

4.3.2. Present Values

Present Values (PV's) were calculated for the capital, energy and operation and maintenance costs associated with each of the alternatives that are investigated. Capital expenditure was assumed to take place during 2023, 2024 and 2025 (in line with the TCTA Strategy for Procurement of Contractors dated 22 June 2021). Capital expenditure is assumed to occur as follows:

a) 20% during 2023;
b) 60% during 2024; and
c) 20% during 2025.

Energy and operation and maintenance expenditure is assumed to commence during 2025 when the scheme would become operational. PV's are indicated in July 2021 terms.

5. RISING MAIN CONCEPTUAL DESIGN

5.1. Infrastructure Adopted for Optimisation

In line with the Pumping Station – Pump Selection Report (Revision C) dated 8 October 2021 prepared by AEJV a three duty and one standby variable speed pump set arrangement was adopted for pumping station sizing undertaken in this report. Based on the EA approved pipeline route the Rising Main will be 6 300 m long. The pipeline route is reflected in Figure 1.

To determine the optimum pipeline diameter, the Feasibility Study Rising Main diameter of DN1 700 was adopted as the base case. The flow velocity in the DN1 700 pipe is 1.57 m/s at average flow of 3.5 m^3/s and 2.07 m/s at design flow of 4.6 m^3/s. The optimum pipeline diameter is expected at higher flow velocities. Therefore, three pipeline diameters smaller than DN1 700 and one pipeline diameters larger than DN1 700 were considered to confirm the optimum diameter. The four alternative diameters that have been considered are DN1 400, DN1 500, DN1 600 and DN1 800.

The alternatives considered during pipeline diameter optimisation and associated flow velocities are provided in Table 3 for average and design flows.

Table 3: Pipeline Diameters Considered and Associated Flow Velocities

Nominal Pipeline Diameter (mm)	Flow velocities (m/s)	
	Average Flow (3.5 m^3/s)	Design Flow (4.6 m^3/s)
DN1 400	2.28	2.99
DN1 500	1.98	2.61
DN1 600	1.75	2.30
DN1 700	1.57	2.07
DN1 800	1.38	1.82

The results of the optimisation calculations shown later in this report confirmed that the above diameters were adequate to identify the optimum pipeline diameter.

5.2. Hydraulic Design

5.2.1. Static Head

Based on the Hydraulic Model Study of the proposed Abstraction Works and Weir (draft final report dated 31 August 2021 prepared by the University of Stellenbosch) the weir will consist of four overflow notches at different levels. The crest levels of the lowest and highest notches are at 51.3 masl and 57.0 masl respectively with the 1:100 year flood level at 58.0 masl. The level of the lowest notch is adopted to determine the maximum static head and the 1:100 year flood level to determine the minimum static head.

The top water level of the Voëlvlei Dam is at 79.25 masl.

The relative levels of the Lorelei Weir and the Voëlvlei Dam are provided in Table 4.

Table 4: Lorelei Weir and Voëlvlei Dam Relative Levels

Lorelei Weir	
Lowest Notch Level	51.3 m
1:100 Year Flood Level	58.0 m
Voëlvlei Dam	
Full Supply Level	79.25 m

Based on the above levels the maximum static head is 27.95 m and was used to determine required pipe wall thicknesses and to calculate pumping energy requirements. Both the lower and maximum static heads will have to be taken into consideration during the pump selection process.

5.2.2. Hydraulic Gradient

The hydraulic gradient for the DN1 700 Rising Main recommended during the Feasibility Study is reflected in Figure 3 for design flow.

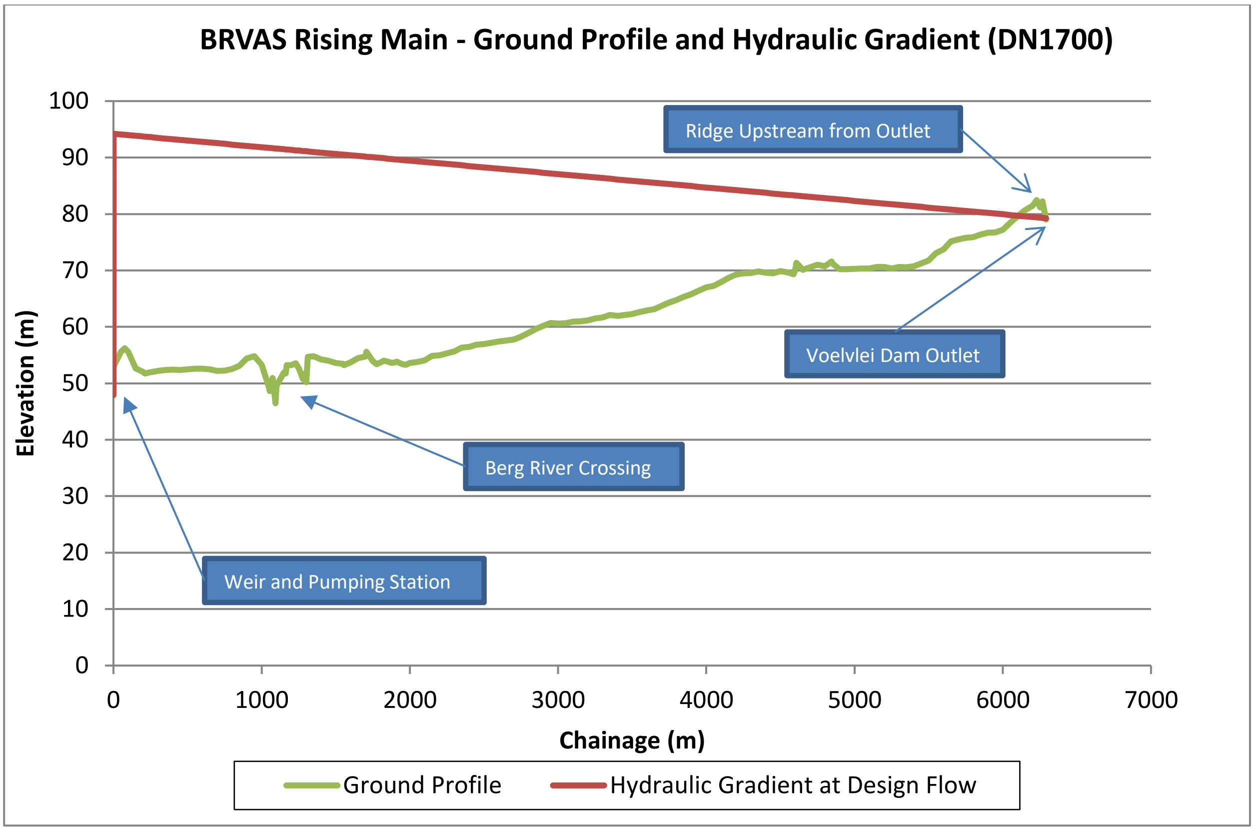


Figure 3: BRVAS Rising Main - Ground Profile and Hydraulic Gradient (DN 1 700)

Figure 3 reflects the following that should be noted:

a) The Berg River crossing has been selected at a location where both the Berg River and a tributary will be crossed, temporary diversion works may be required over a distance of up to approximately 170m; and

b) Ground levels at the “ridge” just upstream from the Voëlvlei Dam Outlet are higher than the hydraulic gradient for a distance of approximately 180 m. It is recommended that the pipeline route be adjusted to avoid the “ridge” as far as practicable and that the pipeline be laid deeper than the norm where necessary along this section so that the pipeline soffit level do not exceed the top water level of the Voëlvlei Dam. The static head can thereby be limited to the minimum and the need for a break pressure point can be avoided.

5.3. Required Pipe Wall Thicknesses

Required pipe wall thicknesses for the alternative pipeline diameters are provided in Table 5. The required pipe wall thicknesses were determined taking steady state working pressures and a typical surge over pressure of 50 m for rising mains into account.

Minimum wall thicknesses are based on maximum D/t ratios of 150.

Table 5: Required Pipe Wall Thicknesses

Wall Thickness (mm)	Pipeline Diameter (mm)				
	DN1 400	DN1 500	DN1 600	DN1 700	DN1 800
	Length Required (m)				
10	6 300	6 300	-	-	-
11	-	-	6 300	-	-
12	-	-	-	6 300	6 300

Operating pressures in the Rising Main are relatively low (relatively low losses and static pressure) and as reflected in Table 5, nominal or minimum wall thicknesses are required for all pipeline diameters.

5.4. Pumping Station Characteristics

The Pumping Station characteristics for the alternative pipeline diameters are provided in Table 6. Duties and power requirements for design flow are indicated. Pump efficiency of 85% and motor and drive efficiency of 95% were adopted for the calculation of power requirements.

Table 6: Pumping Station Characteristics

Description	Alternative				
Pipeline Diameter (mm)	**DN 1400**	**DN1 500**	**DN1 600**	**DN1 700**	**DN1 800**
Duty Flow (m^3/s)	4.6	4.6	4.6	4.6	4.6
Duty Head (m)	64.9	54.3	47.3	42.9	38.9
Power at Duty (kW)	3 627	3 034	2 643	2 397	2 174

6. RESULTS OF PIPE DIAMETER OPTIMISATION CALCULATIONS

6.1. Estimated Construction Costs

The estimated construction costs for the infrastructure associated with the five alternative pipeline diameters are provided in Table 7 below. The base date of costs is July 2021.

Table 7: Estimated Construction Costs for Supply System (July 2021 Base Date)

Component	Pipeline Diameter (mm)				
	DN1 400	DN1 500	DN1 600	DN1 700	DN1 800
Pumping Station - Civil	R 65 000 000	R 62 500 000	R 60 000 000	R 57 500 000	R 55 000 000
Pumping Station – M&E	R 134 338 000	R 110 397 000	R 99 908 000	R 88 800 000	R 80 520 000
Rising Main	R 240 277 000	R 265 101 000	R 293 184 000	R 323 058 000	R 349 093 000
Total (VAT excluded)	**R 439 615 000**	**R 437 998 000**	**R 453 092 000**	**R 469 358 000**	**R 484 613 000**

Pumping station costs in Table 7 are higher for the smaller pipe diameter alternatives (higher power rating) than for the larger pipe diameters (lower power ratings).

6.2. Optimum Pipeline Diameter (Average Flow of 3.5 m^3/s)

The PV's of the supply system for different pipeline diameters are presented in Figure 4 below at 4%, 6% and 8% discount rates. The PV calculations are based on the average flow of 3.5 m^3/s with no allowance for real Eskom tariff increases.

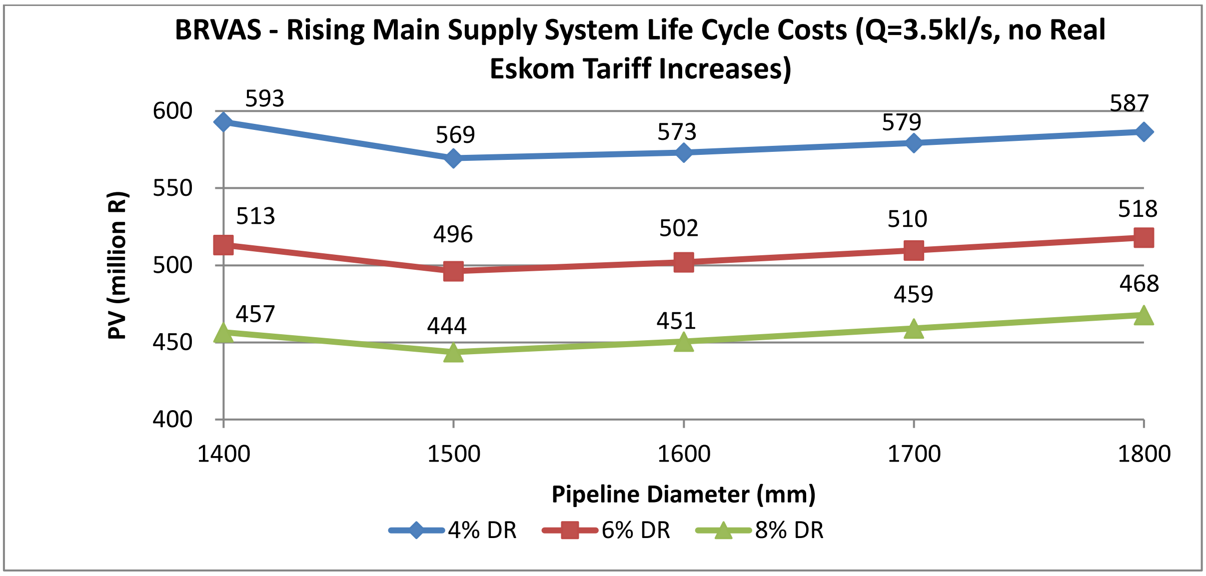


Figure 4: Supply System PV's for Various Pipeline Diameters

Figure 4 reflects a DN 1 500 pipeline to be the optimum at all three discount rates. The differences in PV's between DN 1 500 and DN 1 600 pipelines are relatively small at all three discount rates.

It is concluded that the optimum pipeline diameter is DN 1 500 and the optimum is not sensitive to discount rates between 4% and 8%.

From a technical perspective, the smaller diameters are favoured due to the higher flow velocities that will counteract settlement of silt in the pipeline.

A breakdown of the PV costs for the high lift supply system at a discount rate of 6% is provided in Table 8 below.

Table 8: Breakdown of Supply System PV's for Alternative Pipeline Diameters at 6% Discount Rate (July 2021 Base Date)

Component	Pipeline Diameter				
	DN1 400	DN1 500	DN1 600	DN1 700	DN1 800
Capital Costs	R 369 360 000	R 368 001 000	R 380 683 000	R 394 350 000	R 407 167 000
O&M Costs	R 86 123 000	R 75 388 000	R 71 740 000	R 67 890 000	R 65 241 000
Energy Costs	R 57 731 000	R 52 790 000	R 49 509 000	R 47 461 000	R 45 567 000
Total (VAT excluded)	**R 513 214 000**	**R 496 179 000**	**R 501 932 000**	**R 509 701 000**	**R 517 974 000**

The bulk of the total PV costs reflected in Table 8 above consists of capital costs. For the optimum DN 1 500 pipeline, capital cost contributes 74% of the total with operation and maintenance and energy costs respectively contributing 15% and 11% to the total.

6.3. Future Real Energy Tariff Increases - Sensitivity Analyses

As indicated in Section 4.2.2 of this report, the impact of two real energy tariff increase scenarios were assessed. No real future energy cost increases is presented above as the base case and the other two scenarios are as follows:

a) Real energy cost increases of 3% for the first five years of the project life cycle (2022 to 2026); and

b) Real energy cost increase of 6% for the first five years of the project life cycle (2022 to 2026).

To determine the sensitivity of the optimum Rising Main pipeline diameter to real energy cost increases, the base case and two alternative scenarios are analysed below. The PV's of the supply system for different pipeline diameters and energy cost scenarios are presented in Figure 5. Calculations are based on the average flow of 3.5 m^3/s and a 6% discount rate.

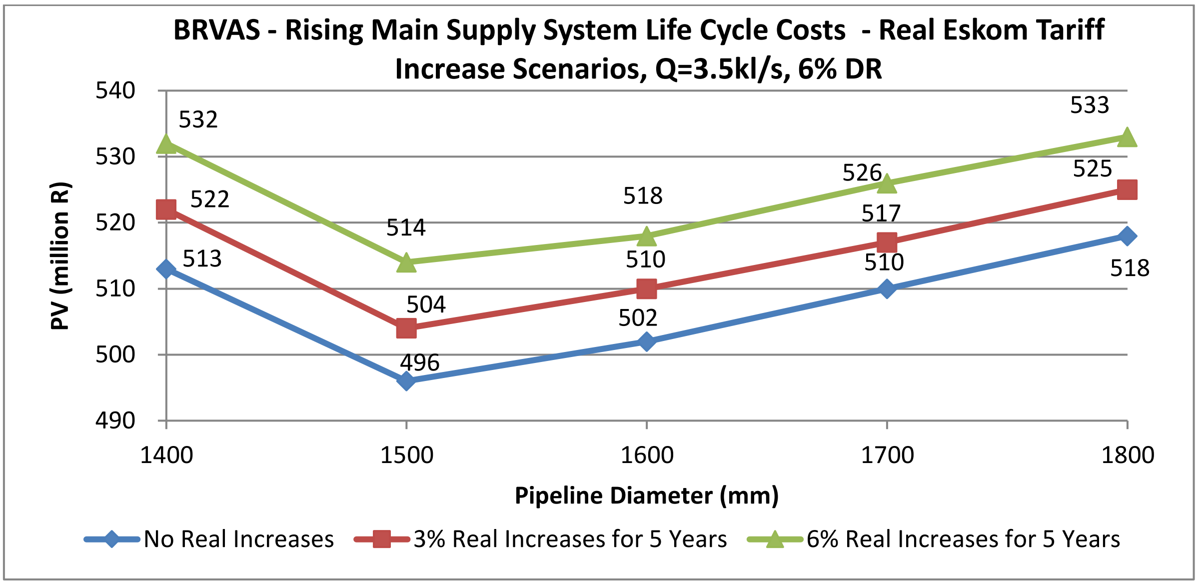


Figure 5: Supply System PV's (6% Discount Rate) for Various Pipeline Diameters and Energy Cost Increase Scenarios using Average Flow of 3.5 m^3/s

Figure 5 reflects the PV of the DN 1 500 pipeline to be the lowest for all three energy cost increase scenarios. The differences in PV's between DN 1 400, DN 1 500 and DN 1 600 pipelines are relatively small for all three cost increase scenarios.

It is concluded that the optimum pipeline diameter is DN 1 500 and the optimum is not sensitive to the real energy cost increases that have been considered.

The effect of real energy cost increases on the PV's of different pipeline diameters are not as pronounced as may be expected. This is attributed to the relatively short pipeline with the friction loss component that would favour the larger diameter pipelines being a relatively small component of the total pumping head and pumping for only 5 months per year.

From a technical perspective, the smaller diameters are favoured due to the higher flow velocities that will counteract settlement of silt in the pipeline.

7. ALTERNATIVE PIPELINE MATERIALS

7.1. Introduction

Glass-fibre reinforced polyester (GRP) pipeline material was recommended in the Feasibility Study. The RID however states that GRP pipes are not recommended by DWS and that the use of ductile iron or steel pipes should be optimised during detail design (with due consideration of practical implications, price and other factors, such as the experience of the City of Cape Town with similar pipelines).

The initial draft tender document for the construction of BRVAS reflected the required pipe material as high-density polyethylene (HDPE) but it was since amended to steel pipes.

A high-level comparison between the optimum steel pipeline diameter (DN 1 500) and ductile iron and HDPE with an equivalent internal diameter are provided in Section 7.2 to Section 7.4 below. The comparison is based on supply costs for the various materials.

7.2. Ductile Iron

Ductile iron piping is not manufactured in South Africa. The local market imports ductile iron piping from China, India, Europe or the Middle East.

The internal diameter of DN 1 500 ductile iron piping is equivalent to DN 1 500 steel piping. The rate for DN 1 500 Class K9 spigot and socket ductile iron piping supplied in 6 m lengths was obtained from a local distributor. The provided rate is for the standard 9 mm thick cement mortar lining and the standard coating of 130g/m^2 metallic zinc with 70-micron black bitumen overcoat. In AEJV's opinion the coating is not adequate for corrosive soil conditions.

Cement mortar is not recommended as lining material for the corrosive Berg River water that will be supplied through the pipeline – refer to Section 10 of this report. Ductile iron piping can be supplied with alternative linings (epoxy etc.) but requires deviation from mass production with the standard materials resulting in substantially higher supply rates and longer delivery times.

The rate for supply and delivery of DN 1 500 ductile iron standard piping amounts to R 19 380/m. The rate is based on an exchange rate of R 13.74 to the US dollar and excludes quality control inspections in China. The delivery period for piping was indicated as 14 to 16 weeks.

Although welding of spigot and socket ductile iron piping are not required as for a welded steel pipeline it requires trust blocks (or alternative methods of restraint) at bends and at other locations where restraint is required. The installation cost of ductile iron piping is considered to be similar to that of welded steel piping.

7.3. High Density Polyethylene (HDPE)

A South African HDPE piping manufacturer was approached to provide rates for HDPE piping. The manufacturer indicated that HDPE piping is only manufactured up to DN 1 000 (only up to class 8 for DN 1 000). DN 1 000, class 8 HDPE piping has 80 mm thick walls and the internal diameter of the pipe is 840 mm. Based on a hydraulic assessment, four DN 1 000 pipelines will be required in parallel to achieve approximately the same pumping head than required for a DN1 500 steel pipeline i.e. four DN 1 000 HDPE pipelines in parallel have approximately the same equivalent internal diameter than a DN 1 500 steel pipeline.

The rate for DN 1 000 PE100 Class 8 HDPE piping supplied in 6 m lengths with ends suitable for welding on site was obtained from the manufacturer. The rate for supply of DN 1 000 HDPE piping amounts to R 9 080/m (delivery excluded). To make allowance for delivery, the supply rate was increased by 10%, a rate of R 9 988/m is therefore used for cost comparison purposes. The rate of R 9 988/m is multiplied by 4 (4 parallel pipelines required) for comparison purposes i.e. the rate for HDPE piping is R 39 952/m.

Although cathodic protection will not be required for HDPE piping, the installation cost of HDPE piping is considered similar to that of a welded steel pipeline.

7.4. Piping Material Cost Comparison

The supply and delivery costs for steel, ductile iron and HDPE are summarized in Table 9.

Table 9: Supply and Delivery Costs of Alternative Piping Materials (VAT excluded)

Piping Material	Cost per Metre	% Difference from Steel
DN 1 500 Steel	R 13 780	-
DN 1 500 Ductile Iron	R 19 380	+40.6%
4 No. DN 1 000 HDPE	R 39 952	+290%

Based on the comparison provided in Table 9, there is no cost advantage to adopt ductile iron or HDPE as pipe material in lieu of steel. Steel piping is a robust material, widely used in South Africa and worldwide as well as previous TCTA and DWS projects, available for all sizes and internal pressures and external loads and manufactured by four companies in South Africa. Steel piping is recommended for BRVAS.

8. CATHODIC PROTECTION AND AC MITIGATION FOR PIPELINE

8.1. Pipeline Data

The conceptual cathodic protection and AC mitigation design for the BRVAS pipeline provided in this Section is based on the pipeline data provided below:

a) Pipeline length: 6 300m;
b) Diameter: DN 1 500mm;
c) Wall thickness 10mm;
d) Specific coating conductance: <60μS/m^2;
e) Foreign services:
   - o Existing steel pipeline from Voëlvlei Dam to Riebeeck Kasteel (under cathodic protection);
   - o High voltage power line crossing near Voëlvlei Dam;
   - o Electrified rail crossing near Voëlvlei Dam.

8.2. Cathodic Protection

The current demand to provide cathodic protection to the entire pipeline with a coating that complies with the adopted performance requirements would be in the order of 600mA. This level of current can easily be supplied using zinc sacrificial anodes installed in banks at midpoints between valve chambers which are able to provide protection for a design life of 30 years or more.

The pipeline will need to be isolated from the civil / mechanical works at both the Lorelei Weir and the Voëlvlei Dam.

Monitoring facilities including coupons should be installed at valve chambers.

8.3. DC Stray Current Interference

The BRVAS pipeline crosses the Cape Town – Johannesburg rail near the Voëlvlei Dam. This rail is electrified at 3kV DC. The crossing is at right angles and some distance from the traction sub-stations at Gouda and Soetendal. The potential of the rail at the crossing is unknown, but is likely to be predominantly positive with respect to soil, given the distance from the traction substations. Historical information related to the Riebeeck Kasteel pipeline indicates that the pipeline does not suffer anodic interference at the rail crossing.

The BRVAS pipeline may well pick up current from the rail, but as it is at right angles to the rail there is no obvious return path to the traction substations. Any current picked up should therefore be discharged along the pipeline route by the sacrificial anodes.

Installation of a natural drainage unit (NDU) at the rail crossing should be considered in order to discharge transients and negative rail excursions related to locomotive operations and possible regenerative braking. Given the high electrical resistance characteristics of the new pipeline, this NDU may require customised design to limit drainage currents.

The pipeline should be armour-wrapped in the region of the rail crossing to limit current pickup from the rail. The extent of armour wrapping will need to be determined based on rail characteristics determined during design.

8.4. AC Interference Mitigation

The pipeline crosses a single high voltage AC overhead power line at chainage 3 700 m near the Voëlvlei Dam. The details of this power line are not known.

Given that the crossing is at right angles, there is unlikely to be any steady state inductive interference. The pipeline will however be subjected to transients and conductive interference related to tower faults from lightning or switching surges.

AC mitigation is likely to be required at the crossing, and provision should be made for parallel earth conductors (zinc ribbon) for at least 250m each side of the crossing. Given that a sacrificial anode system is proposed, these conductors can be directly coupled to the pipeline.

Personnel protection in the form of gradient control mats will be required at valve chambers. This may include the use of bonded reinforcing in the valve chamber floors and walls, depending on valve chamber design. Encased reinforcing will require de-coupling from the pipeline.

The extent and detail of the AC interference mitigation system will need to be determined during design.

8.5. Foreign Services

Given that there is an existing steel pipeline with cathodic protection from Voëlvlei Dam to Riebeeck Kasteel, there is the possibility of interference between the existing and new pipelines.

Depending on the separation and spatial arrangement between the pipelines at Voëlvlei Dam, provision should be made in the cathodic protection design for cross bonding facilities between the two pipelines.

8.6. Summary of Proposed Installations

Based on the conceptual cathodic protection and AC mitigation design for the BRVAS pipeline provided in Sections 8.1 to 8.5, the installations listed below will be required:

i. Zinc sacrificial anodes (likely Type 4 ribbon) at midpoints between valve chambers;

ii. Monitoring stations including coupons at valve chambers;

iii. Insulating flanges with surge protection at the two pipeline ends;

iv. NDU (controlled) at the rail crossing with armour-wrapping to the pipeline in the region of the rail crossing;

v. AC mitigation at the power line crossing (zinc ribbon);

vi. Gradient control mats at valve chambers; and

vii. Cross bonding facility to the pipeline from Voëlvlei Dam to Riebeeck Kasteel.

The installations proposed above should be considered in detail during the design of the infrastructure. Adjustments should be made to the proposed installations during design to ensure an efficient and reliable cathodic protection and AC mitigation system.

9. PIPELINE ROUTING, SERVITUDE DETAILS AND WAYLEAVES

9.1. Pipeline Servitudes

A permanent pipeline servitude width of 25 m was adopted to allow sufficient space for future access and maintenance to the pipeline. No second future pipeline to be constructed in the same servitude is foreseen and no allowance was therefore made for a second pipeline.

A temporary construction servitude width of 40 m (including the 25 m permanent servitude) was adopted for the Berg River crossing on Zonquasdrif No. 1129 Ptn3/Rem and for the two farms east of the Berg River (Sonquas Doordrift No. 647 Ptn 2 and Halfgewaagd No. 73 Ptn 25), to limit the impact of construction on these farms with orchards and future orchards.

A temporary construction servitude width of 75 m was (including the 25 m permanent servitude) was adopted for the remainder of the pipeline route as approved with the Environmental Authorization and as directed by TCTA. This may be a problem on farms with winter crops for example Mr Rust of The Farm No. 648 Ptn1 at the weir. A width of 75 m is conservative and will most probably only be used in areas where construction materials will be stored along the pipeline route.

Permanent and temporary servitude boundaries are reflected on the drawings discussed in Section 9.2.

9.2. Pipeline Routing

Drawing numbers 3177.00.00.GZA.05.U001 to U006 included in Annexure A reflect both the EIA pipeline route and the proposed alternative route. Proposed specific changes are referred to in Sections 9.2.1 to 9.2.5 below.

The proposed route form part of the concept/outline design and should be finalized during the detail design by the P&DB contractor, subject to the applicable limitation e.g. land acquired for the servitude.

9.2.1. Drawing Number 3177.00.00.GZA.05.U001

The pipeline route between chainage 0 m and chainage 180 m will be finalized after completion of the Pumping Station concept design.

9.2.2. Drawing Number 3177.00.00.GZA.05.U002

The alignment through the Berg River was adjusted slightly to avoid having a power line pole located within the permanent servitude and to allow sufficient clearance (for relocation of services as discussed in the next paragraph) between the permanent servitude and the orchards located on Zonquasdrif No. 1129 Ptn3/Rem on the southern side of the servitude.

The pipeline alignment traverse an existing pump house structure at chainage 1 110 m. The landowner is aware of this clash. During discussions with the landowner and TCTA it was agreed that the pump house structure will be relocated to outside the permanent servitude prior to construction in the area. The power supply cable and irrigation pipeline will also require relocation to the south of the permanent servitude on the Zonquasdrif No. 1129 Ptn3/Rem.

9.2.3. Drawing Number 3177.00.00.GZA.05.U003

An appeal was lodged against the project by the owner of Halfgewaagd No. 73 Ptn 25 during the Environmental Approval process. To address the appeal the pipeline route was moved to the south of the canal on Halfgewaagd No. 73 Ptn 25 – refer to alternative route (orange line) reflected on the drawing.

AEJV undertook an assessment of impacts during the construction and future operations for the EIA route and three alternatives on Halfgewaagd No. 73 Ptn 25. Refer to drawing number 3177.00.00.GZA.05.D010 (Rev D) included in Annexure B for detail of the routes that were considered. The impact assessment for the four routes is also included in Annexure B.

The pipeline routing alternatives and impacts were discussed with the landowner and TCTA and agreement was reached for the pipeline to be located on the northern side of the canal (EIA route).

9.2.4. Drawing Number 3177.00.00.GZA.05.U005

The proposed alternative alignment aims to cross the Cape Town – Johannesburg rail and Road R44/R46 perpendicularly while also avoiding power line poles in the pipeline servitude.

9.2.5. Drawing Number 3177.00.00.GZA.05.U006

The proposed alternative alignment aims to reduce the height where the pipeline crosses the “ridge” just upstream from the Voëlvlei Dam. Also refer to section 5.2.2 for further clarification.

9.3. Wayleaves

Drawing numbers 3177.00.00.GZA.05.A100 to A104 included in Annexure C reflect power line, rail way and road crossings. AEJV are preparing wayleave applications to obtain approval for the crossing of these services.

10. PIPELINE LINING – SUITABILITY OF CEMENT MORTAR LINING

The water quality data from the Feasibility Study is approximately ten years old. To assess the latest water quality, AEJV commissioned water quality tests to determine corrosive nature of the water.

Water samples were taken from the Berg River at the farm Zonquasdrift on 24 June 2021 and 30 July 2021 after rain in the area. Refer to Annexure D for the laboratory results of these water samples. The laboratory results of the two samples reflect Calcium Carbonate Precipitation Potential (CCPP) values -59.9 mg/l as $CaCO_3$ and -11 mg/l as $CaCO_3$ respectively. The high negative CCPP values indicate that the water is corrosive (aggressive).

Cement mortar lining is not suitable for aggressive water. It is recommended that the BRVAS steel pipelines be lined with epoxy.

11. CONCEPTUAL DESIGN FOR REVERSE FLOW APPLICATION

11.1. Required Infrastructure for Reverse Flow Application

Existing infrastructure to transfer water from the Voëlvlei Dam to the Berg River consists of:

- An outlet structure located in the Voëlvlei Dam;
- A 900 m long outlet culvert from the outlet structure to the point of daylight at the existing Swartland Water Treatment Plant (refer to Figure 1 for the location); and
- A 2 700 m long canal from the end of the outlet culvert to the Berg River.

Raw water for the Swartland Water Treatment Plant is abstracted at the outlet culvert point of daylight and water for downstream requirements in the Berg River are release through the canal.

The reverse flow philosophy, to release ecological and other downstream water requirements from the Voëlvlei Dam to the Berg River through the new BRVAS pipeline, was adopted during the Feasibility Study. Reverse flow will be by gravity and the Feasibility Study indicated a design capacity of 0.5 m^3/s.

In addition to the BRVAS pipeline, the following infrastructure will be required for the reverse flow application (water from the Voëlvlei Dam abstracted at the existing outlet culvert point of daylight):

i. A connection pipeline between the existing canal and the BRVAS pipeline. Isolating valves will be required for pumping from the Berg River to the Voëlvlei Dam during winter months and gravity flow from the Voëlvlei Dam to the Berg River during summer months. For gravity flow (without syphon/s) to occur from the canal to the Berg River, the soffit of BRVAS pipeline will have to be below the hydraulic gradient. Refer to drawing number 3177.00.00.GZA.05.D002 included in Annexure E for a concept design drawing of the link pipeline and isolating valve chamber; and

ii. Piping, valves and a flow meter will be required at the Berg River release point. To facilitate ease of operation, control, maintenance and security, the release infrastructure should be located at the Pumping Station (the release infrastructure could be located either upstream or downstream from the weir). A flow meter will be required to measure the release flow rate and cumulative flow. A sleeve valve was adopted to control and adjust the rate of release. Two release pipes (one duty, one standby) was adopted and an isolating valve is provided on each release pipe. Refer to drawing number 3177.00.00.GZA.05.D001 included in Annexure E for a concept design drawing of the release piping, valves, flow meter and chambers.

11.2. Hydraulic Design

11.2.1. Static Head

The invert level of the existing outlet culvert and the start of the canal is at approximately 60.3 masl. The water level in the canal was 61.0 masl at the time when the recent topographical survey was undertaken and this level is used to determine the static head available to "drive" reverse flow.

A water level of 56.5 masl was adopted as the release water level at the Berg River i.e. 1.5 m below the 1:100 year flood level. The hydraulic gradient just clears a high point at approximately chainage 100 m along the pipeline route and lowering the release point will not increase the hydraulic capacity (except if the pipeline depth is increased at the high point or the pipeline/release point is moved to avoid the high point)– refer to Figure 6.

The relative levels for reverse flow releases to the Berg River are provided in Table 10.

Table 10: Lorelei Weir and Voëlvlei Dam Relative Levels

Outlet Culvert from Voëlvlei Dam	
Water Level in Canal	61.0 masl
Berg River Release Point at Pumping Station	
1:100 Year Flood Level	56.5 masl

Based on the above levels the maximum static head is 4.5 m to "drive" reverse flows to the release point.

11.2.2. Hydraulic Capacity for Reverse Flow

The DN1 500 optimum pipeline diameter determined in Section 6 was used to calculate the reverse flow capacity to the Berg River. The maximum reverse flow capacity was calculated as 2.4 m^3/s and the hydraulic gradient at this flow rate is reflected in Figure 6.

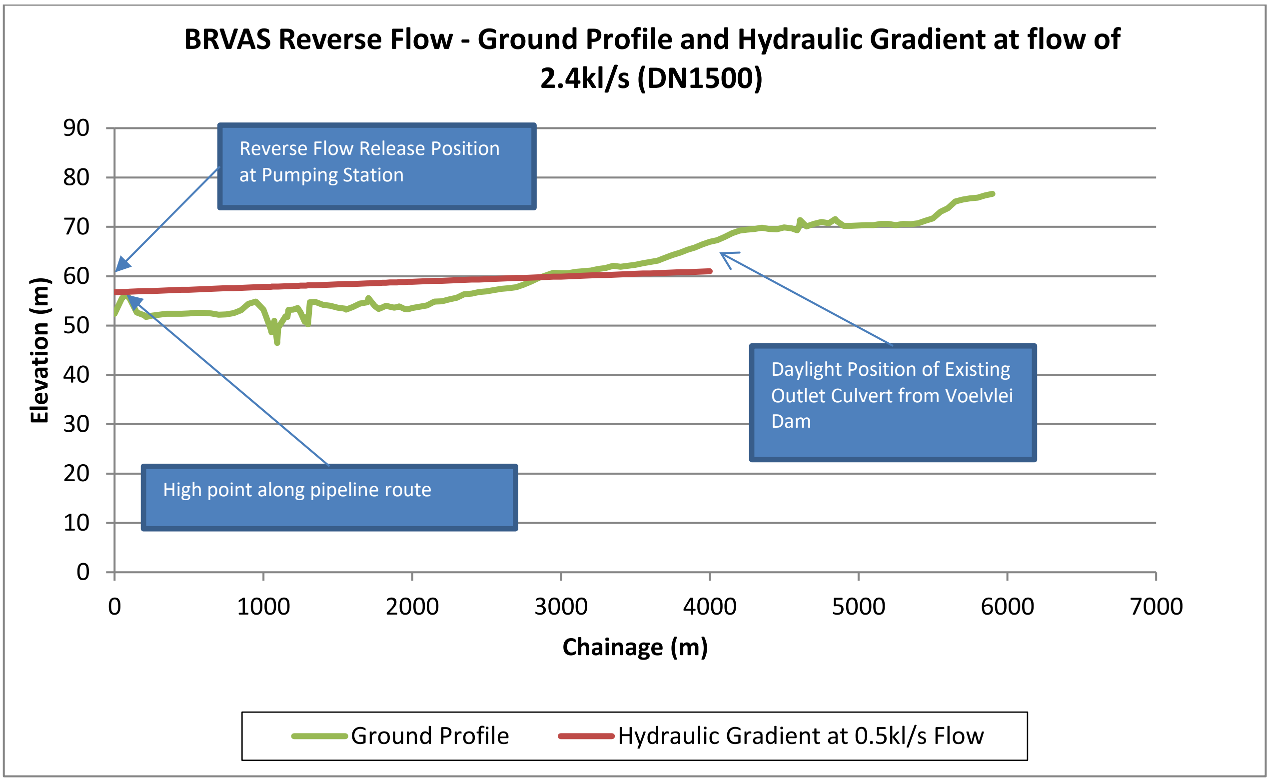


Figure 6: BRVAS Reverse Flow - Ground Profile and Hydraulic Gradient (DN 1 500)

Drawings from DWS of the existing outlet culvert from the Voëlvlei Dam reflect the capacity of the culvert as 7 m^3/s. The pipeline will therefore not have sufficient reverse flow capacity to match the capacity of the outlet culvert.

11.3. Implications and Concerns Associated with the Reverse Flow Application

Implications and concerns associated with the reverse flow application are listed below:

i. An accurate flow balance between the volume released from the Voëlvlei Dam and the volume abstracted (to the Water Treatment Plant and released to the Berg River) will have to be maintained. When the volume released from the Voëlvlei Dam exceeds the volume abstracted, flooding at the location where the outlet culvert daylight will occur. When the volume released from the Voëlvlei Dam is less than the volume abstracted, air will be introduced into the BRVAS and/or the Swartland pipeline/s. The abstraction rate to the Swartland Water Treatment Plant is expected to vary on a daily basis and maintaining an accurate flow balance between Voëlvlei Dam releases and abstractions will be a challenge (with the current canal arrangement all excess water at the outlet culvert daylight point simply flows into the canal);

ii. The depth to pipeline invert at the connection to the existing canal will increased from approximately 2.5 m to approximately 6.5 m to achieve gravity flow. The pipeline depth will increased over a distance of 1 200 m with an average depth to pipeline invert of 4.5 m;

iii. The estimated additional cost for the valve chambers, deeper excavation and fibre optic and backup telemetry communication infrastructure to accommodate the reverse flow application is R 12 000 000 (preliminary and general and design costs, an allowance for contactor's risk and 10% contingencies included but the acquisition of servitudes, contract price adjustment and VAT excluded));

iv. During a site visit by AEJV in February 2021 it was noted that the existing canal was being operated at more than full capacity. The required design capacity of 0.5 m^3/s does not correspond with the actual transfer of more than 2 m^3/s observed on 18 February 2021 (it is assumed that downstream users were being supplied through the canal during the site visit). The required transfer capacity from the Voëlvlei Dam to the Berg River should be confirmed before a decision is taken to implement the reverse flow application.

v. During a site visit on 16 August 2021, Mr Sakkie Rust of The Farm No. 648 Ptn1 at the weir raised the following concerns:

- If the point of delivery of water he is currently receiving from the Voëlvlei Dam via the canal is moved downstream of his current withdrawal point to the weir, his current irrigation system will not work which will have serious consequences to his farming business.
- That the capacity of the BRVAS pipeline delivering water from the Voëlvlei Dam to the Berg River in reverse will be less than the capacity of the existing canal to provide water from the Voëlvlei Dam to the Berg River during summer months and that the Lower Berg River users will then receive less water than from the existing canal.

12. CONCLUSIONS AND RECOMMENDATIONS

Based on the assessments in this report the conclusions and recommendation are as follows:

i. DN 1 500 is the optimum pipeline diameter for BRVAS;

ii. The spike in steel prices since December 2020 is likely to be of a cyclical or temporary nature and is likely to drop in the foreseeable future – it should however be recorded as a cost risk and steel prices should be monitored;

iii. Welded steel piping is recommended for BRVAS. A high level assessment of ductile iron and HDPE piping indicate both to be more expensive than steel;

iv. Zinc sacrificial anodes are recommended for cathodic protection of the pipeline. A natural drainage unit, insulating flanges at the pipeline ends and cross bonding to the existing pipeline to Riebeeck Kasteel are likely to be required;

v. Zinc ribbon and gradient control mats at valve chambers are likely to be required;

vi. Proposed changes to the pipeline route are reflected on the drawings. The pipeline route and proposed servitude widths should be considered and approved before land acquisition drawings are finalized;

vii. Drawings for service crossings are included in Annexure C of the report. Wayleave applications need to finalized and submitted for approval;

viii. Water in the Berg River is corrosive (aggressive). Cement mortar lining is not suitable for aggressive water. It is recommended that the BRVAS steel pipelines be lined with epoxy. There are various suitable steel pipe coating alternatives available in South Africa which will be in the Employer's Requirements in the tender document for the construction of BRVAS.

ix. Various implications and concerns associated with the reverse flow application are highlighted. The required transfer capacity from the Voëlvlei Dam to the Berg River should be confirmed before a decision is taken to implement the reverse flow application. The additional cost to implement reverse flow is estimated on R 12 million (excluding land acquisition costs, contract price adjustment and VAT). An accurate flow balance will have to be maintained between Voëlvlei Dam releases and abstractions (to the Swartland Water Treatment Plant and released to the Berg River) to avoid flooding at the outlet culvert daylight point or air being introduced into BRVAS/Swartland pipelines.

x. Conceptual design drawings for structures associated with the reverse flow application and for the outlet at the Voëlvlei Dam are provided in Annexure E of the report.

ANNEXURE A

Rising Main Route Drawings

Drawing no. 3177.00.00.GZA.05.U001 Rev G – Rising Main - Route Plan – Layout 1

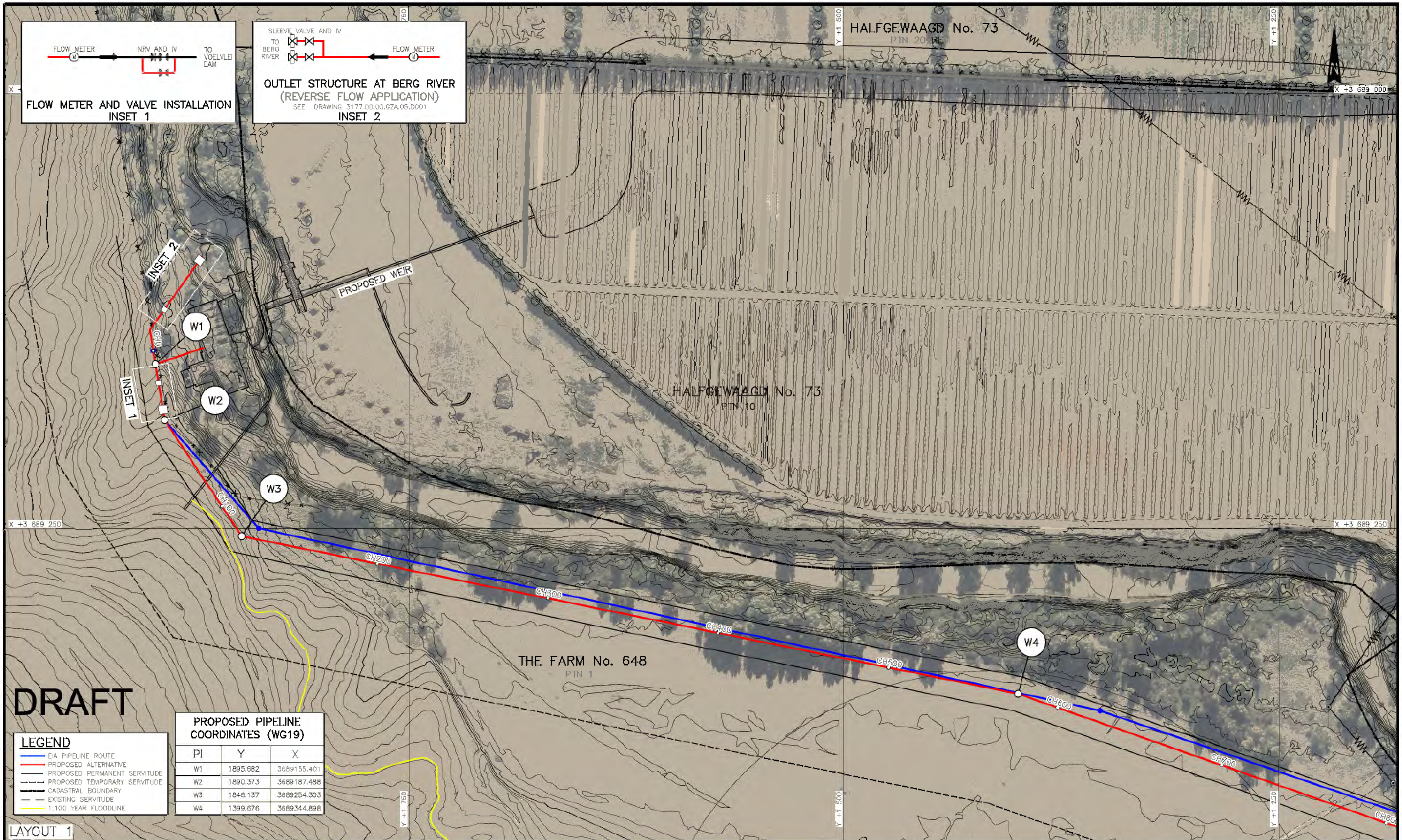
Drawing no. 3177.00.00.GZA.05.U002 Rev E – Rising Main - Route Plan – Layout 2

Drawing no. 3177.00.00.GZA.05.U003 Rev E – Rising Main - Route Plan – Layouts 3 & 4

Drawing no. 3177.00.00.GZA.05.U004 Rev D – Rising Main - Route Plan – Layouts 5 & 6

Drawing no. 3177.00.00.GZA.05.U005 Rev D – Rising Main - Route Plan – Layouts 7 & 8

Drawing no. 3177.00.00.GZA.05.U006 Rev D – Rising Main - Route Plan – Layout 9



LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
- PROPOSED TEMPORARY SERVITUDE
- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
- 1:100 YEAR FLOODLINE

PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W1	1895.662	3689155.401
W2	1890.373	3689187.488
W3	1846.137	3689254.303
W4	1399.676	3689344.898

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE: DATE:

JV DRAWING NUMBER

3177.00.00.GZA.05.U001

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

IMPLEMENTING AGENT: TCTA — A new word for water

CONSULTING ENGINEER: Aurecon Ethiabo JV

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336–7500

DESIGN:

CHECKED: DATE: DRAWN: AUTOCAD

ENGINEER DATE: EXTERNAL APPROVAL: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

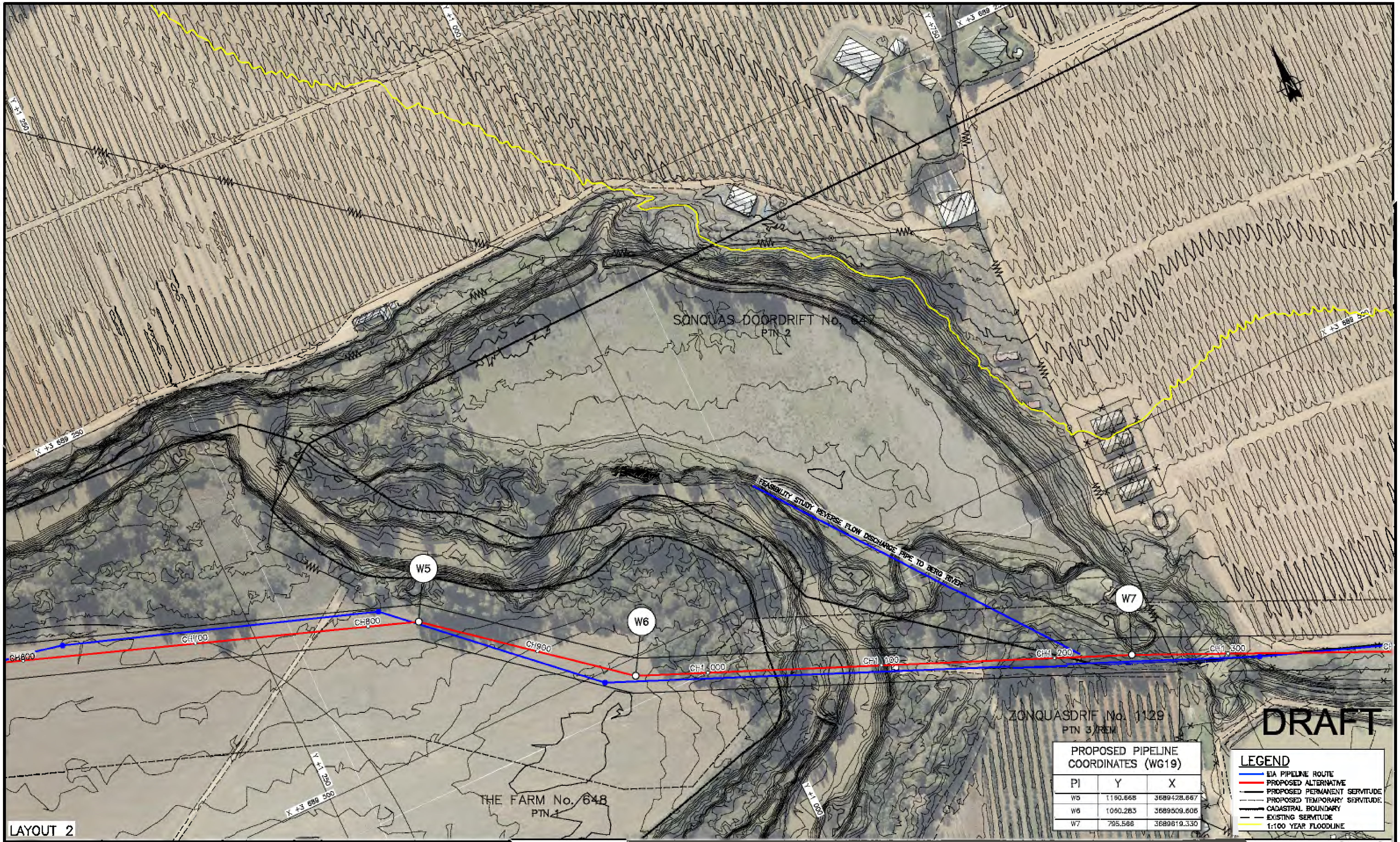
RISING MAIN ROUTE PLAN

LAYOUT 1

PROVINCE: WESTERN CAPE DISTRICT: DRAKENSTEIN/SWARTLAND KEYCODES: OTHER NUMBER XX

LOCALITY No. XXX TENDER/ CONTRACT No. XXX SHEET 1 OF 6 REG. No REV. G

CALC. FILE. XXX



PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W5	1160.668	3689428.667
W6	1060.283	3689509.606
W7	795.586	3689619.330

LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
- PROPOSED TEMPORARY SERVITUDE
- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
- 1:100 YEAR FLOODLINE

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE: DATE:

JV DRAWING NUMBER

3177.00.00.GZA.05.U002

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

IMPLEMENTING AGENT: TCTA – A new word for water

CONSULTING ENGINEERS

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
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CHECKED: DATE: DESIGN:
DRAWN: AUTOCAD
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

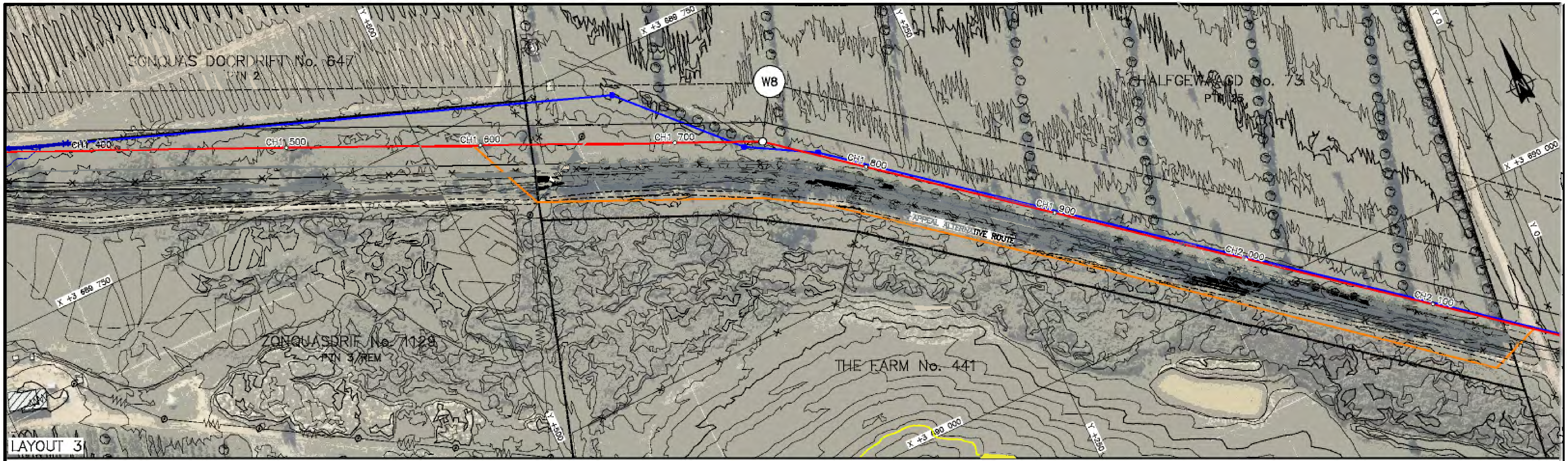
RISING MAIN ROUTE PLAN

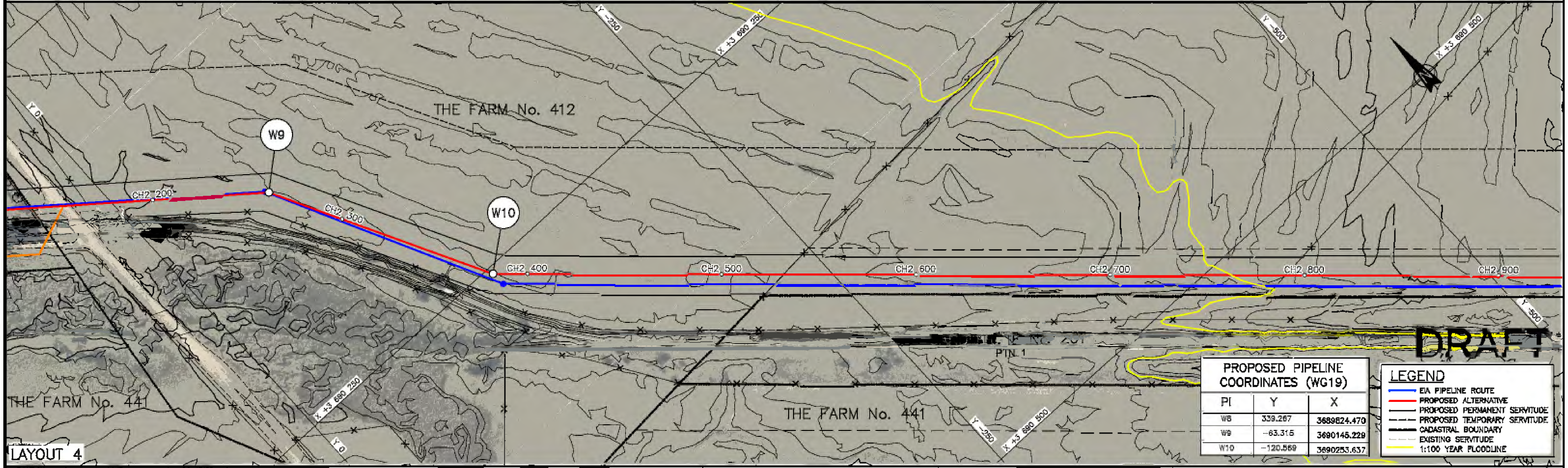
LAYOUT 2

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER: XX

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 2 OF 6 | REG. No. | REV. E

CALC. FILE XXX





PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W8	339.267	3689824.470
W9	-63.315	3690145.229
W10	-120.569	3690253.637

LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
- PROPOSED TEMPORARY SERVITUDE
- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
- 1:100 YEAR FLOODLINE

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE: DATE:

JV DRAWING NUMBER

3177.00.00.GZA.05.U003

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SCALE 1:1 000

TCTA – A new word for water

REVISION

No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

DESIGN:
CHECKED: DATE
DRAWN: AUTOCAD
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng) DATE DIRECTOR (Pr. Eng) DATE

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

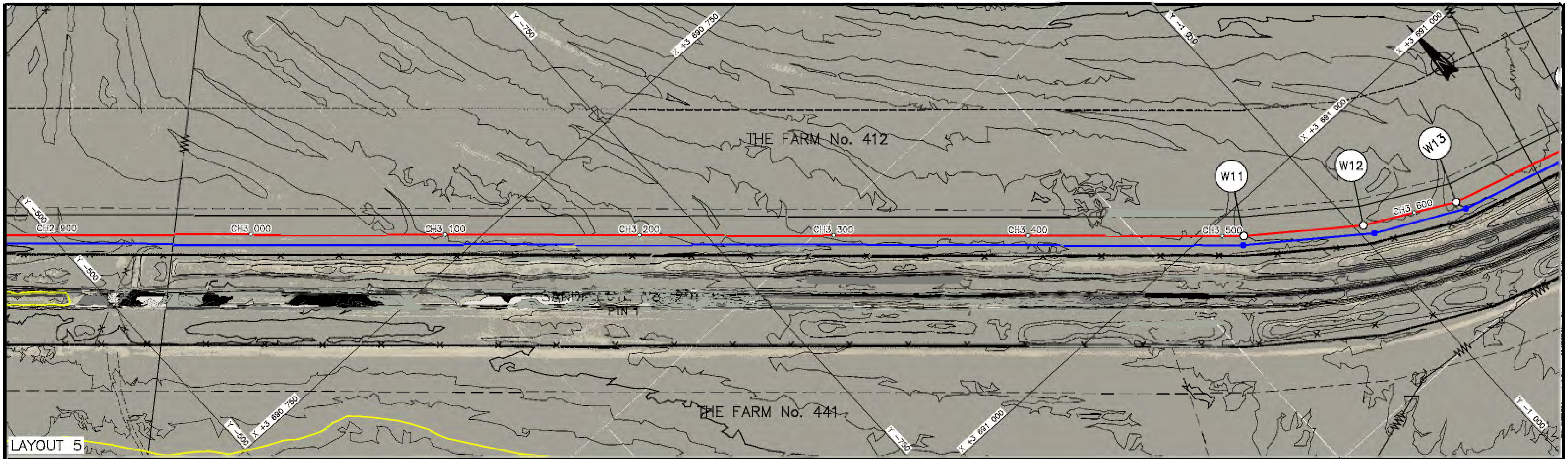
RISING MAIN ROUTE PLAN

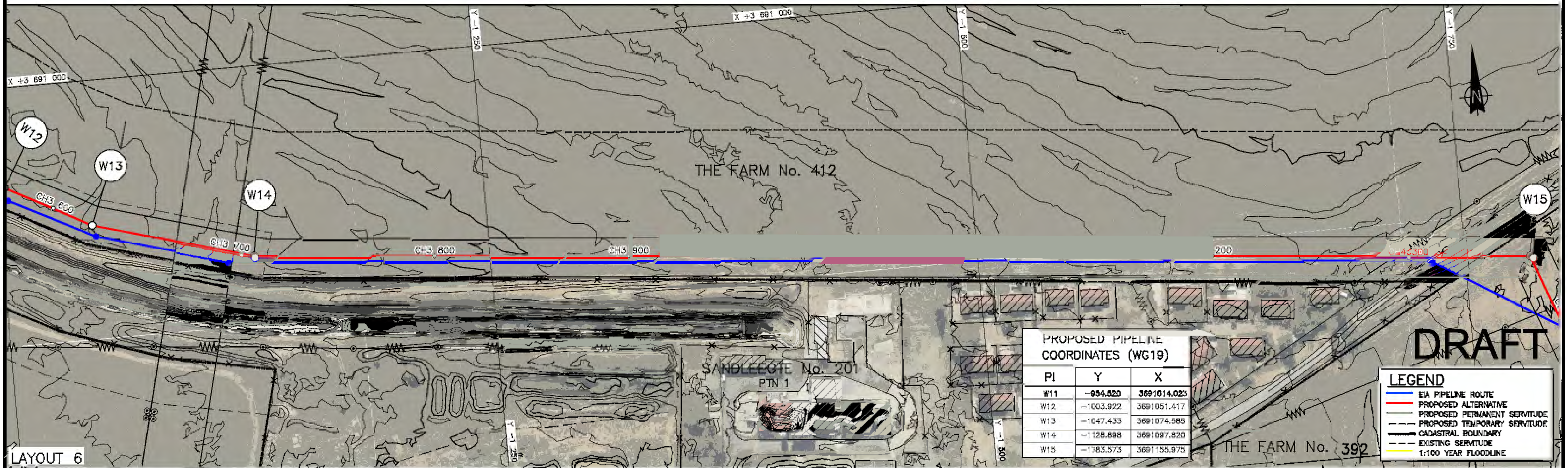
LAYOUTS 3 AND 4

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER: XX

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 3 OF 6 | REF. No. | REV. E

CALC. FILE. XXX





PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W11	−954.520	3691014.023
W12	−1003.922	3691051.417
W13	−1047.433	3691074.585
W14	−1128.898	3691097.820
W15	−1783.573	3691155.975

LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
- PROPOSED TEMPORARY SERVITUDE
- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
- 1:100 YEAR FLOODLINE

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE DATE

DRAWING NUMBER

3177.00.00.GZA.05.U004

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

TCTA A new word for water

CONSULTING ENGINEERS

REVISION

No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

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CIVIL DESIGN
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PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

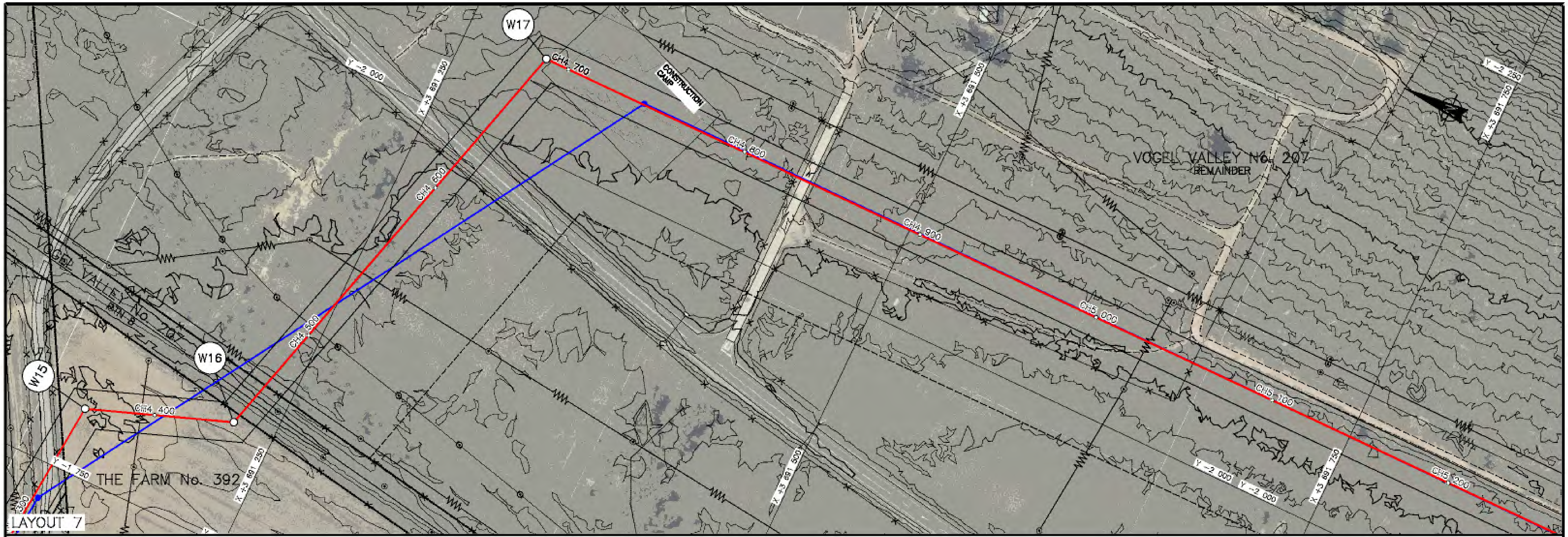
DESIGN:
CHECKED: DATE: DRAWN: AUTOCAD
ENG./EXP: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

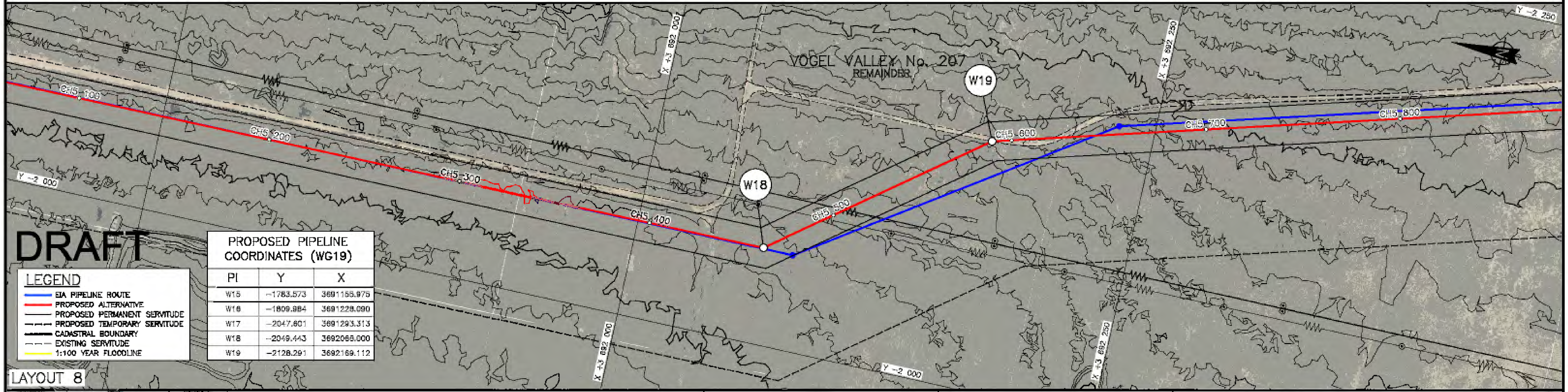
BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN

LAYOUTS 5 AND 6

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER XX
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 4 OF 6 | No. | REV. D
CALC. FILE. XXX





LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
- PROPOSED TEMPORARY SERVITUDE
- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
- 1:100 YEAR FLOODLINE

PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W15	–1783.573	3691155.975
W16	–1809.984	3691228.090
W17	–2047.601	3691293.313
W18	–2049.443	3692066.000
W19	–2128.291	3692169.112

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT
NAME: P. VAN HEERDEN REG. No.
SIGNATURE: DATE:

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3177.00.00.GZA.05.U005

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SCALE 1:1 000

IMPLEMENTING AGENT: TCTA — A new word for water
CONSULTING ENGINEER

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWN

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

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PRIVATE BAG X313
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ENGINEER: DATE: | EXTERNAL APPROVAL: DATE:
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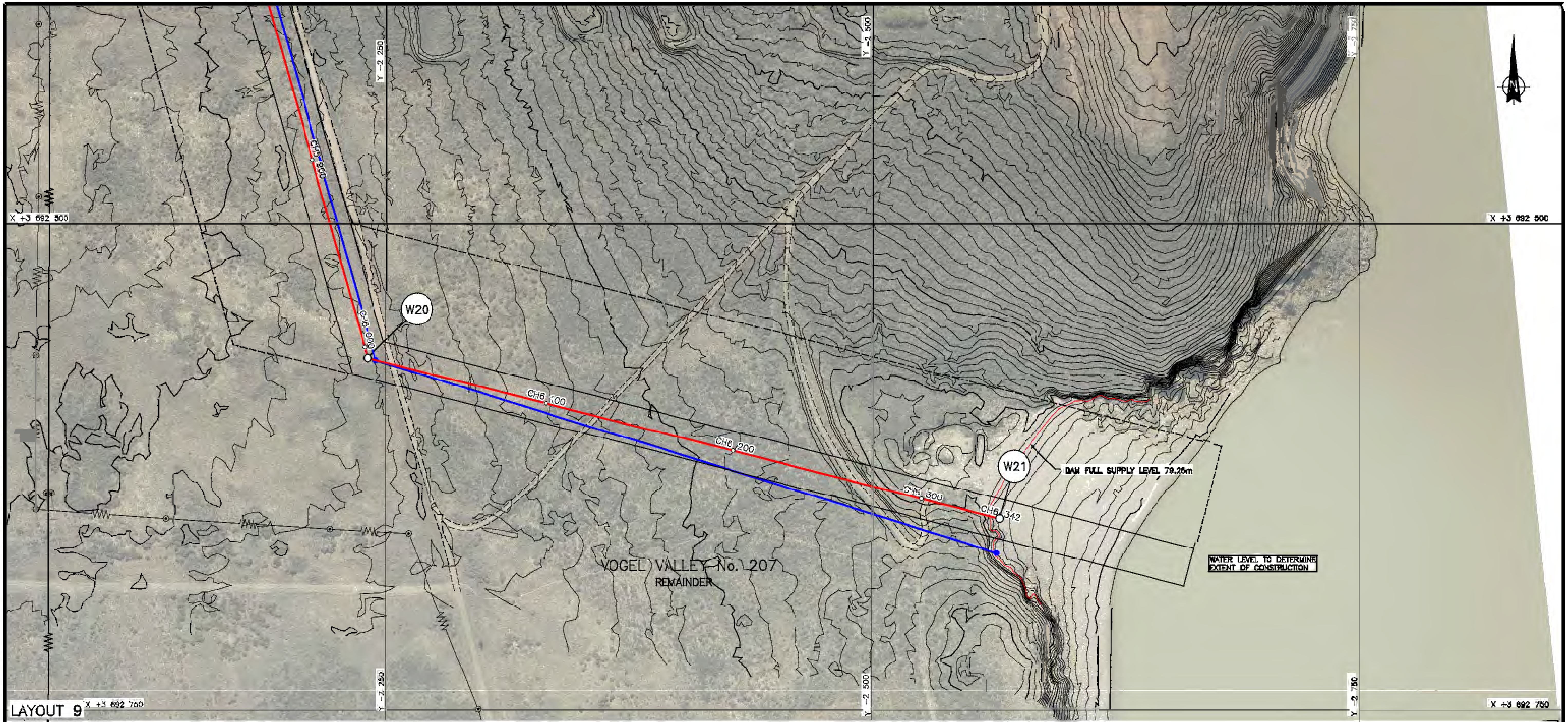
BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN

LAYOUTS 7 AND 8

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODE: | OTHER NUMBER XX
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 5 OF 6 | REG. No. | REV. D
CALC. FILE. XXX



DRAFT

PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W20	-2240.569	3692569.577
W21	-2565.635	3692652.486

LEGEND

- EIA PIPELINE ROUTE
- PROPOSED ALTERNATIVE
- PROPOSED PERMANENT SERVITUDE
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- CADASTRAL BOUNDARY
- EXISTING SERVITUDE
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DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE: DATE:

JV DRAWING NUMBER

3177.00.00.GZA.05.U006

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SCALE 1:1 000

IMPLEMENTING AGENT

CONSULTING ENGINEERS

REVISION				
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PRETORIA 0001

SEDIBENG BUILDING
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BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN

LAYOUT 9

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER: XX

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 6 OF 6 | REG. No. | REV. D

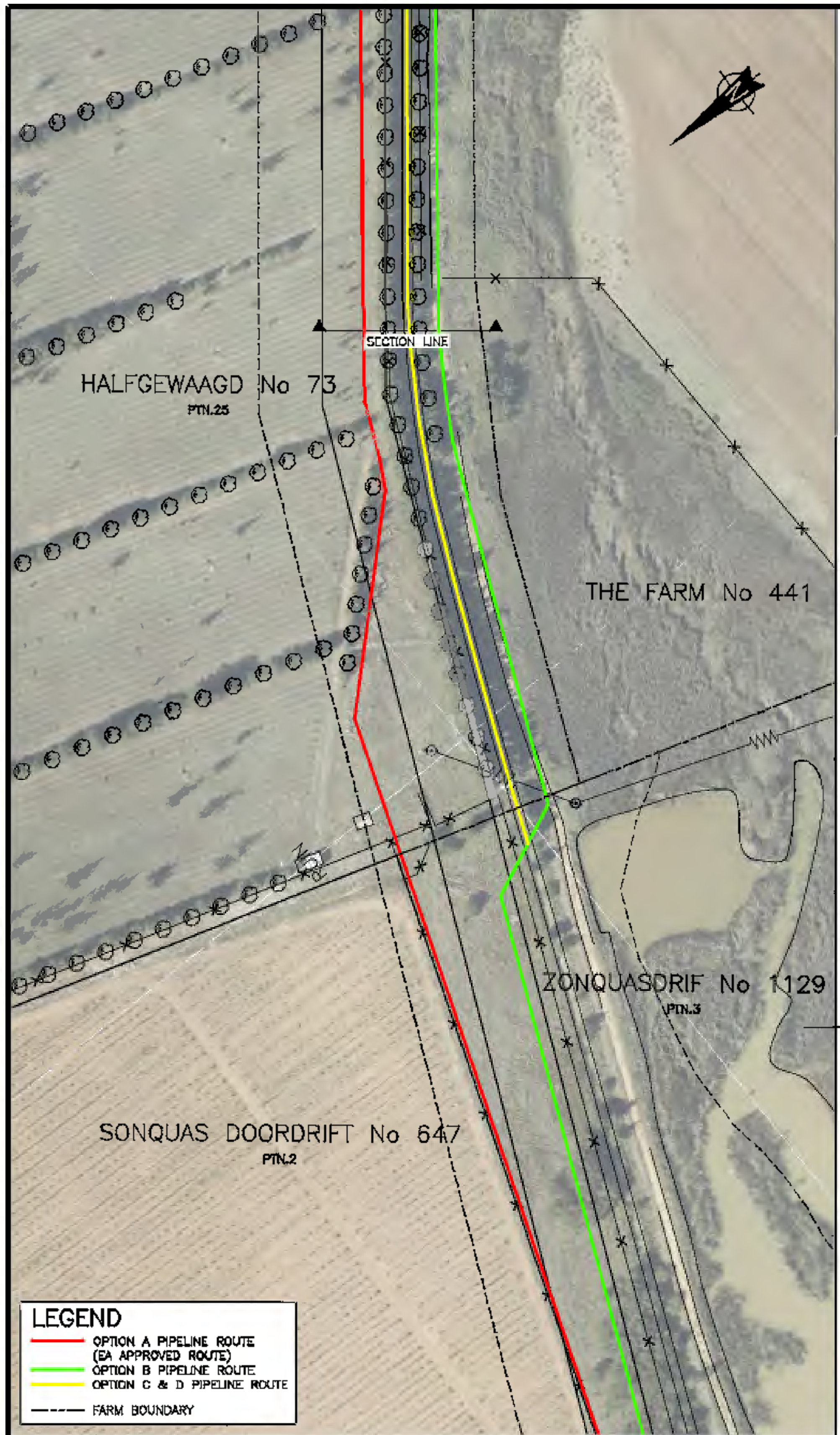
CALC. FILE XXX

ANNEXURE B

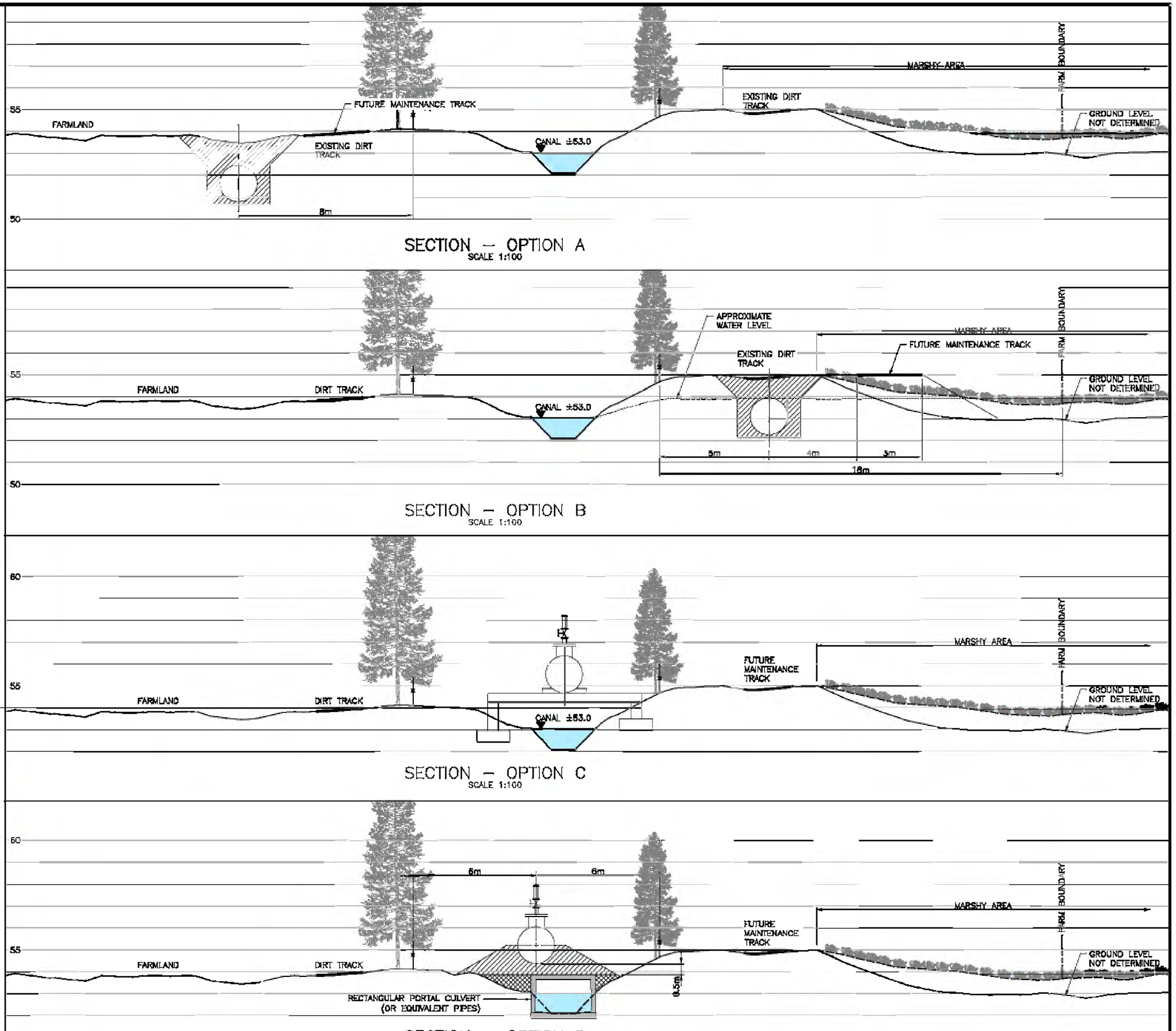
Rising Main Route on Halfgewaagd No. 73 Ptn 25

Drawing no. 3177.00.00.GZA.05.D010 Rev D – Rising Main - Cross Sections on Farm Halfgewaagd No. 73 Ptn 25

BRVAS: Assessment of Impacts during the Construction and Future Operations of the BRVAS Pipeline on the Farm Halfgewaagd No. 73 Ptn 25 for various Pipeline Route Options



LAYOUT PLAN
SCALE 1:1000



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DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT
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SIGNATURE: DATE:

JV DRAWING NUMBER
3177.00.00.GZA.05.D010

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER

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ENGINEER: DATE:
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DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN

CROSS SECTION ON FARM
HALFGEWAAGD No 73 PORTION 25

PROVINCE: WESTERN CAPE
DISTRICT: DRAKENSTEIN/SWARTLAND
KEYCODES:
OTHER NUMBER: XX
LOCALITY No. XXX
TENDER/ CONTRACT No. XXX
CALC. FILE XXX
SHEET 1 OF 1
REG. No.
REV. D

BRVAS: Assessment of Impacts during the Construction and Future Operations of the BRVAS Pipeline on the Farm Halfgewaagd 73 for various Pipeline Route Options

Impact Description	Original EIA route	Revised EIA route following appeal by Bonaire Property		
	Option A	Option B	Option C	Option D
During Construction				
Acquisition of land, and land rights (temporary and permanent servitudes) from landowner*	Compensation for servitudes, acquired by expropriation.	Compensation for servitudes, acquired by expropriation	Compensation for servitudes, acquired by expropriation.	Compensation for servitudes, acquired by expropriation.
Impacts on landowner operations	Short-term impact on landowner operations (narrow strip of land, i.e. cultivated area), landowner to be compensated in accordance the Expropriation Act.	Existing canal to be decommissioned temporarily for the period when canal crossings are constructed.	Existing canal to be decommissioned temporarily for an extended period for construction purposes.	Existing canal to be decommissioned temporarily for an extended period for construction purposes.
Impact on operation of existing canal and water conveyance by the Department of Water and Sanitation	Status quo will be applicable, i.e. canal will continue to operate. No impact on the wetland and landowner's dam.	Existing canal decommissioned temporarily for a period of approximately 8 months to facilitate the construction process.	Existing canal decommissioned temporarily for a period of approximately 3 months to facilitate the construction process.	Existing canal decommissioned temporarily for a period of approximately 8 months to facilitate the construction process.
Environmental impacts	Limited; to be rehabilitated.	Temporary impact on wetland (ecology and bird life), will require extensive rehabilitation of the wetland area.	Limited; to be rehabilitated.	Limited; to be rehabilitated.
Impact on existing trees acting as windbreak	None	None	Damage to trees on the wetland side of the canal is likely where sufficient clearances are not available between trees/branches to accommodate construction equipment.	Damage to trees on the wetland side of the canal is likely where sufficient clearances are not available between trees/branches to accommodate construction equipment.

Impact Description	Original EIA route	Revised EIA route following appeal by Bonaire Property		
	Option A	Option B	Option C	Option D
Construction Duration on Land Portion (approx. estimate)	4 to 6 weeks	4 to 6 months	3 to 4 months	6 to 8 months
During Operation and Maintenance				
Noise impact	None	Not foreseen.	Elevation of pipeline higher than upstream and downstream sections. Air valve/s will be required and noise pollution is likely during pump start-up, shut down and during filling/draining of pipeline when air is expelled from or introduced into the pipeline.	Elevation of pipeline higher than upstream and downstream sections. Air valve/s will be required and noise pollution is likely during pump start-up, shut down and during filling/draining of pipeline when air is expelled from or introduced into the pipeline.
Visual impact	None	None	Above ground installation of supporting structure, pipeline and air valves installation will have a visual impact.	Same as above ground earth berm, pipeline and air valve installation will have a visual impact.
Environmental impacts, i.e. bio-physical	Limited; to be rehabilitated.	Limited; impact on wetland ecology and bird life after rehabilitation of the wetland area.	Limited; to be rehabilitated.	Limited; to be rehabilitated.
Impact on landowner Operations	Not foreseen.	None	None	None
Notes: * In general, the restriction on the pipeline servitudes will be as follows: Only crops or plants with shallow rooting systems may be cultivated or planted on the permanent servitude area.				

Photographs showing pre-construction, construction, and post construction activities in wetlands on other pipeline projects

Pre-construction	Construction	Post-construction
		
	Use of bog mats in wetland to minimise impacts.	

ANNEXURE C

Wayleave Drawings

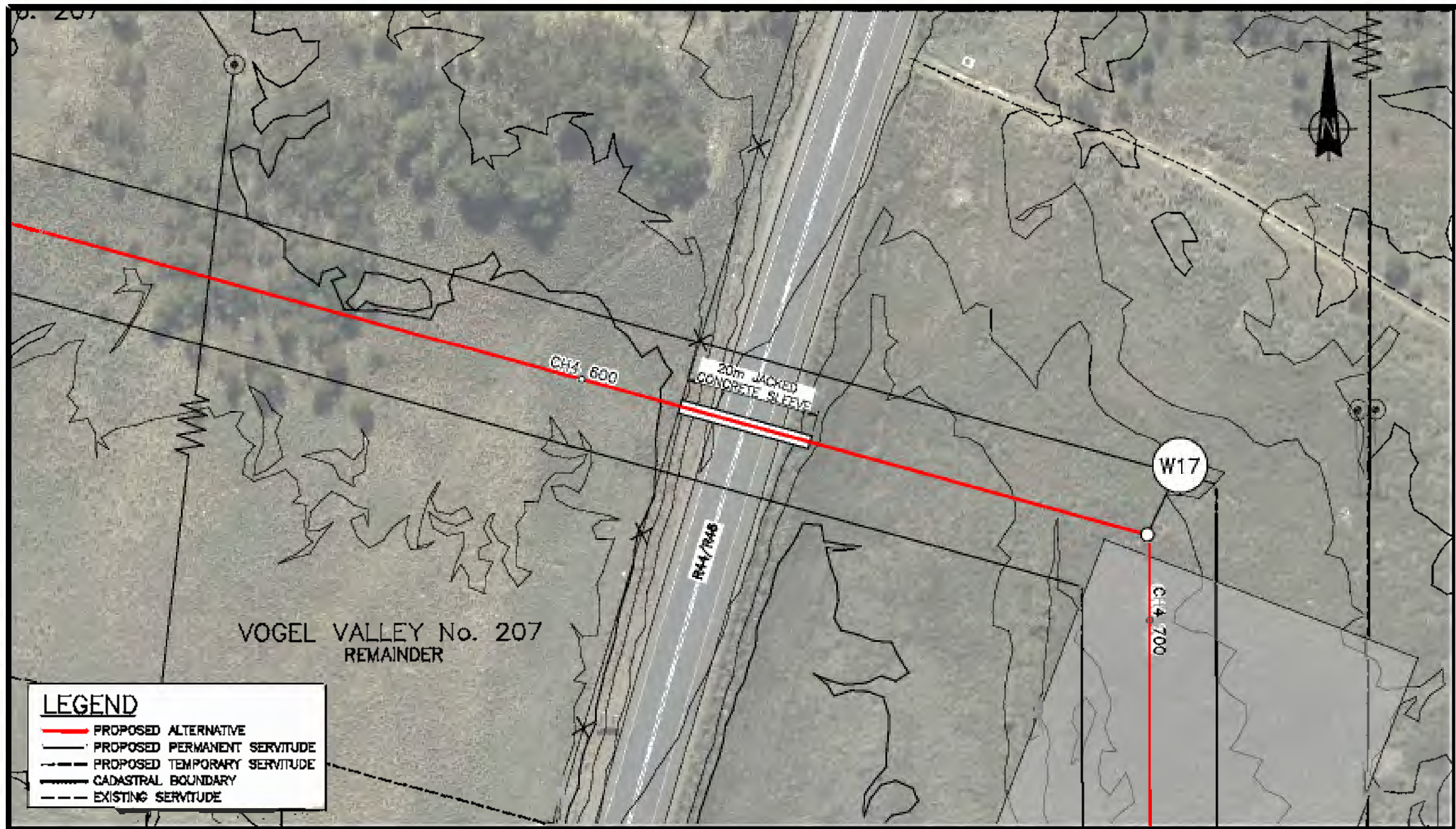
Drawing no. 3177.00.00.GZA.05.A100 Rev A – Rising Main - Jacked Road Crossing – Road R44/R46 at Pipeline CH4625

Drawing no. 3177.00.00.GZA.05.A101 Rev A – Rising Main - Jacked Railway Crossing at Pipeline CH 4455

Drawing no. 3177.00.00.GZA.05.A102 Rev A – Rising Main - Powerline Crossing at Pipeline CH 2960

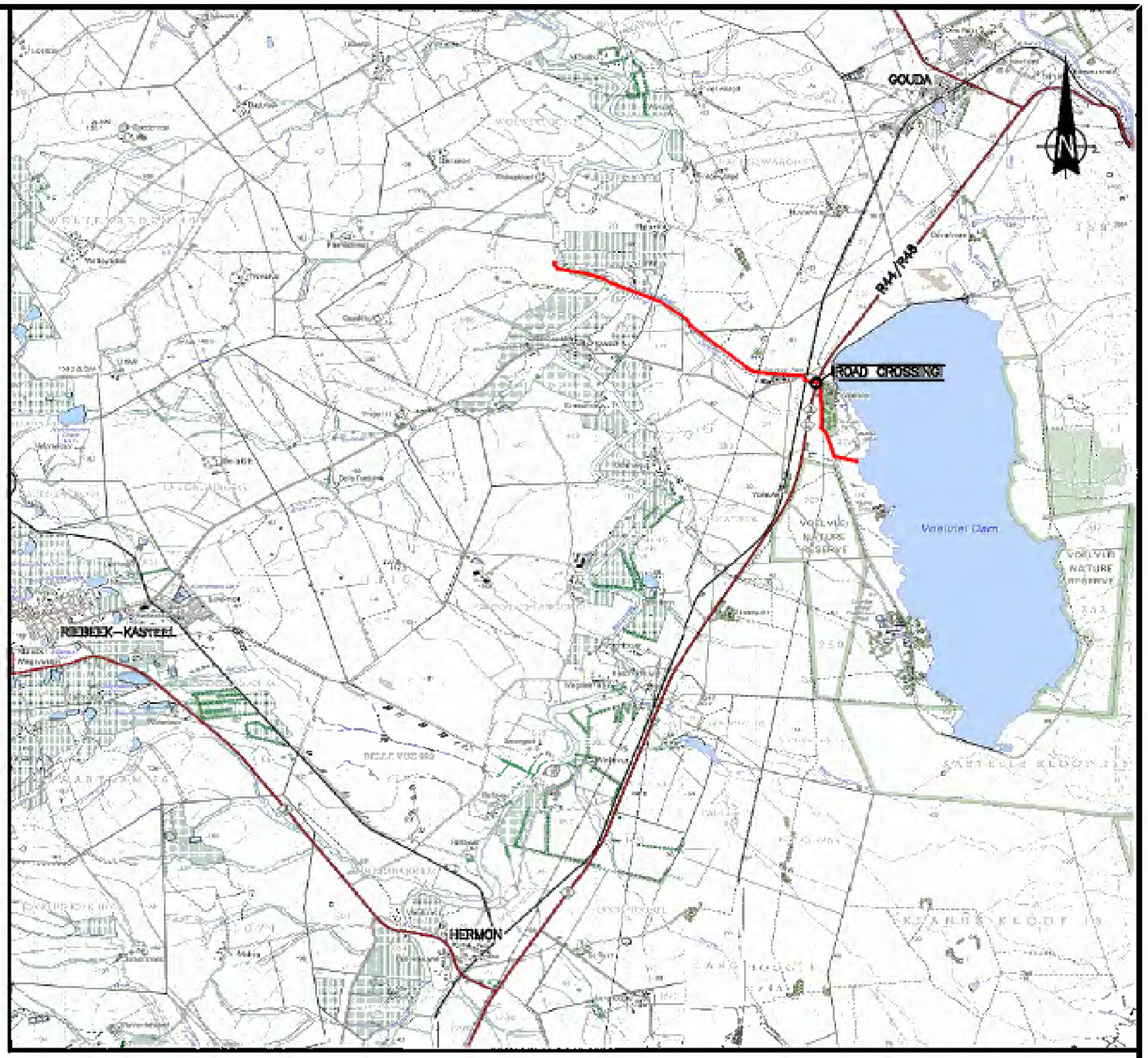
Drawing no. 3177.00.00.GZA.05.A103 Rev A – Rising Main - Powerline Crossing at Pipeline CH 3685

Drawing no. 3177.00.00.GZA.05.A104 Rev A – Rising Main - Powerline Crossing at Pipeline CH 5505



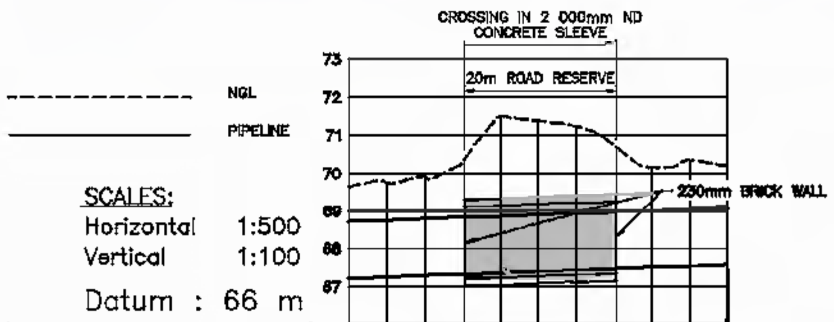
LAYOUT PLAN

SCALE 1:500



LOCALITY PLAN

SCALE 1:50 000



SCALES:
Horizontal 1:500
Vertical 1:100

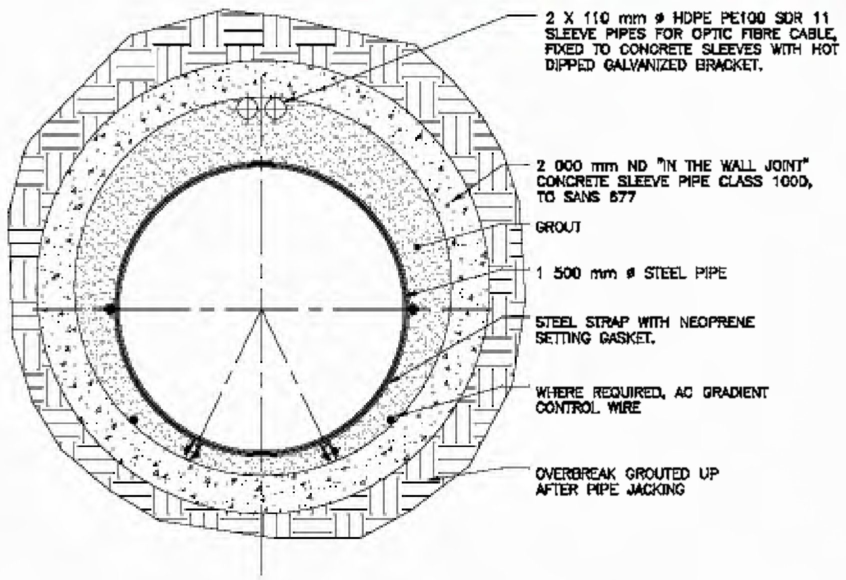
Datum : 66 m

CHAINAGE (m)	4800.000	4805.000	4810.000	4815.253	4820.000	4825.000
INVERT LEVEL	67.227	67.264	67.300	67.336	67.372	67.408
DEPTH TO INVERT	-2.417	-2.488	-2.612	-2.973	-4.129	-3.976
GROUND LEVEL	69.644	69.752	69.912	70.308	71.501	71.384

CHAINAGE (m)	4830.000	4835.253	4840.000	4845.000	4850.000
INVERT LEVEL	67.444	67.480	67.516	67.552	67.589
DEPTH TO INVERT	-3.793	-3.258	-2.631	-2.791	-2.607
GROUND LEVEL	71.237	70.738	70.147	70.343	70.196

PIPE GRADES: 0.722%

PIPE DETAILS: 1800mm ND STEEL PIPELINE



CROSS SECTION

SCALE 1:20

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT
NAME: P. VAN HEERDEN REG. No.
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JV DRAWING NUMBER
3177.00.00.GZA.05.A100

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SCALE 1:500

0 1 000 2 000 3 000 4 000 5 000 10 000 m
SCALE 1:50 000

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEERS: Aurecon Ninham JV

REVISION

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PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

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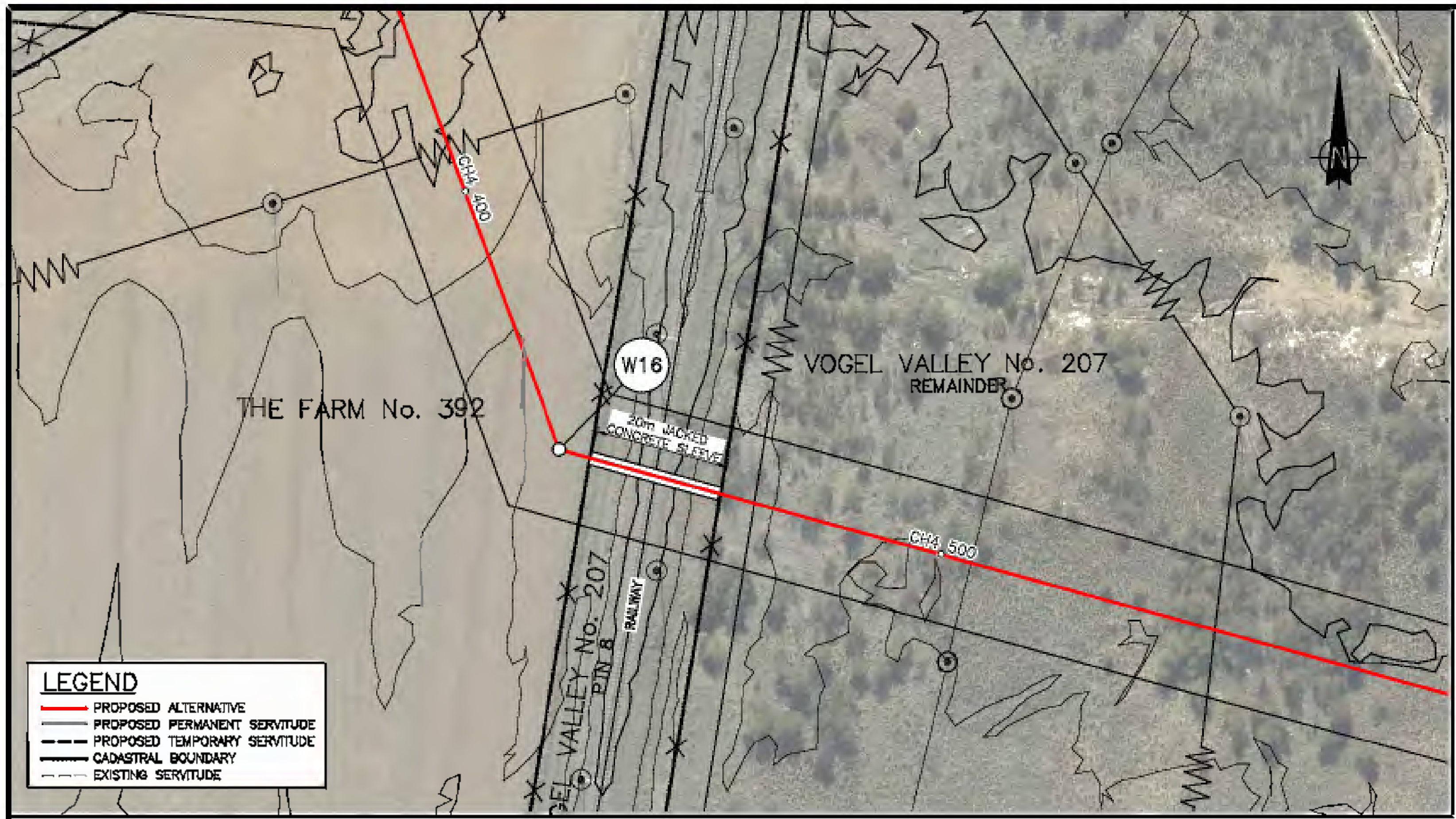
CHECKED: DATE: DRAWN: AUTOCAD
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN

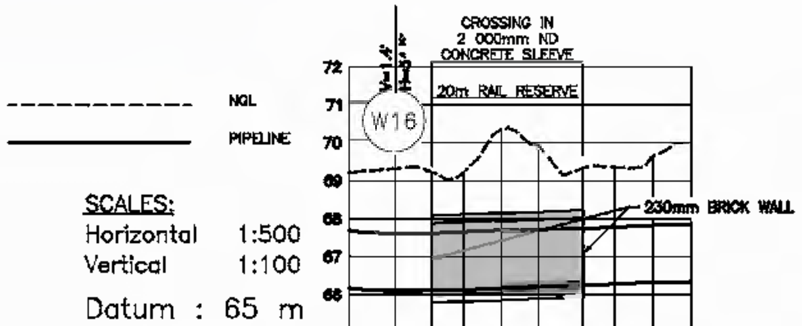
JACKED ROAD CROSSING
ROAD R44/R46
AT PIPELINE CH 4 625

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES | OTHER NUMBER XX
LOCALITY No. XXX | TENDER/ CONTRACT No.XXX | SHEET 1 OF 1 | REG. No. | REV. A
CALC. FILE XXX



LAYOUT PLAN

SCALE 1:500



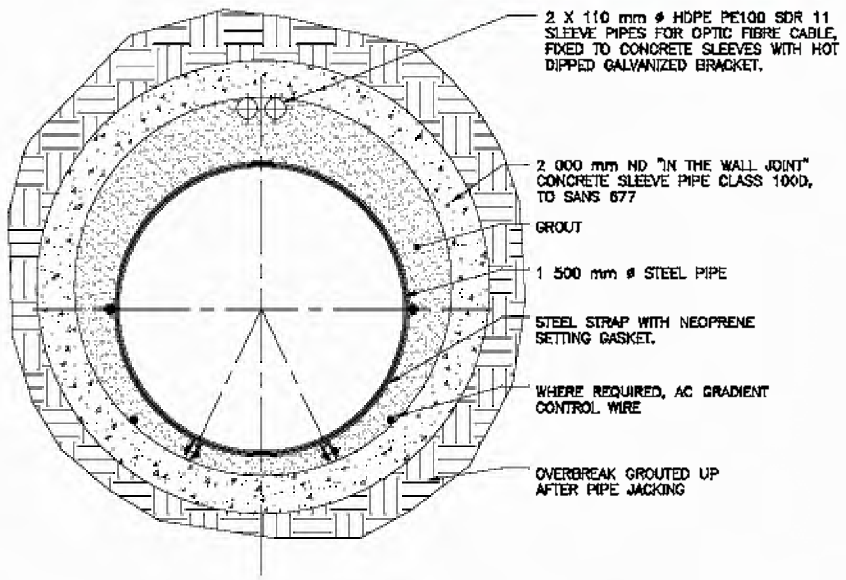
SCALES:

Horizontal 1:500

Vertical 1:100

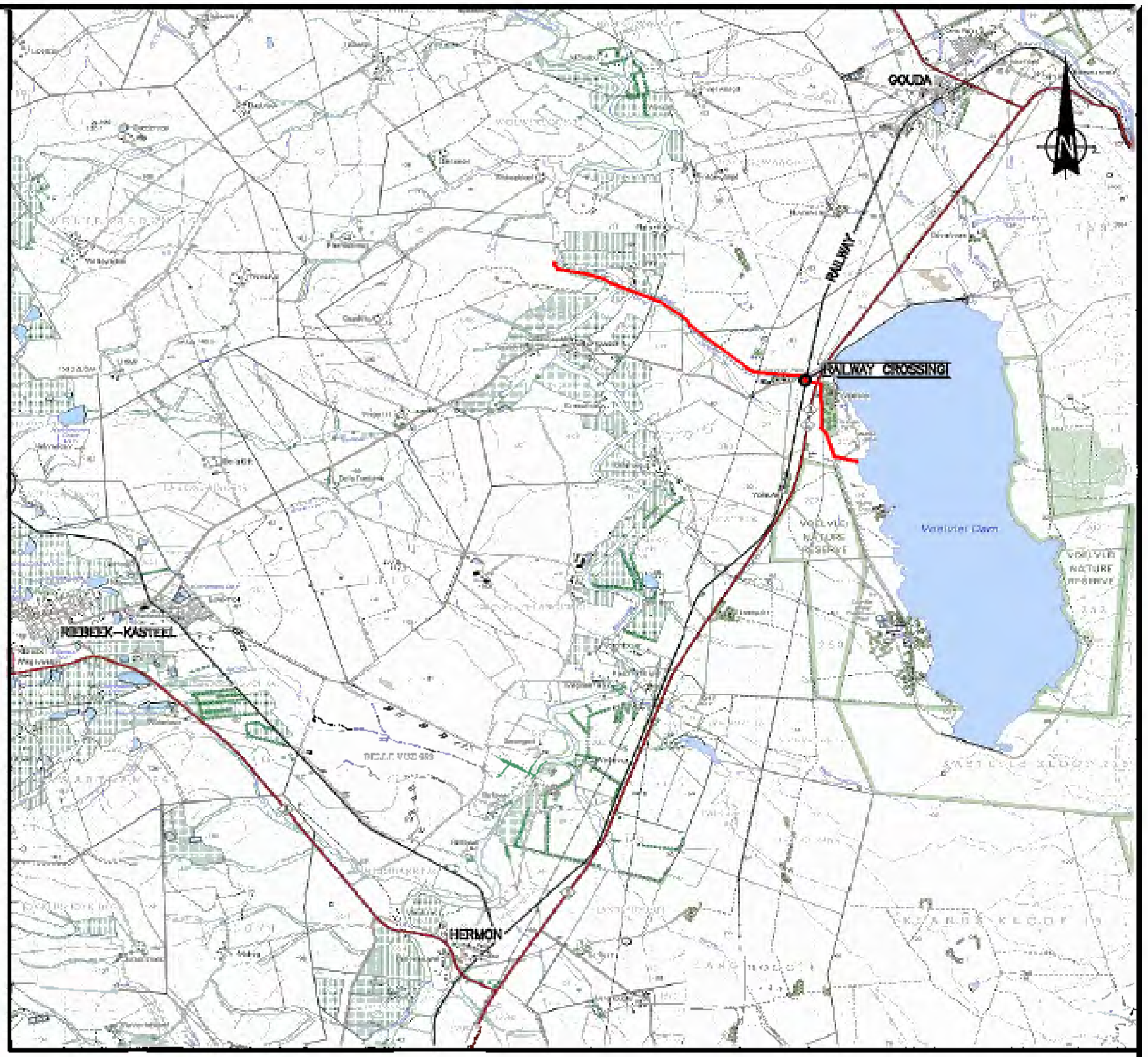
Datum : 65 m

CHAINAGE (m)	4435.000	4441.027	4445.826	4450.000	4455.000	4460.000	4465.826	4470.000	4475.000	4480.000
INVERT LEVEL	66.184	66.079	66.114	66.144	66.180	66.216	66.258	66.288	66.324	66.361
DEPTH TO INVERT	-3.025	-3.238	-3.111	-3.066	-4.193	-3.657	-3.072	-3.063	-3.305	-3.560
GROUND LEVEL	69.206	69.317	69.225	69.210	70.373	69.873	69.330	69.351	69.629	69.921
PIPE GRADES	-1.740%		0.722%							
PIPE DETAILS	1500mm ND STEEL PIPELINE									



CROSS SECTION

SCALE 1:20



LOCALITY PLAN

SCALE 1:50 000

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT

NAME: P. VAN HEERDEN REG. No.

SIGNATURE: DATE:

DRAWING NUMBER

3177.00.00.GZA.05.A101

0 5 10 20 30 40 50 100 m

SCALE 1:500

0 1 000 2 000 3 000 4 000 5 000 10 000 m

SCALE 1:50 000

TCTA A new word for water

CONSULTING ENGINEER

REV No.	DATE	REVISION DESCRIPTION	FOR	INIT

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CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

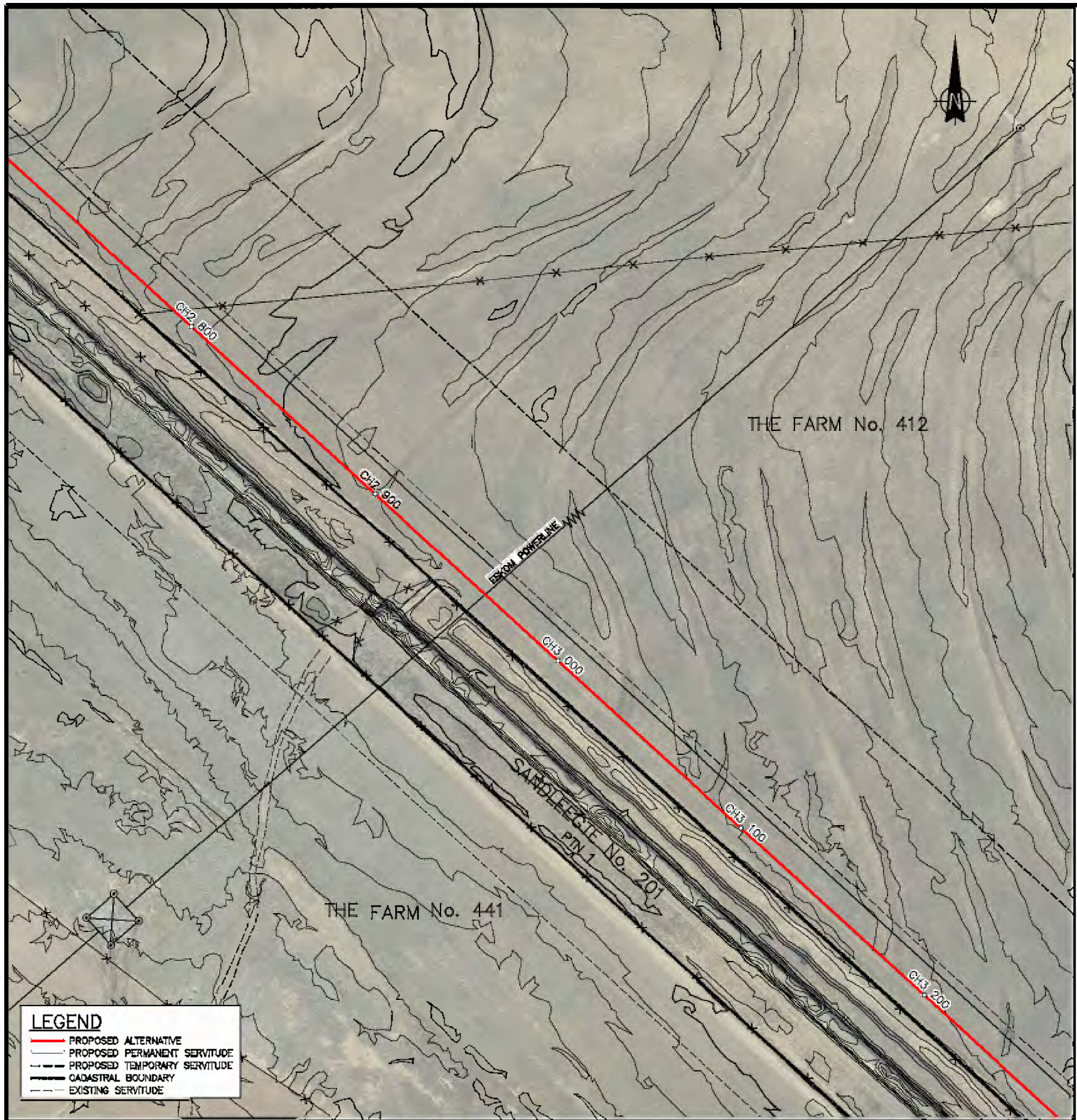
RISING MAIN

JACKED RAILWAY CROSSING
AT PIPELINE CH 4 455

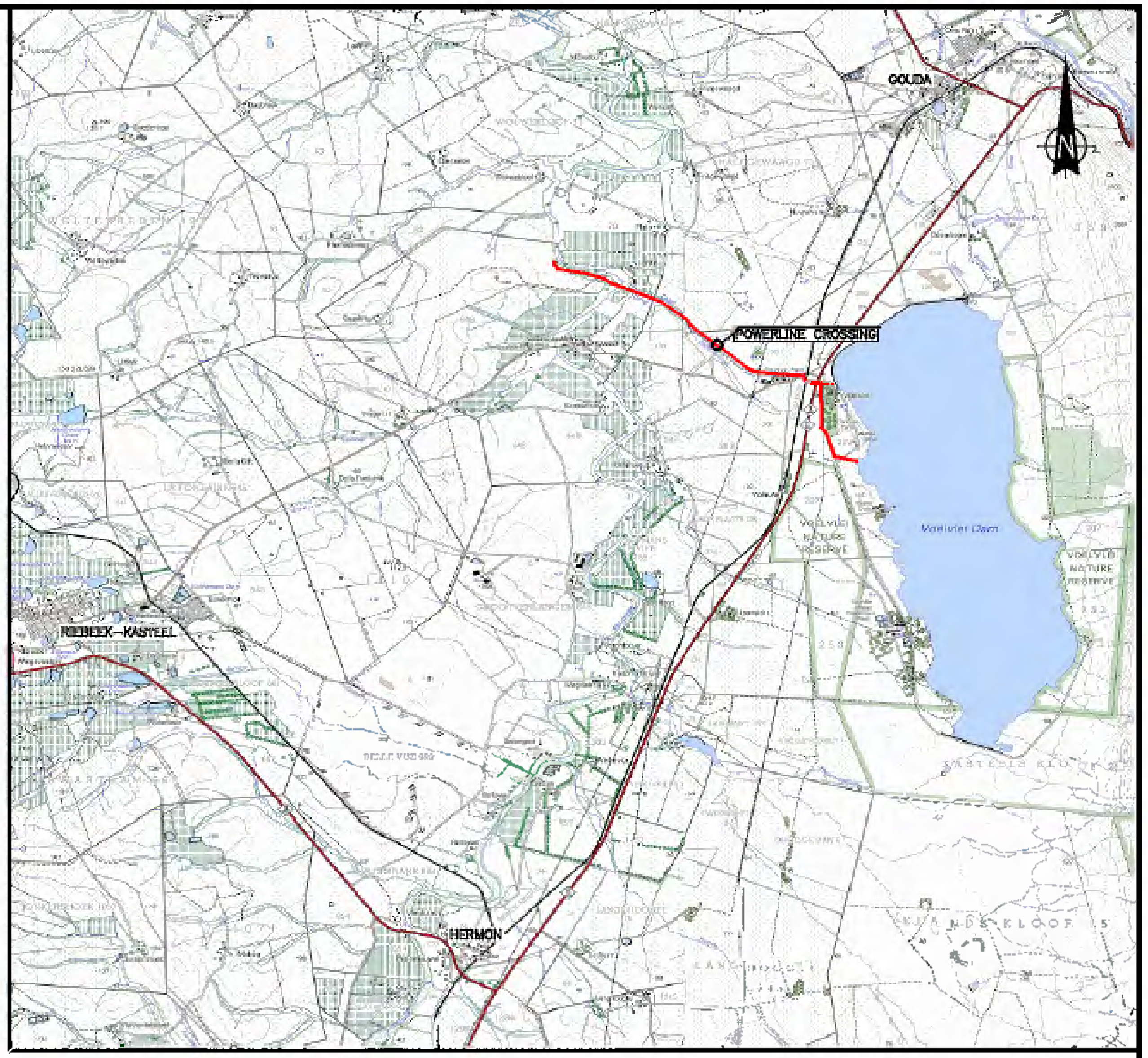
PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES | OTHER NUMBER

LOCALITY No. XXX | TENDER/ CONTRACT No.XXX | SHEET 1 OF 1 | REV. A

CALC. FILE XXX



LAYOUT PLAN
SCALE 1:1000



LOCALITY PLAN
SCALE 1:50 000

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DRAWING CHECKED	A. STEENBERG	N/A

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NAME: P. VAN HEERDEN REG. No.
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JV DRAWING NUMBER
3177.00.00.GZA.05.A102

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SCALE 1:1 000

0 1 000 2 000 3 000 4 000 5 000 10 000 m
SCALE 1:50 000

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IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEERS:

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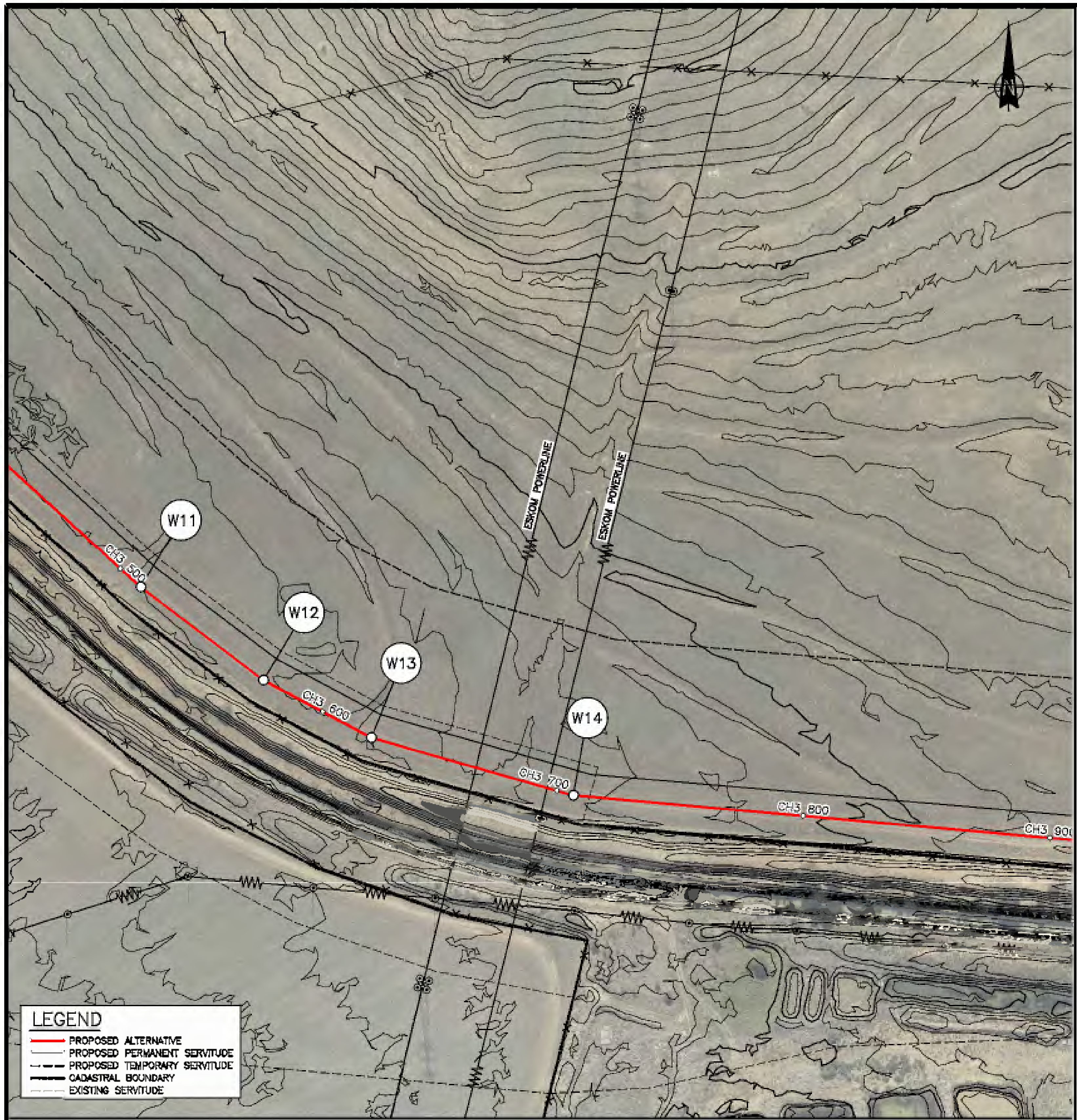
BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

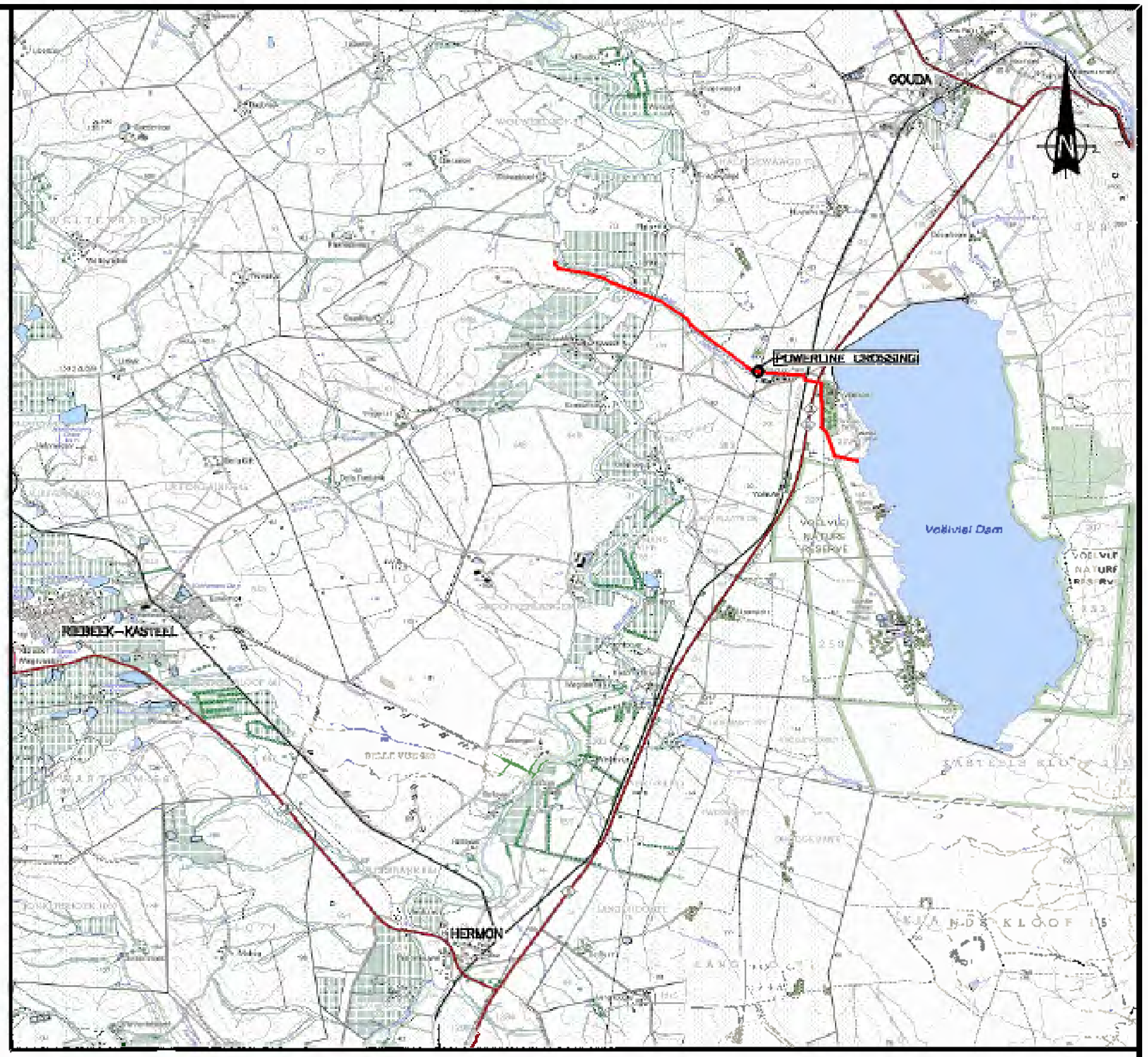
RISING MAIN

POWERLINE CROSSING
AT PIPELINE CH 2 960

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER: XX
LOCALITY No. XXX | TENDER/ CONTRACT No.XXX | SHEET 1 OF 1 | REG. No. | REV. A
CALC. FILE XXX



LAYOUT PLAN
SCALE 1:1000



LOCALITY PLAN
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DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT
NAME: P. VAN HEERDEN REG. No.
SIGNATURE: DATE:

JV DRAWING NUMBER
3177.00.00.GZA.05.A103

0 5 10 20 30 40 50 100 200 m
SCALE 1:1 000

0 1 000 2 000 3 000 4 000 5 000 10 000 m
SCALE 1:50 000

IMPLEMENTING AGENT: TCTA — A new word for water
CONSULTING ENGINEERS

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

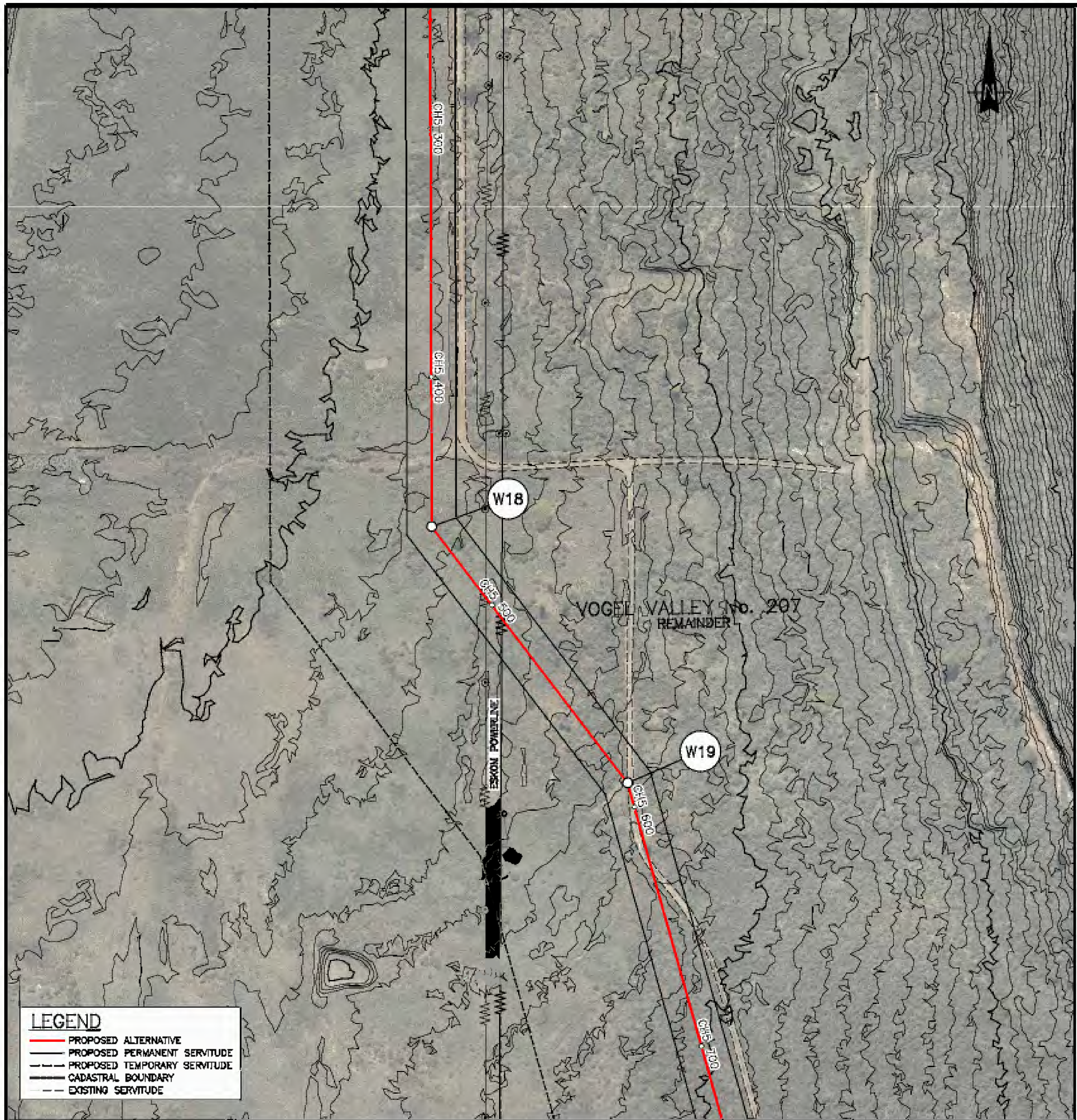
DESIGN:
CHECKED: DATE: DRAWN: AUTOCAD
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

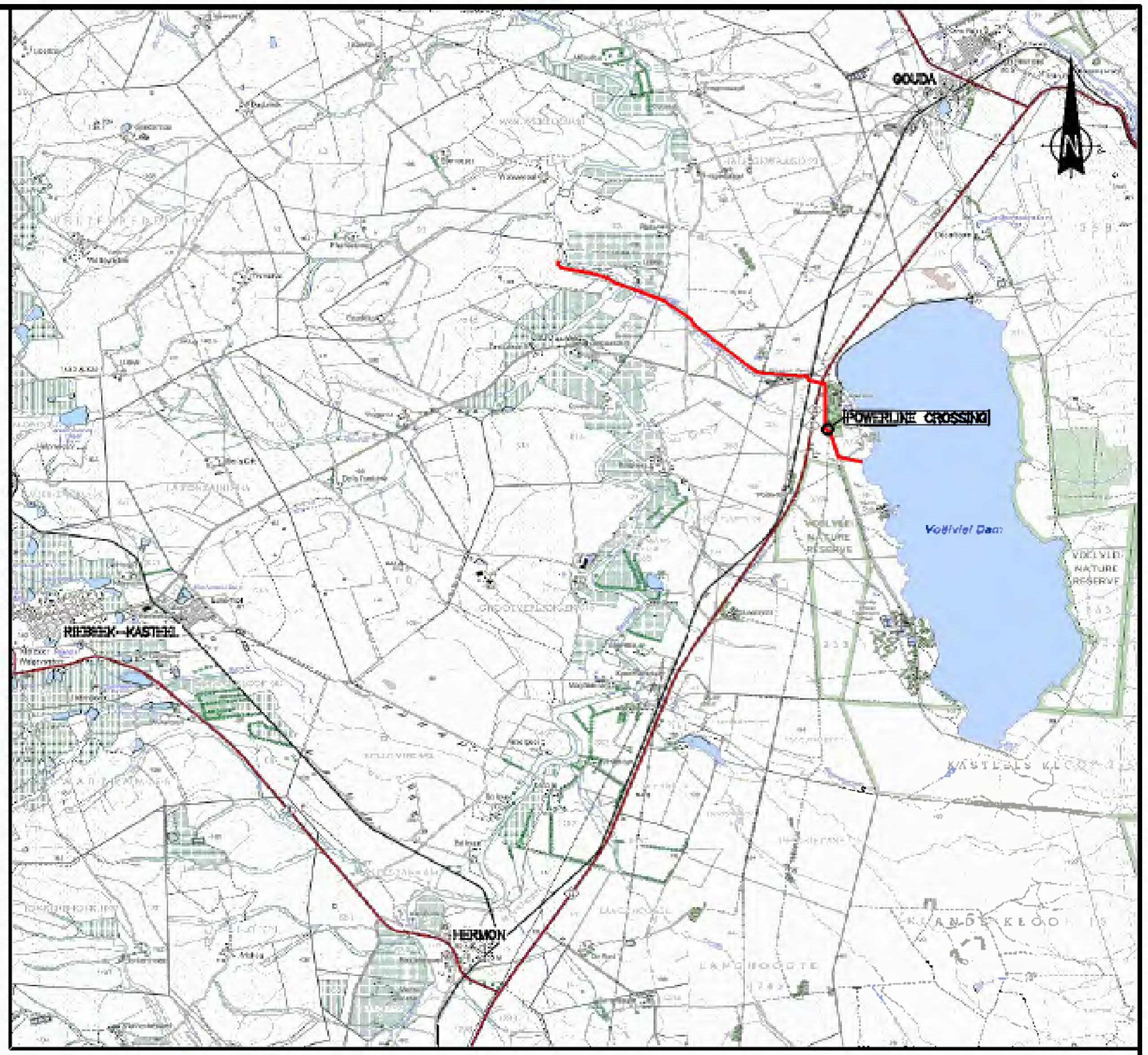
RISING MAIN

POWERLINE CROSSING
AT PIPELINE CH 3 685

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES | OTHER NUMBER XX
LOCALITY No. XXX | TENDER/ CONTRACT No.XXX | SHEET 1 OF 1 | REG. No. | REV. A
CALC. FILE XXX



LAYOUT PLAN
SCALE 1:1000



LOCALITY PLAN
SCALE 1:50 000

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A

APPROVAL – CONSULTANT
NAME: P. VAN HEERDEN REG. No.
SIGNATURE: DATE:

JV DRAWING NUMBER
3177.00.00.GZA.05.A104

0 5 10 20 30 40 50 100 200 m
SCALE 1:1 000

0 1 000 2 000 3 000 4 000 5 000 10 000 m
SCALE 1:50 000

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER: Amanzi Entuba JV

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWA

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
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PRETORIA 0001

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CHECKED: DATE: DESIGN:
DRAWN: AUTOCAD
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN

POWERLINE CROSSING
AT PIPELINE CH 5 505

PROVINCE: WESTERN CAPE
DISTRICT: DRAKENSTEIN/SWARTLAND
KEYCODES:
OTHER NUMBER XX
LOCALITY No. XXX
TENDER/ CONTRACT No. XXX
CALC. FILE. XXX
SHEET 1 OF 1
REG. No.
REV. A