



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)



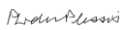
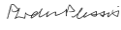
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CONSULTING SERVICES FOR THE BERG RIVER-VOELVLEI AUGMENTATION SCHEME (BRVAS)

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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 m³/s stepped pumping rule and a 6 m³/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 m³/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.

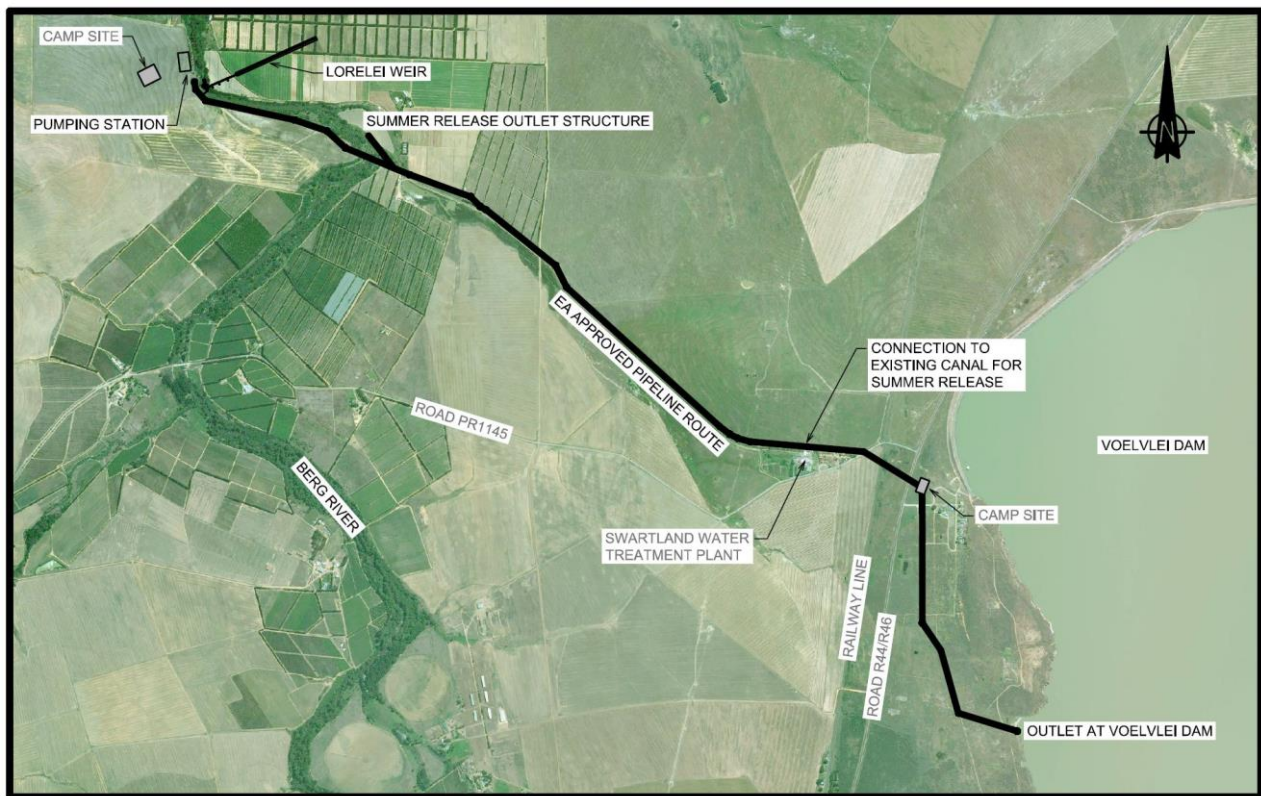


Figure 1: BRVAS Infrastructure Layout (Feasibility Study)

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 were considered during the Feasibility Study to supplement the Western Cape Water Supply System i.e.:

- Option 1: 4 m³/s supply system with stepped pumping rule providing a 1:50 year incremental yield of 23 million m³/a (operating rule allows for pumping in flow increment steps of 1 m³/s up to the pumping station capacity of 4 m³/s and a base flow of at least 1 m³/s is allowed to pass the site at all times); and

- Option 2: 6 m³/s supply system with variable speed pumping units providing a 1:50 year incremental yield of 20 million m³/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 m³/s supply system providing the higher incremental yield of 23 million m³/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 m³/s supply system with an incremental yield of 23 million m³/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 m³/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 m³/s flow increment steps for Berg River, flows between for example 2 m³/s and 2.99 m³/s only 1 m³/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 m³/s and 3.99 m³/s can the abstraction rate be increased to 2 m³/s. With variable speed units, it will be possible to also abstract the flows between the step increments of 1 m³/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 m³/a will be abstracted during five months of the year which equates to an average continuous pumping rate of 1.75 m³/s. An average pumping rate of 3.5 m³/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 m³/s; and
- Average flow (adopted for economic evaluation) - 3.5 m³/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 m³/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.

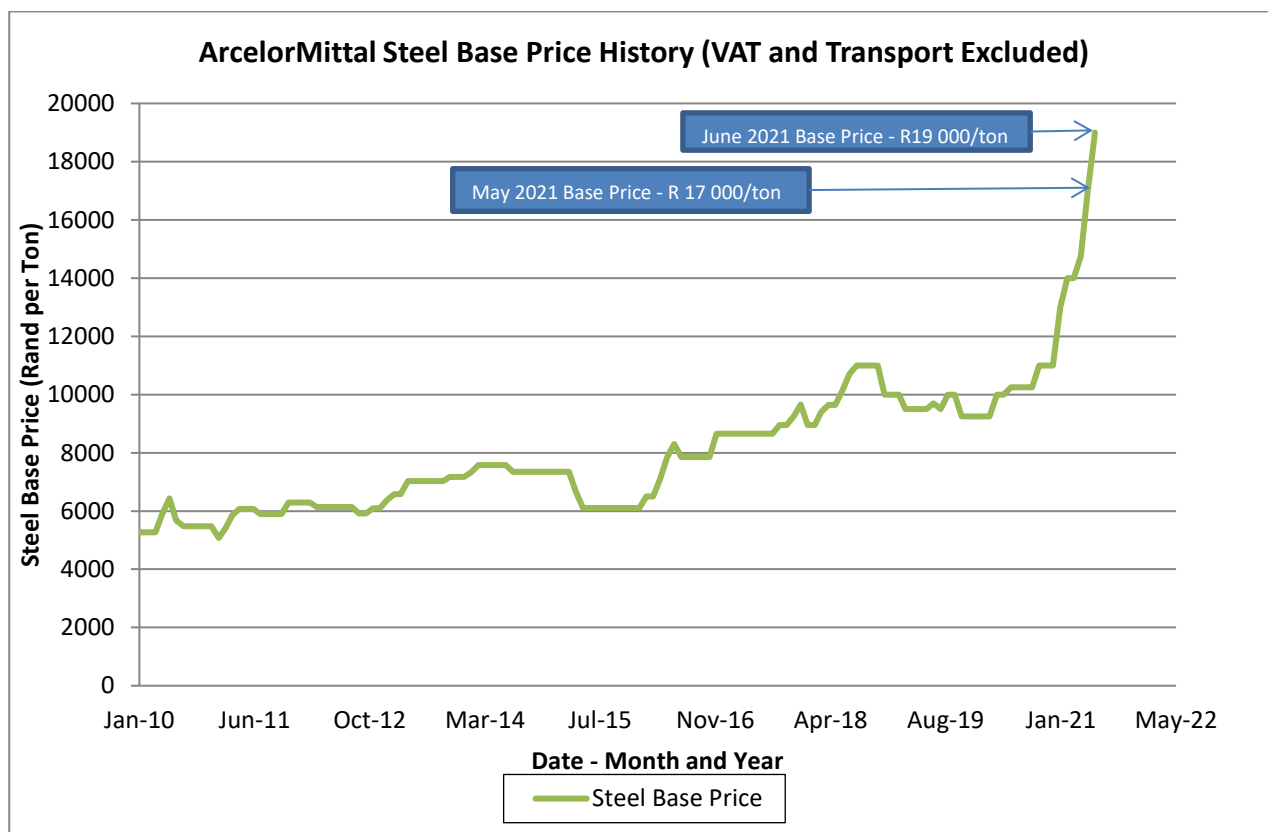


Figure 2: ArcelorMittal Steel Base Price History (VAT and Transport Excluded)

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 m³/s and 2.07 m/s at design flow of 4.6 m³/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.

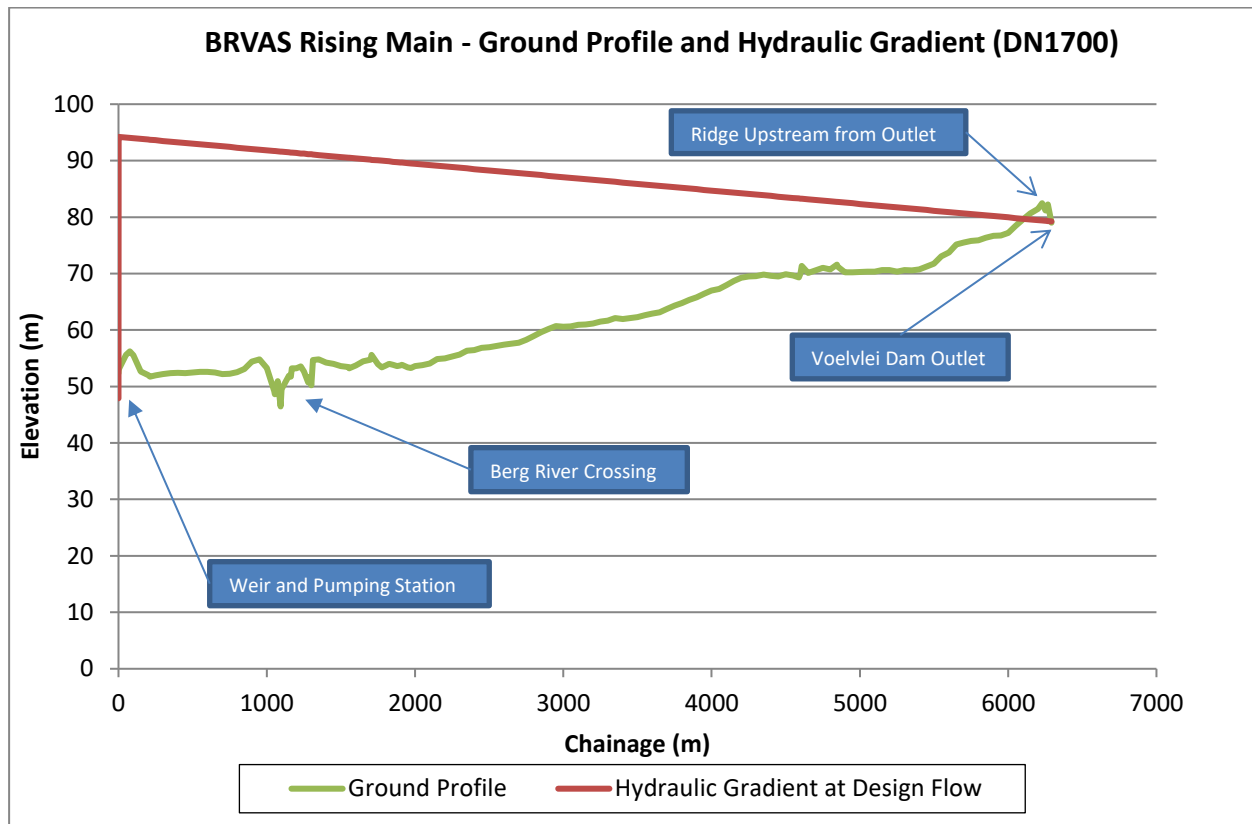


Figure 3: BRVAS Rising Main - Ground Profile and Hydraulic Gradient (DN 1 700)

Figure 3 reflects the following that should be noted:

- 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
- Ground levels at the “ridge” just upstream from the Voelvlei 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 Voelvlei 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 m³/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 m³/s with no allowance for real Eskom tariff increases.

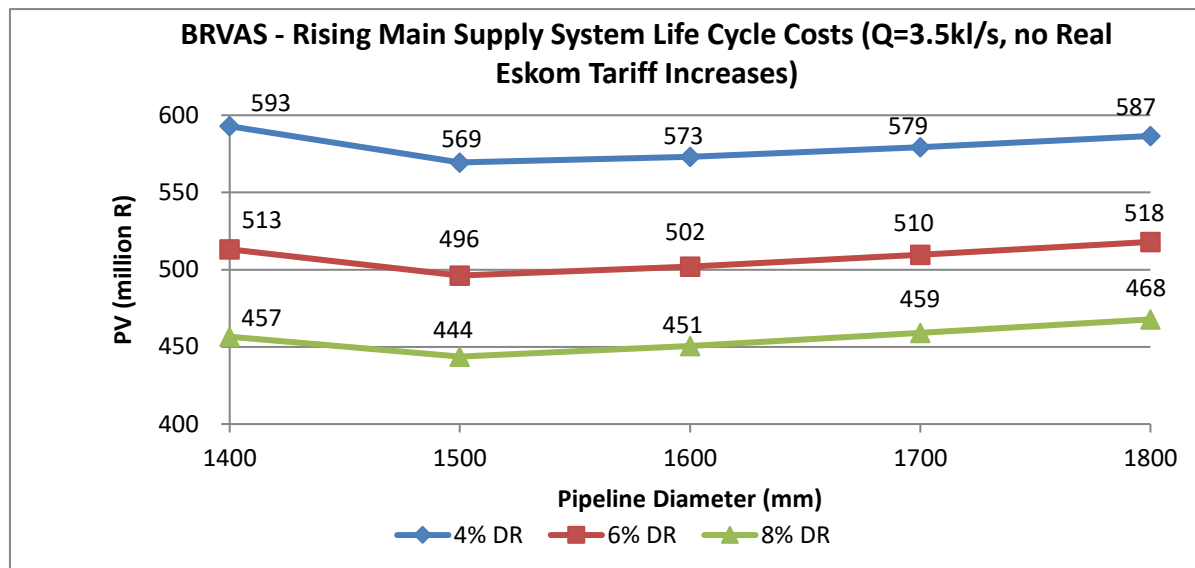


Figure 4: Supply System PV's for Various Pipeline Diameters

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 m³/s and a 6% discount rate.

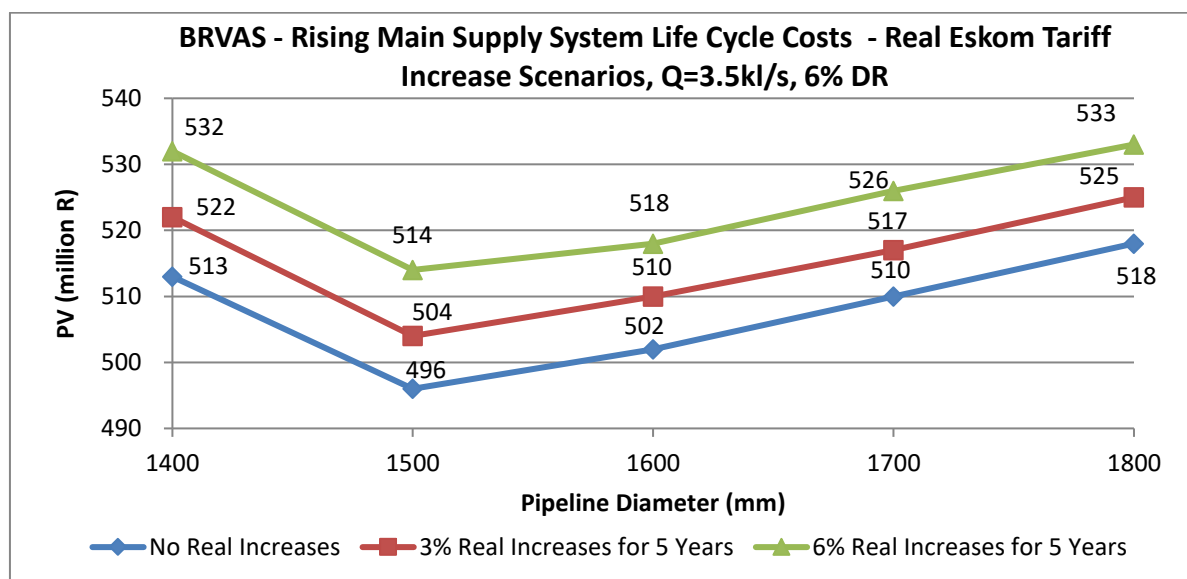


Figure 5: Supply System PV's (6% Discount Rate) for Various Pipeline Diameters and Energy Cost Increase Scenarios using Average Flow of 3.5 m³/s

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/m² 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: $<60\mu\text{S}/\text{m}^2$;
- 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 released 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 m³/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 m³/s and the hydraulic gradient at this flow rate is reflected in Figure 6.

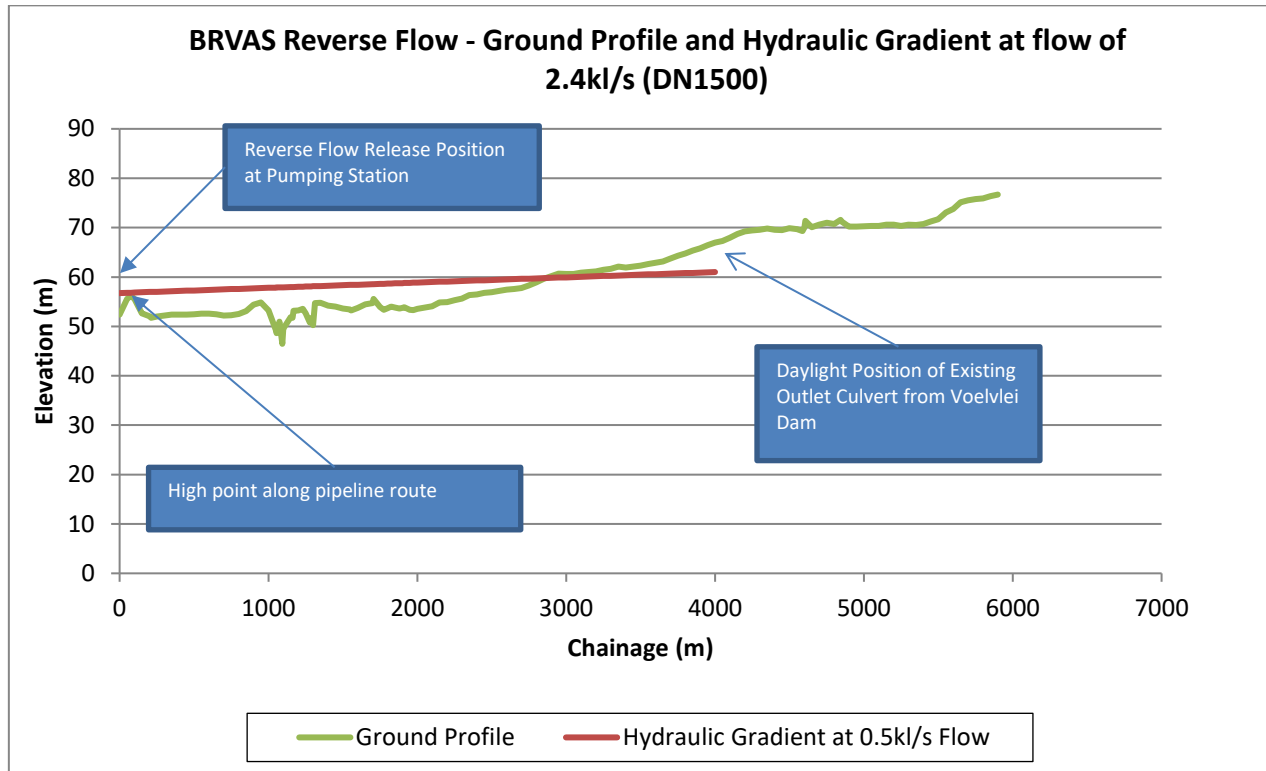


Figure 6: BRVAS Reverse Flow - Ground Profile and Hydraulic Gradient (DN 1 500)

Drawings from DWS of the existing outlet culvert from the Voëlvlei Dam reflect the capacity of the culvert as 7 m³/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 contractor'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 m³/s does not correspond with the actual transfer of more than 2 m³/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 be 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

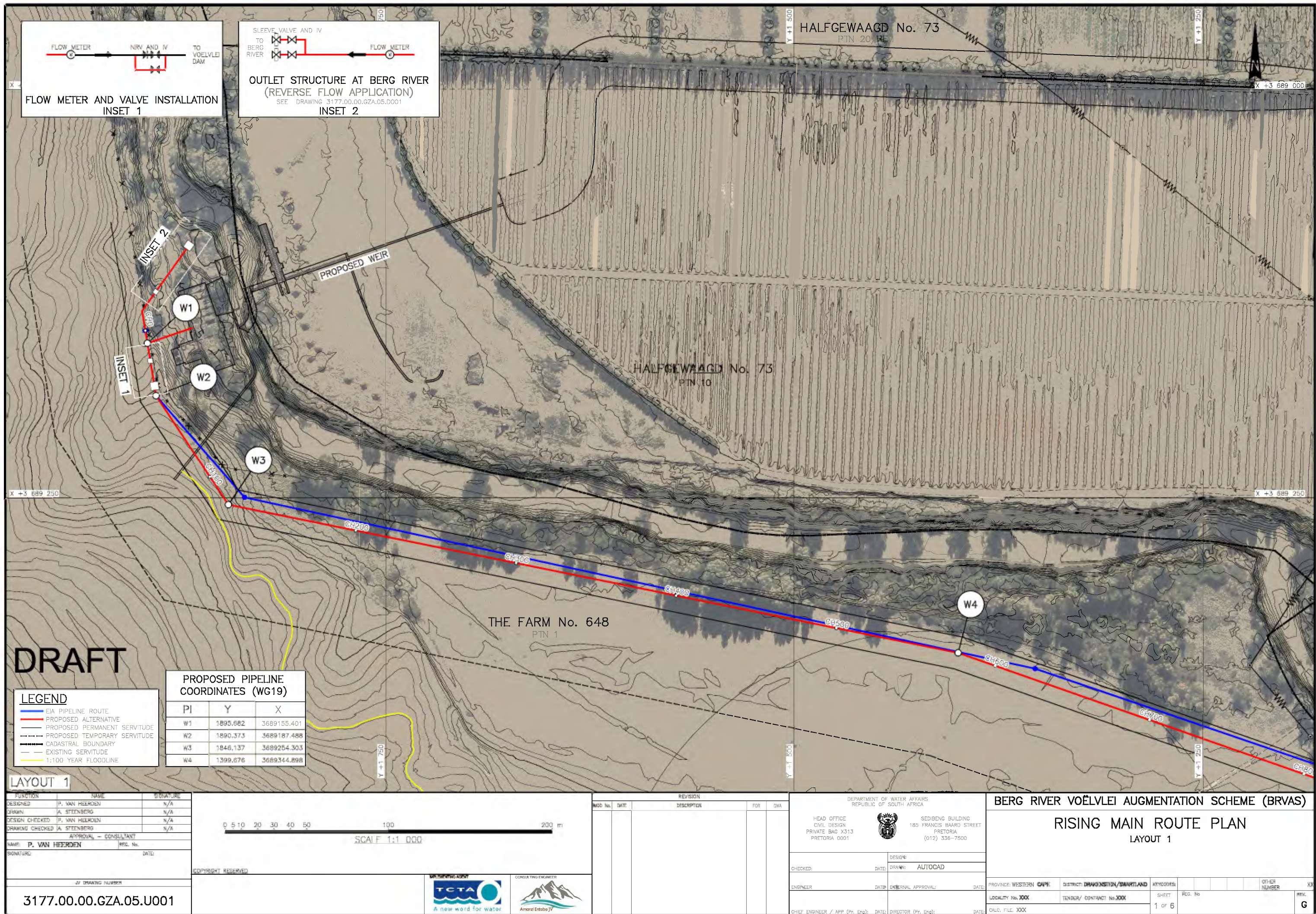
Drawing no. 3177.00.00.GZA.05.U002 Rev E – Rising Main - Route Plan – Layout 2

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



FLOW METER AND VALVE INSTALLATION
INSET 1

OUTLET STRUCTURE AT BERG RIVER
(REVERSE FLOW APPLICATION)
SEE DRAWING 3177.00.00.GZA.05.U001
INSET 2

DRAFT

- 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	1895.682	3689155.401
W2	1890.373	3689187.488
W3	1846.137	3689254.303
W4	1399.676	3689344.898

LAYOUT 1

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:	

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

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TCTA
A new word for water

CONSULTING ENGINEER
Amant Embaba JV

REVISION		FOR	
NO.	DATE	DESCRIPTION	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

CHECKED: DATE: DRAWN: AUTOCAD

ENGINEER DATE: ENGINEER APPROVAL: DATE:

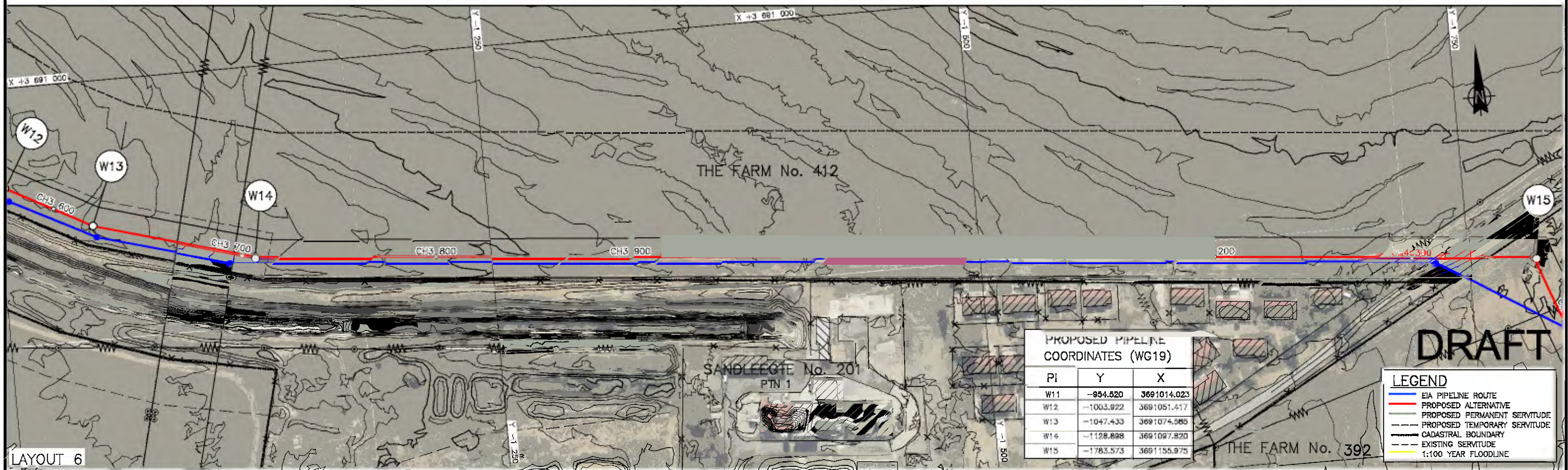
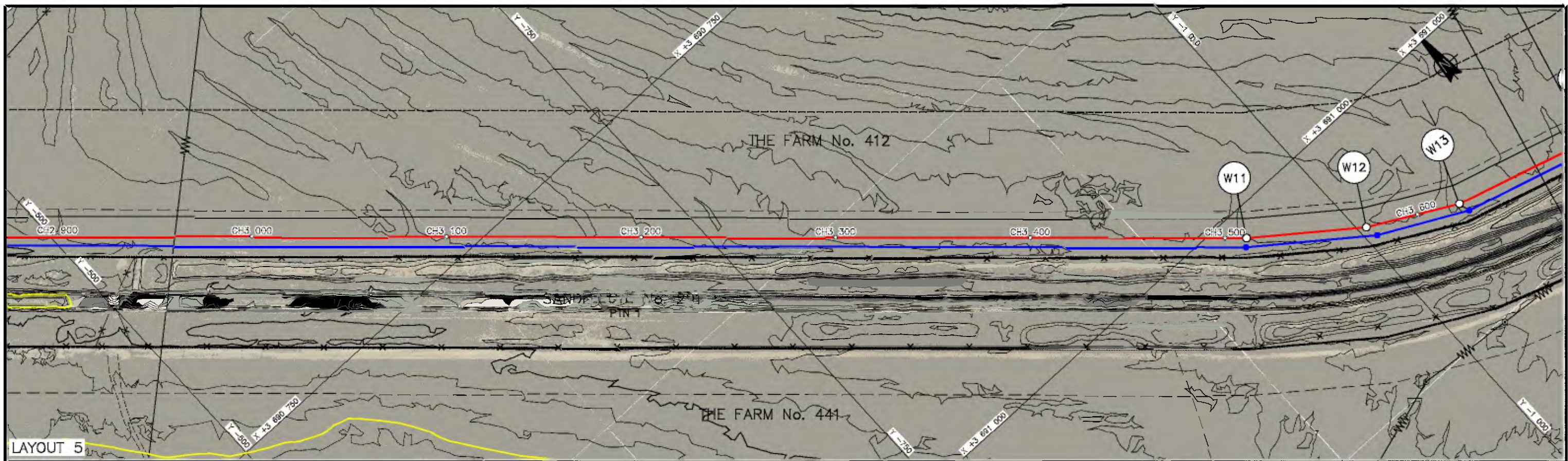
CHIEF ENGINEER / APP. (Pr. Eng.) DATE: DIRECTOR (Pr. Eng.) DATE:

BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN
LAYOUT 1

PROVINCE: WESTERN CAPE DISTRICT: DRAKENSTEN/BARWLAND KEYCODES: OTHER NUMBER: XX

LOCALITY No. XXX TENDER/ CONTRACT No. XXX SHEET 1 OF 6 REG. No. 166 G



PROPOSED PIPELINE COORDINATES (WG19)		
PI	Y	X
W11	-954.520	3691014.023
W12	-1003.922	3691051.417
W13	-1047.433	3691074.985
W14	-1128.898	3691087.820
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	
DRAWN	A. STEENBERG	
DESIGN CHECKED	P. VAN HEERDEN	
DRAWING CHECKED	A. STEENBERG	
APPROVAL - CONSULTANT		
NAME	P. VAN HEERDEN	REG. NO.
SIGNATURE		
BY DRAWING NUMBER		
3177.00.00.GZA.05.U004		

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

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TCTA

A new word for water

CONSULTING ENGINEER

Amanda Entobu JV

REV	DATE	REVISION	FOR	BY

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) 338-7500

CHECKED: DATE: DRAWN: AUTOCAD

ENGINEER: DATE: EXTERNAL APPROVAL: DATE:

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

BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

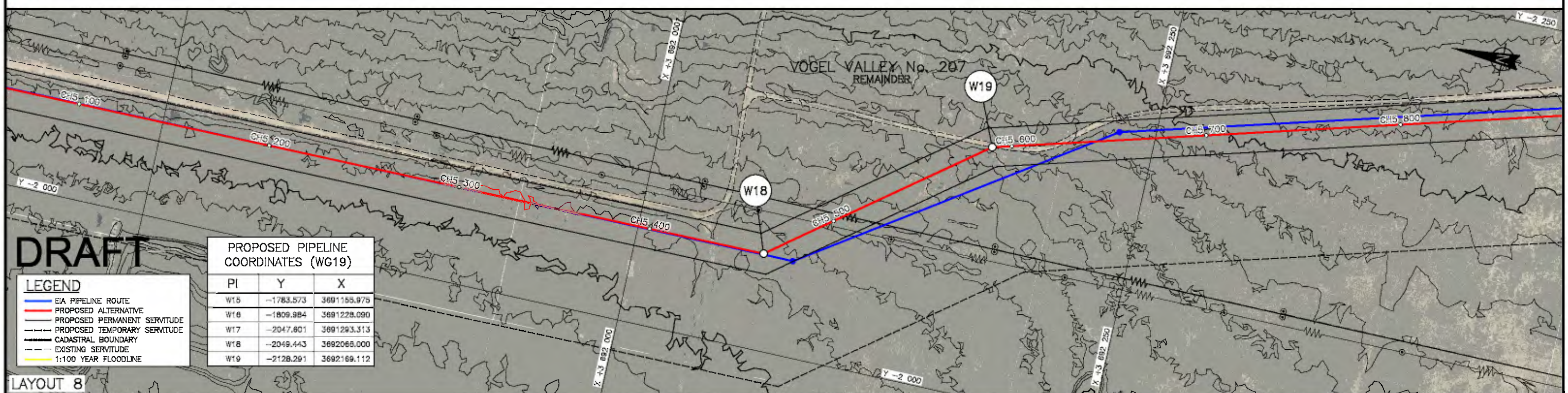
RISEING MAIN ROUTE PLAN

LAYOUTS 5 AND 6

PROVINC: WESTERN CAPE DISTRICT: DRAKENSTEEN/SHARPLAND REGION:

LOCALITY No. XXX TENDER/ CONTRACT No. XXX SHEET: 4 of 6 REV: D

CALC. FILE: XXX



DRAFT

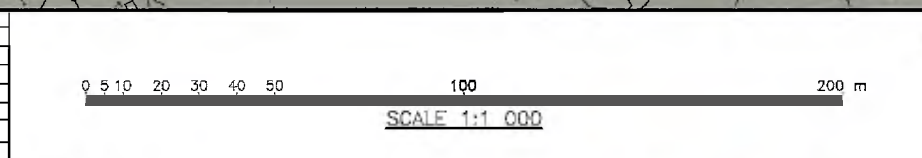
LEGEND	
—	EIA PIPELINE ROUTE
—	PROPOSED ALTERNATIVE
---	PROPOSED PERMANENT SERVITUDE
---	PROPOSED TEMPORARY SERVITUDE
---	CADASTRAL BOUNDARY
---	EXISTING SERVITUDE
---	1:100 YEAR FLOODLINE

PROPOSED PIPELINE COORDINATES (WG19)

PI	Y	X
W15	-1783.573	3691185.975
W16	-1809.984	3691228.090
W17	-2047.801	3691293.313
W18	-2049.443	3692065.000
W19	-2128.291	3692169.112

LAYOUT 8

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STENBERG	N/A
APPROVAL - CONSULTANT		
NAME	P. VAN HEERDEN	REF. No.
SIGNATURE		DATE



NO.	DATE	REVISION	DESCRIPTION	FOR	DWA

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BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)									
RISING MAIN ROUTE PLAN									
LAYOUTS 7 AND 8									
PROVINCE: WESTERN CAPE	DISTRICT: DRAKENSTEIN/SWARTLAND	KEYCODES:						OTHER NUMBER	XX
LOCALITY No. XXX	TENDER/ CONTRACT No. XXX	SHEET	5 OF 6	REV. No.					REV. D
CALC. FILE. XXX									

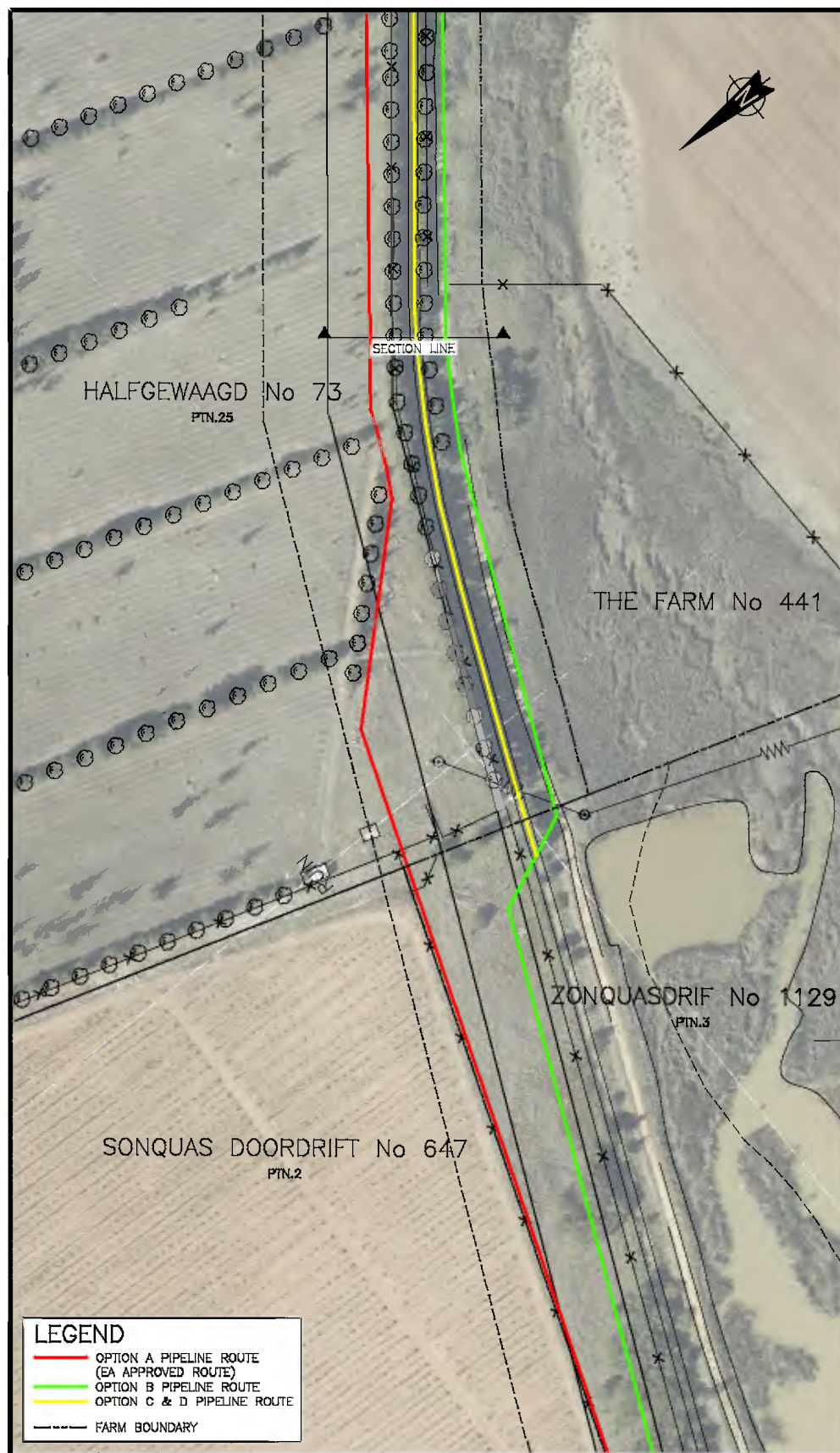
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ANNEXURE B

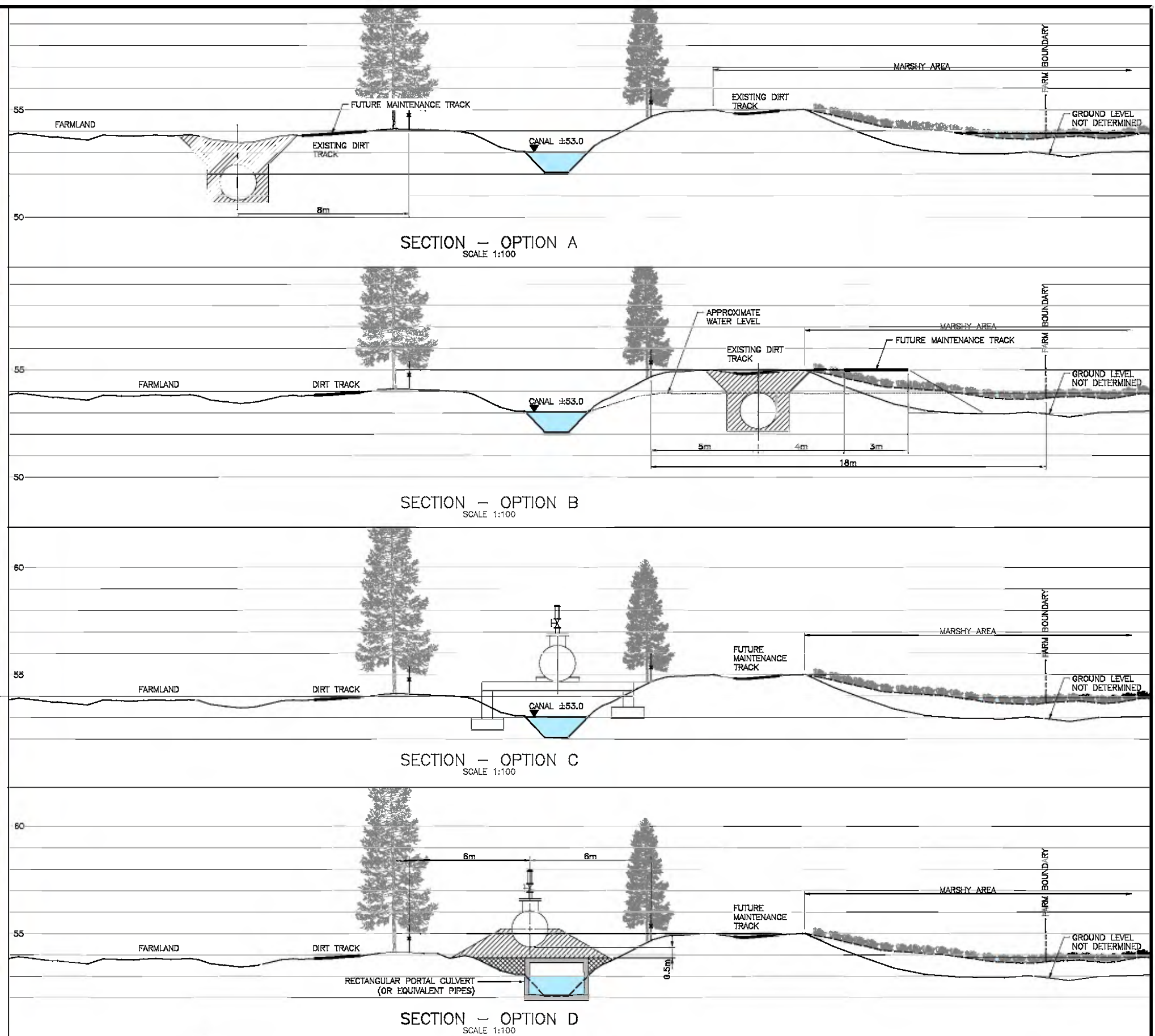
Rising Main Route on Halfgewaagd No. 73 Ptn 25

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



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.	DATE:
SIGNATURE:		

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NO	DATE	REVISION DESCRIPTION	FOR	BY

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

BERG RIVER VOELVLEI 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	SHEET	1 OF 1	REV. No.					REV. D
CALC. FILE. XXX									

3177.00.00.GZA.05.D010

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/drainage 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/drainage 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

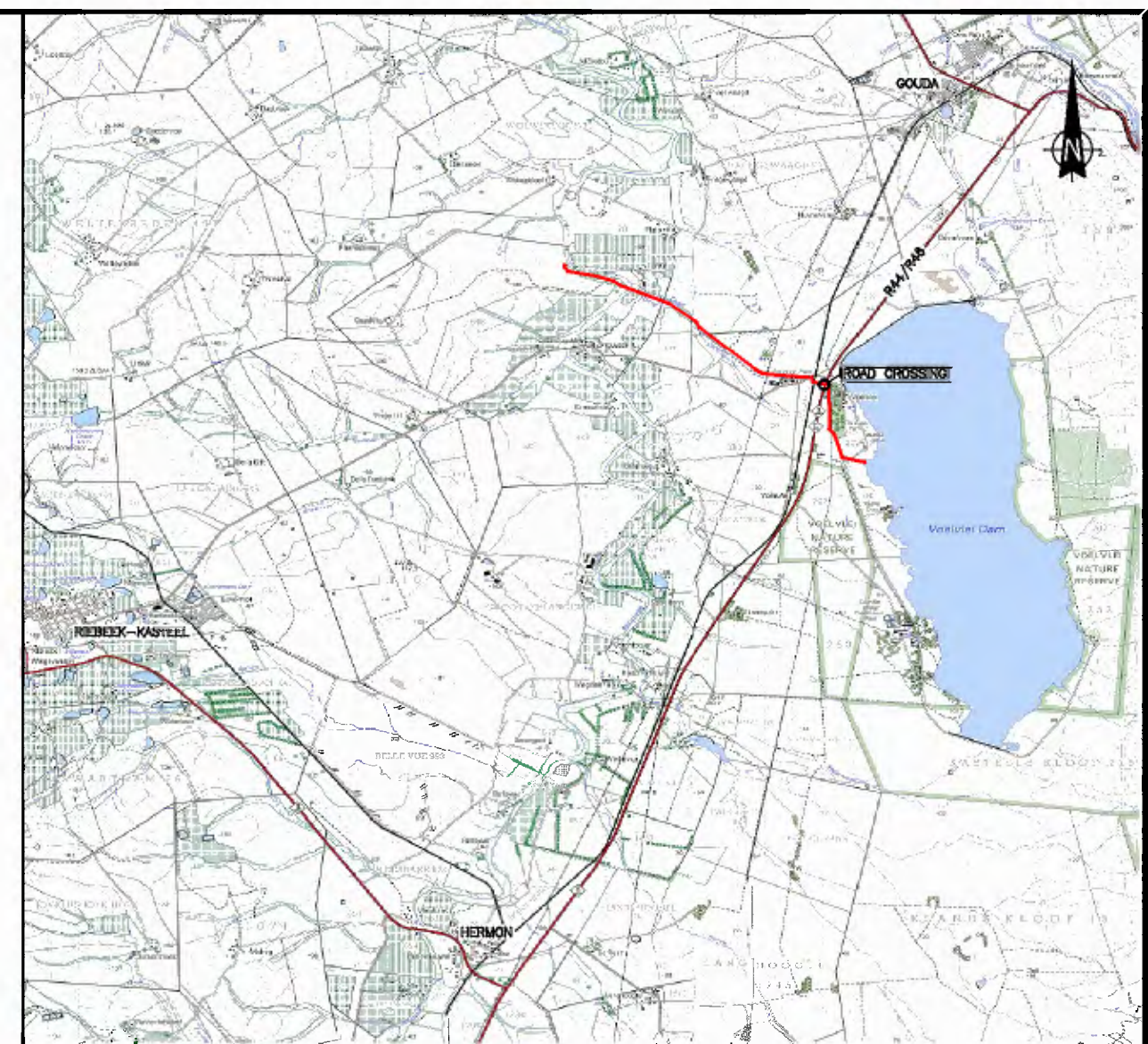
Drawing no. 3177.00.00.GZA.05.A100 Rev A – Rising Main - Jacked Road Crossing – Road R44/R46 at Pipeline CH4625

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

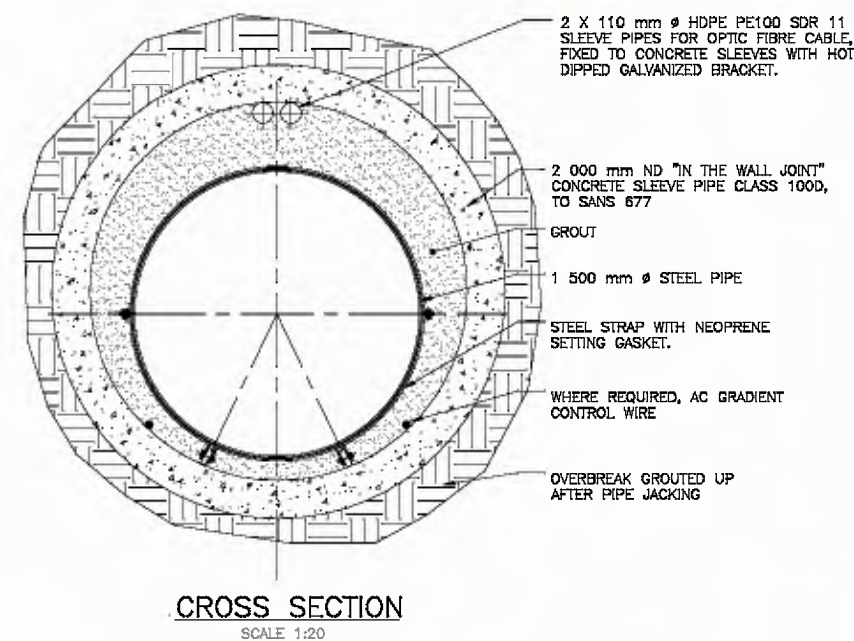
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Drawing no. 3177.00.00.GZA.05.A103 Rev A – Rising Main - Powerline Crossing at Pipeline CH 3685

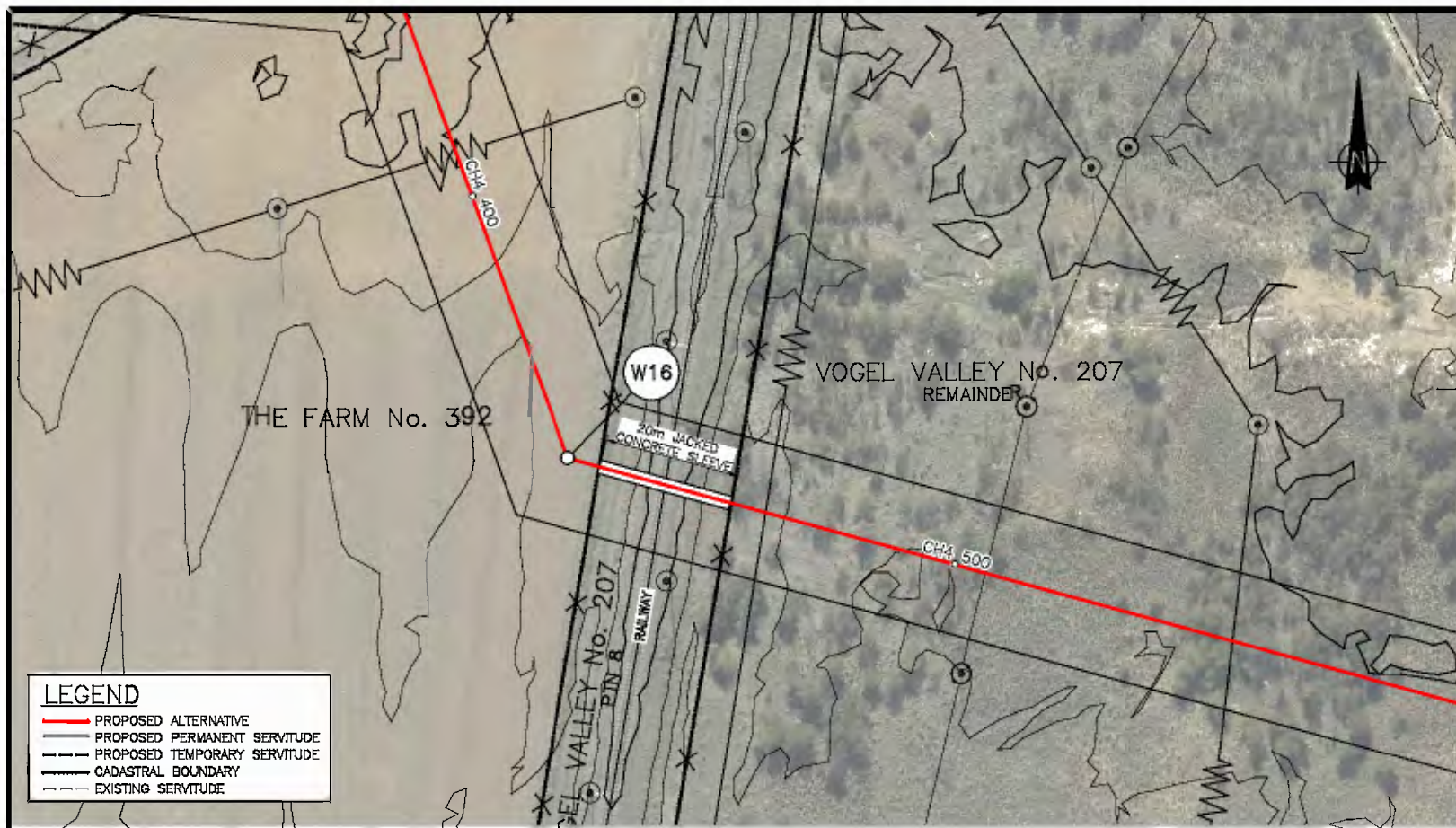
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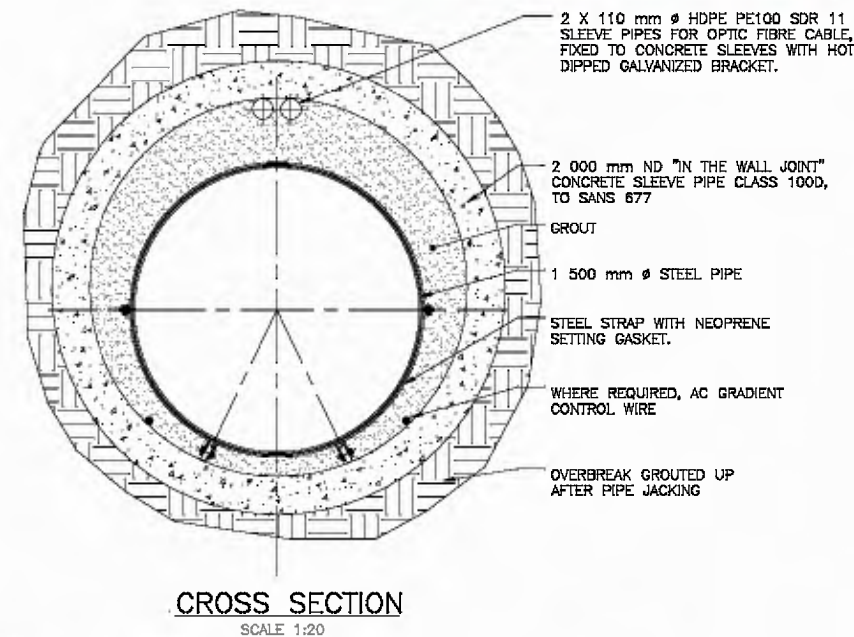
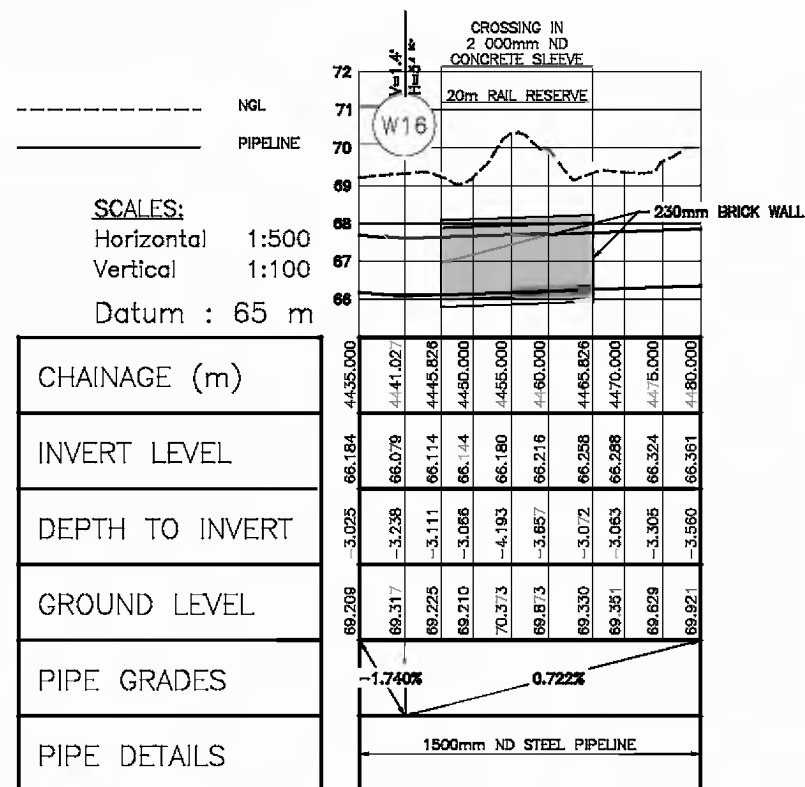
LOCALITY PLAN
SCALE 1:50 000



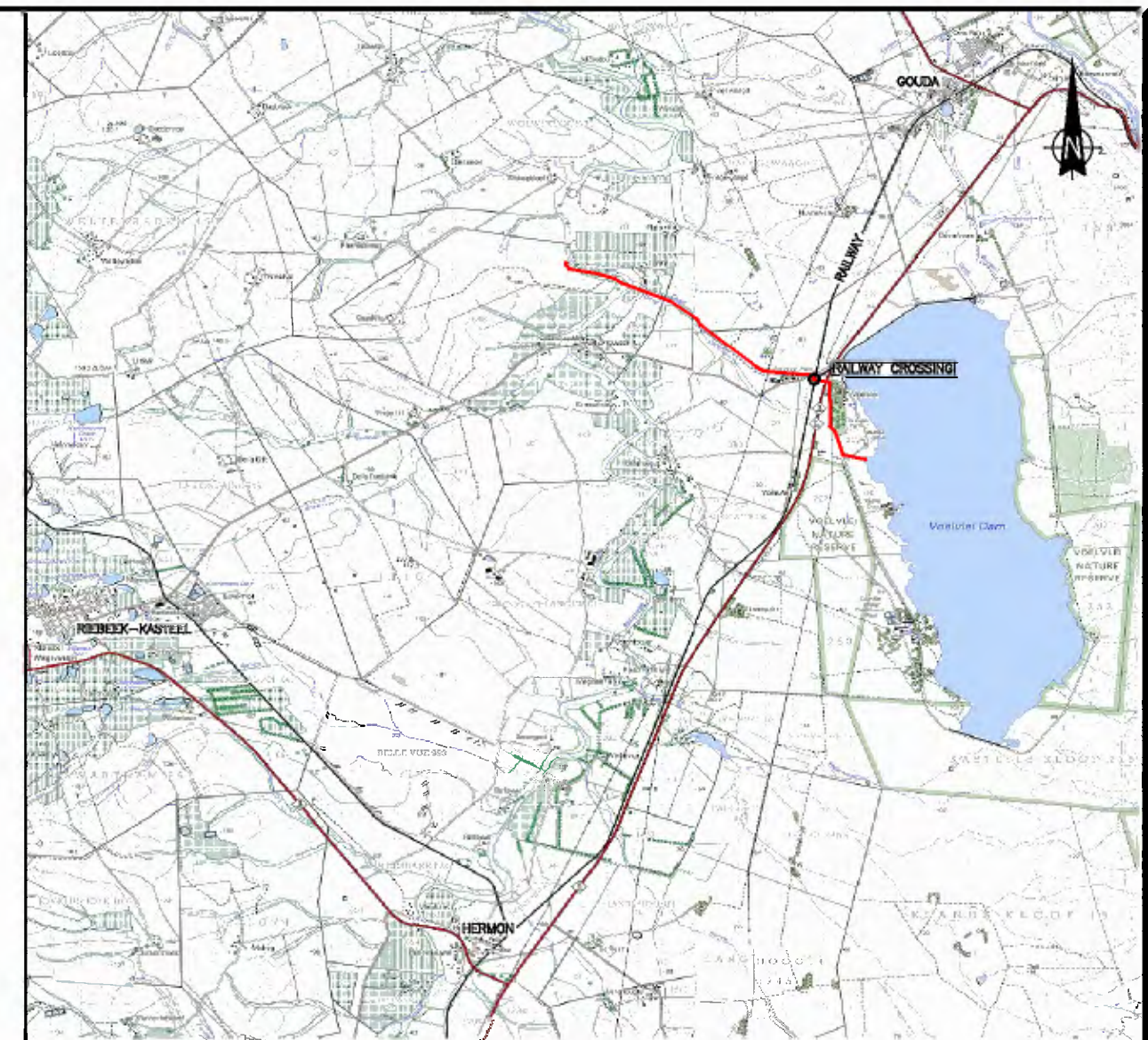
BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)											
RISING MAIN											
JACKED ROAD CROSSING											
ROAD R44/R46											
AT PIPELINE CH 4 625											
PROVINCE: WESTERN CAPE		DISTRICT: DRACENSTEIN/SHARTLAND		KEYWORDS:						OTHER NUMBER	XX
LOCALITY No. XXX		TENDER/ CONTRACT No. XXX		SHEET		REG. No.				REV.	
CALC. FILE XXX				1 OF 1						A	



LAYOUT PLAN
SCALE 1:500

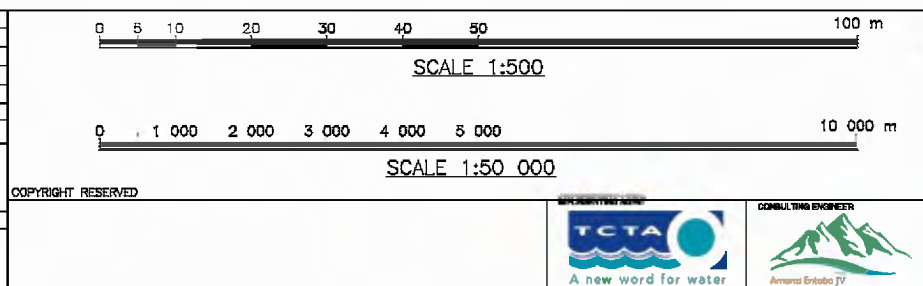


CROSS SECTION
SCALE 1:20



LOCALITY PLAN
SCALE 1:50 000

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STENBERG	N/A
APPROVAL - CONSULTANT		
NAME	P. VAN HEERDEN	RES. No.
SIGNATURE		DATE
DRAWING NUMBER		
3177.00.00.GZA.05.A101		



REVISION	DESCRIPTION	DATE	BY	CHK
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2				
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DEPARTMENT OF WATER AFFAIRS REPUBLIC OF SOUTH AFRICA	
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CHECKED:	DATE: DRAWING: AUTOCAD
ENGINEER:	DATE: EXTERNAL APPROVAL: (DATE)
CHIEF ENGINEER / APP. (Pr. Eng.):	DATE: DIRECTOR (Pr. Eng.): DATE:

BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)									
RISING MAIN JACKED RAILWAY CROSSING AT PIPELINE CH 4 455									
PROVINCE: WESTERN CAPE	DISTRICT: DRAKENSTEN/SMARTLAND	KEYCODES:						OTHER NUMBER	XX
LOCALITY No. XXX	TENDER/ CONTRACT No. XXX	SHEET						REV.	
CALC. FILE. XXX		1 of 1						A	

ANNEXURE D

Berg River Water Quality Laboratory Results

Water Quality Results – 24/06/2021 Sample

Water Quality Results – 30/07/2021 Sample



Consulting Analytical & Industrial Chemists
Specialists in Water & Waste Water Treatment
Telephone (021)448 6340/1
After Hours (083-3263887)
e-Mail Address :
info@alabbott.co.za



T0276

No. 1, Vine Park
Vine Road
7925
P.O. Box 483
WOODSTOCK, CAPE
7915

Certificate of Analysis

BIGEN(HENK AARTSMA)**ANALYSES****BERG RIVIER AT ZONQUASDRIFT (AFTER RAIN)****DATE SAMPLED :** 2021/06/24**DATE RECEIVED :** 2021/06/24**DATE ANALYSIS**
COMMENCED : 2021/06/24**OUR REF. :** 2021/06/24/17048**REPORT NO. :** 3523

	Sample Number	17048		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
9	Conductivity (mS/m) (at 25 °C)	24.0	≤170 Aesthetic	4.5
7	Total Dissolved Solids (mg/l)	162	≤1200 Aesthetic	-
19	pH (at 25 °C) Field	8.00	≥5 - ≤ 9.7 Operational	-
6A	Total Suspended Solids (mg/l)	16	N/A	18
27	Turbidity (NTU)	17.9	≤1 Operational : ≤5 Aesthetic	11
Calc	Langelier Saturation Index (at 25 °C)	-3.1	N/A	-
19	pH (at 25 °C)	6.00	≥5 - ≤ 9.7 Operational	1.5
N/A	Temperature (°C) (Field)	16.1	N/A	-
Calc	Ryznar Index	-6.0	N/A	-
100	Nitrate & Nitrite Nitrogen (mg/l as N)	3.3	≤12 Acute Health	10.2
Calc	Nitrate Nitrogen (mg/l as N)	3.3	≤11 Acute Health	3.4
99	Nitrite Nitrogen (mg/l as N)	<0.20	≤0.9 Acute Health	4
102	Sulphate (mg/l as SO ₄)	12.6	≤250 Aesthetic ≤500 Acute Health	8.3
95	Ammonia Nitrogen (mg/l as N)	<0.10	≤1.5 Aesthetic	5.2
96	Chloride (mg/l as Cl)	36.6	≤300 Aesthetic	10
94	Total Alkalinity (mg/l as CaCO ₃)	26.6	N/A	4
92a	Sodium (mg/l as Na)	29.4	≤200 Aesthetic	5.1
Calc	Total Hardness (mg/l as CaCO ₃)	28.0	N/A	-
92a	Calcium (mg/l as Ca)	8.1	N/A	5.6
Calc	Calcium Hardness (mg/l as CaCO ₃)	20.3	N/A	-
92	Magnesium (mg/l as Mg)	1.9	N/A	6.9

Sampler : JACQUES MOUTON(ALA)

This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.



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After Hours (083-3263887)
e-Mail Address :
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COMMENCED : 2021/06/24**OUR REF. :** 2021/06/24/17048**REPORT NO. :** 3523

	Sample Number	17048		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
Calc	Magnesium Hardness (mg/l as CaCO ₃)	7.8	N/A	-
Calc	Carbonate (mg/l)	31.8	N/A	-
11	Total Phosphate (mg/l as P)	1.4	N/A	-
Calc	CaCO ₃ Precipitation Potential (mg/l)	-59.9	N/A	-
92a	Potassium (mg/l as K)	6.8	N/A	4.5

Sampler : JACQUES MOUTON(ALA)*This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.*



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BIGEN(HENK AARTSMA)**ANALYSES****BERG RIVIER AT ZONQUASDRIFT (AFTER RAIN)****DATE SAMPLED :** 2021/06/24**DATE RECEIVED :** 2021/06/24**DATE ANALYSIS**
COMMENCED : 2021/06/24**OUR REF. :** 2021/06/24/17048**REPORT NO. :** 3523**Notes:**

1. Test marked with an asterisk (*) on attached Appendix 1 (Doc. 7.8#3) are SANAS Accredited and are included in the SANAS Schedule of Accreditation for this laboratory.
2. Schedule of Accreditation excludes sampling. Where applicable pH and Free & Total Chlorine Residual results are supplied by the sampling officer and will be indicated on the Certificate of Analysis. This is marked as "Field".
3. Sampling plans are as requested by the customer. Sampling is done according to A.L. Abbott and Associates (Pty) Ltd sampling procedures which are available on request.
4. Uncertainty of Measurement and Method Description will be provided upon request.
5. Results are reported at the 95% Confidence Interval with a Coverage Factor K = 2.
6. The laboratory does not normally issue any statement of conformity, unless by prior arrangement.
Decision Rule: Results reflecting on the Certificate of Analysis are actual results as obtained at the time of testing and do not include any uncertainty consideration.
7. The quality and integrity of samples submitted has a direct correlation on the results reported. Results reflected on this report therefore relate only to the sample as received.
8. In the absence of customer specified limits, SANS 241-1:2015 or General Limits will appear, as applicable.
9. This report may not be reproduced, except in full, without the prior written approval of the laboratory.
10. Opinions and interpretations are not included in the Certificate of Analysis.

Natasia van
Binsbergen

Digitally signed by Natasia
van Binsbergen
Date: 2021.07.06 11:43:50
+02'00'

N. VAN BINSBERGEN (Pr.Sci.Nat.)
DIRECTOR
05 July 2021

TO: BIGEN GROUP
Attention: Henk Aartsma <Henk.Aartsma@bigengroup.com>



Consulting Analytical & Industrial Chemists
Specialists in Water & Waste Water Treatment
Telephone (021)448 6340/1
After Hours (083-3263887)
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BIGEN (HENK AARTSMA)**ANALYSES****ZONQUASDRIFT RIVER AFTER RAIN****DATE SAMPLED :** 2021/07/30**DATE RECEIVED :** 2021/07/30**DATE ANALYSIS**
COMMENCED : 2021/07/30**OUR REF. :** 2021/07/30/20583**REPORT NO. :** 4213

	Sample Number	20583		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
9	Conductivity (mS/m) (at 25 °C)	30.5	≤170 Aesthetic	4.5
7	Total Dissolved Solids (mg/l)	202	≤1200 Aesthetic	-
19	pH (at 25 °C) Field	7.40	≥5 - ≤ 9.7 Operational	-
19	pH (at 25 °C) Field	7.51	≥5 - ≤ 9.7 Operational	-
6A	Total Suspended Solids (mg/l)	31	N/A	18
27	Turbidity (NTU)	39.3	≤1 Operational : ≤5 Aesthetic	11
Calc	Langelier Saturation Index (at 25 °C)	-1.7	N/A	-
19	pH (at 25 °C)	7.23	≥5 - ≤ 9.7 Operational	1.5
N/A	Temperature (°C) (Field)	15.2	N/A	-
Calc	Ryznar Index	-7.2	N/A	-
100	Nitrate & Nitrite Nitrogen (mg/l as N)	2.1	≤12 Acute Health	10.2
Calc	Nitrate Nitrogen (mg/l as N)	1.9	≤11 Acute Health	3.4
99	Nitrite Nitrogen (mg/l as N)	<0.20	≤0.9 Acute Health	4
102	Sulphate (mg/l as SO ₄)	14.6	≤250 Aesthetic ≤500 Acute Health	8.3
95	Ammonia Nitrogen (mg/l as N)	<0.10	≤1.5 Aesthetic	5.2
96	Chloride (mg/l as Cl)	54.1	≤300 Aesthetic	10
94	Total Alkalinity (mg/l as CaCO ₃)	32.7	N/A	4
92a	Sodium (mg/l as Na)	38.9	≤200 Aesthetic	5.1
Calc	Total Hardness (mg/l as CaCO ₃)	49.3	N/A	-
92a	Calcium (mg/l as Ca)	9.7	N/A	5.6
Calc	Calcium Hardness (mg/l as CaCO ₃)	24.3	N/A	-

Sampler : Eden van Eyssen (ALA)

This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.



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BIGEN (HENK AARTSMA)

ANALYSES

ZONQUASDRIFT RIVER AFTER RAIN

DATE SAMPLED : 2021/07/30

DATE RECEIVED : 2021/07/30

DATE ANALYSIS
COMMENCED : 2021/07/30

OUR REF. : 2021/07/30/20583

REPORT NO. : 4213

	Sample Number	20583		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
92a	Magnesium (mg/l as Mg)	6.1	N/A	5.1
Calc	Magnesium Hardness (mg/l as CaCO ₃)	25.0	N/A	-
Calc	Carbonate (mg/l)	39.1	N/A	-
11	Total Phosphate (mg/l as P)	0.60	N/A	-
Calc	CaCO ₃ Precipitation Potential (mg/l)	-11.0	N/A	-
92a	Potassium (mg/l as K)	4.9	N/A	4.5
19	pH (at 25 °C) Field	7.40	≥5 - ≤ 9.7 Operational	-
19	pH (at 25 °C) Field	7.51	≥5 - ≤ 9.7 Operational	-

Notes:

1. Test marked with an asterisk (*) on attached Appendix 1 (Doc. 7.8#3) are SANAS Accredited and are included in the SANAS Schedule of Accreditation for this laboratory.
2. Schedule of Accreditation excludes sampling. Where applicable pH and Free & Total Chlorine Residual results are supplied by the sampling officer and will be indicated on the Certificate of Analysis. This is marked as "Field".
3. Sampling plans are as requested by the customer. Sampling is done according to A.L. Abbott and Associates (Pty) Ltd sampling procedures which are available on request.
4. Uncertainty of Measurement and Method Description will be provided upon request.
5. Results are reported at the 95% Confidence Interval with a Coverage Factor K = 2.
6. The laboratory does not normally issue any statement of conformity, unless by prior arrangement.
Decision Rule: Results reflecting on the Certificate of Analysis are actual results as obtained at the time of testing and do not include any uncertainty consideration.
7. The quality and integrity of samples submitted has a direct correlation on the results reported. Results reflected on this report therefore relate only to the sample as received.
8. In the absence of customer specified limits, SANS 241-1:2015 or General Limits will appear, as applicable.
9. This report may not be reproduced, except in full, without the prior written approval of the laboratory.
10. Opinions and interpretations are not included in the Certificate of Analysis.

Sampler: Eden van Eyssen (ALA)

This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.



Consulting Analytical & Industrial Chemists
Specialists in Water & Waste Water Treatment
Telephone (021)448 6340/1
After Hours (083-3263887)
e-Mail Address :
info@alabbott.co.za



T0276

No. 1, Vine Park
Vine Road
7925
P.O. Box 483
WOODSTOCK, CAPE
7915

Certificate of Analysis

BIGEN (HENK AARTSMA)

ANALYSES

ZONQUASDRIFT RIVER AFTER RAIN

DATE SAMPLED : 2021/07/30

DATE RECEIVED : 2021/07/30

DATE ANALYSIS
COMMENCED : 2021/07/30

OUR REF. : 2021/07/30/20583

REPORT NO. : 4213

José Luis
da Silva

Digitally signed by
José Luis da Silva
Date: 2021.08.16
08:49:22 +02'00'

J.L. DA SILVA (Cert.Sci.Nat.)
TECHNICAL MANAGER
13 August 2021

TO: BIGEN GROUP
Attention: Henk Aartsma <Henk.Aartsma@bigengroup.com>

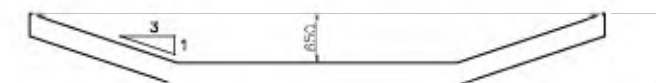
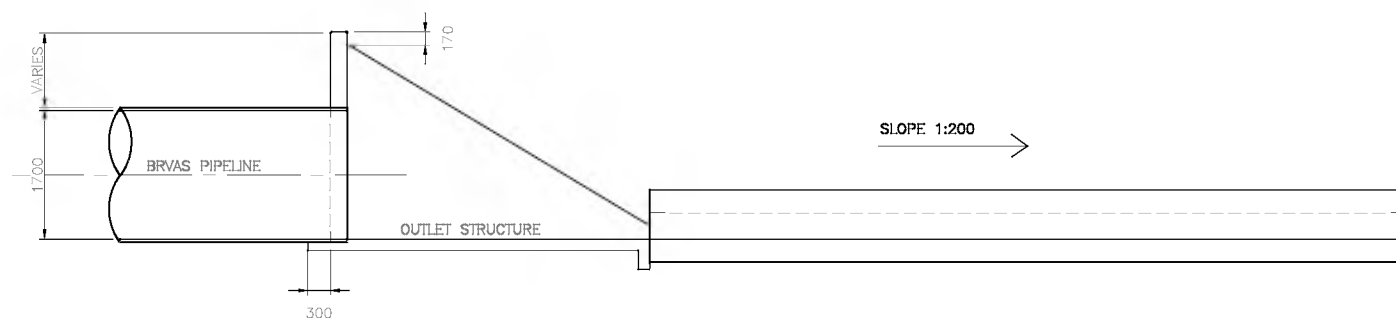
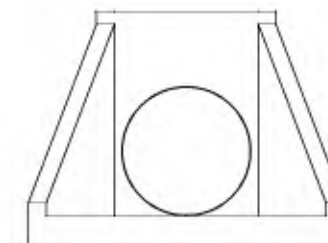
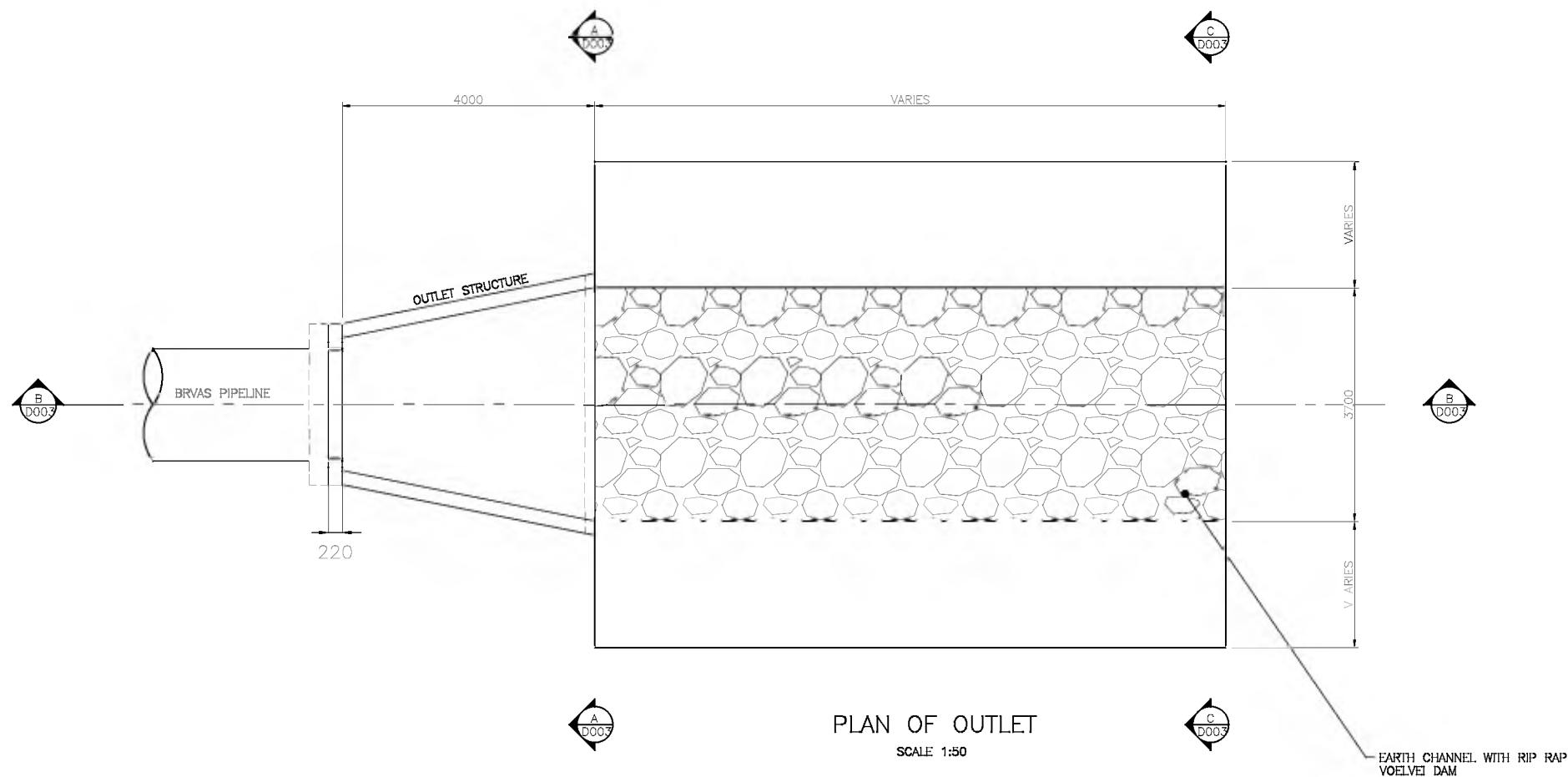
ANNEXURE E

Conceptual Design Drawings

Drawing no. 3177.00.00.GZA.05.D001 Rev A – Rising Main – Outlet Structure at Berg River

Drawing no. 3177.00.00.GZA.05.D002 Rev A – Rising Main – Connection to existing outlet culvert/channel

Drawing no. 3177.00.00.GZA.05.D003 Rev A – Rising Main – Outlet at Voëlvlei Dam



FUNCTIONNAMESIGNATURE DESIGNEDP. VAN HEERDENN/A DRAWNN. MSELENN/A DESIGN CHECKEDP. VAN HEERDENN/A DRAWING CHECKEDN. MSELENN/A APPROVALCONSULTANT NAMEP. VAN HEERDENREG. No. SIGNATUREDATE:			COPYRIGHT RESERVED			TCTA A new word for water			CONSULTING ENGINEER Amazel Entsoha JV			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 VOELVLEI AUGMENTATION SCHEME (BRVAS) RISING MAIN OUTLET AT VOELVLEI DAM PROVINCE: WESTERN CAPEDISTRICT: DRAKENSTEIN/SWARTLANDKEYCODES:OTHER NUMBER XX LOCALITY No. XXXTENDER/ CONTRACT No. XXXSHEET 1 OF 1REV. A CALC. FILE. XXX					
JV DRAWING NUMBER 3177.00.00.GZA.05.D003																							

ANNEXURE F

Cost Calculation Sheets

DN 1400 Cost Calculations

DN 1500 Cost Calculations

DN 1600 Cost Calculations

DN 1700 Cost Calculations

DN 1800 Cost Calculations

BRVAS Cost Calculations for DN1400 Pipeline

Capital Costs

Pipeline	R240 277 000
Pumping Station - Civil	R65 000 000
Pumping Station - M&E	R134 338 000
Total	R439 615 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R87 923 000	R0	R0	R78 251 157	R0	R0
2024	R263 769 000	R0	R0	R221 465 539	R0	R0
2025	R87 923 000	R6 737 405	R4 516 267	R69 643 251	R5 336 656	R3 577 306
2026		R6 737 405	R4 516 267		R5 034 581	R3 374 817
2027		R6 737 405	R4 516 267		R4 749 605	R3 183 790
2028		R6 737 405	R4 516 267		R4 480 759	R3 003 576
2029		R6 737 405	R4 516 267		R4 227 131	R2 833 562
2030		R6 737 405	R4 516 267		R3 987 860	R2 673 172
2031		R6 737 405	R4 516 267		R3 762 132	R2 521 860
2032		R6 737 405	R4 516 267		R3 549 181	R2 379 113
2033		R6 737 405	R4 516 267		R3 348 284	R2 244 446
2034		R6 737 405	R4 516 267		R3 158 758	R2 117 402
2035		R6 737 405	R4 516 267		R2 979 961	R1 997 549
2036		R6 737 405	R4 516 267		R2 811 284	R1 884 480
2037		R6 737 405	R4 516 267		R2 652 154	R1 777 812
2038		R6 737 405	R4 516 267		R2 502 032	R1 677 181
2039		R6 737 405	R4 516 267		R2 360 408	R1 582 246
2040		R6 737 405	R4 516 267		R2 226 800	R1 492 685
2041		R6 737 405	R4 516 267		R2 100 755	R1 408 193
2042		R6 737 405	R4 516 267		R1 981 844	R1 328 484
2043		R6 737 405	R4 516 267		R1 869 664	R1 253 287
2044		R6 737 405	R4 516 267		R1 763 834	R1 182 346
2045		R6 737 405	R4 516 267		R1 663 995	R1 115 421
2046		R6 737 405	R4 516 267		R1 569 806	R1 052 284
2047		R6 737 405	R4 516 267		R1 480 949	R992 721
2048		R6 737 405	R4 516 267		R1 397 122	R936 529
2049		R6 737 405	R4 516 267		R1 318 040	R883 518
2050		R6 737 405	R4 516 267		R1 243 433	R833 508
2051		R6 737 405	R4 516 267		R1 173 050	R786 328
2052		R6 737 405	R4 516 267		R1 106 651	R741 819
2053		R6 737 405	R4 516 267		R1 044 011	R699 829
2054		R6 737 405	R4 516 267		R984 916	R660 216
2055		R6 737 405	R4 516 267		R929 166	R622 845
2056		R6 737 405	R4 516 267		R876 572	R587 590
2057		R6 737 405	R4 516 267		R826 954	R554 330
2058		R6 737 405	R4 516 267		R780 146	R522 953
2059		R6 737 405	R4 516 267		R735 986	R493 352
2060		R6 737 405	R4 516 267		R694 327	R465 426
2061		R6 737 405	R4 516 267		R655 025	R439 081
2062		R6 737 405	R4 516 267		R617 948	R414 228
2063		R6 737 405	R4 516 267		R582 970	R390 781
2064		R6 737 405	R4 516 267		R549 972	R368 661
2065		R6 737 405	R4 516 267		R518 841	R347 794
2066		R6 737 405	R4 516 267		R489 473	R328 107
Totals				R369 359 947	R86 123 036	R57 730 629
TOTAL						R513 213 612

BRVAS Cost Calculations for DN1500 Pipeline

Capital Costs

Pipeline	R265 101 000
Pumping Station - Civil	R62 500 000
Pumping Station - M&E	R110 397 000
Total	R437 998 000

Year	Annual Costs			Present Value (2021) @ 6% DR			
	Capital	O&M	Energy	Capital	O&M	Energy	
2021		R0		R0	R0	R0	R0
2022		R0		R0	R0		R0
2023	R87 599 600	R0		R77 963 332	R0		R0
2024	R262 798 800	R0		R220 650 940	R0		R0
2025	R87 599 600	R5 897 635	R2 863 867	R69 387 088	R4 671 479	R3 271 138	
2026		R5 897 635	R2 863 867		R4 407 056	R3 085 979	
2027		R5 897 635	R2 863 867		R4 157 600	R2 911 301	
2028		R5 897 635	R2 863 867		R3 922 264	R2 746 511	
2029		R5 897 635	R2 863 867		R3 700 249	R2 591 048	
2030		R5 897 635	R2 863 867		R3 490 801	R2 444 385	
2031		R5 897 635	R2 863 867		R3 293 209	R2 306 023	
2032		R5 897 635	R2 863 867		R3 106 801	R2 175 494	
2033		R5 897 635	R2 863 867		R2 930 944	R2 052 353	
2034		R5 897 635	R2 863 867		R2 765 041	R1 936 182	
2035		R5 897 635	R2 863 867		R2 608 530	R1 826 586	
2036		R5 897 635	R2 863 867		R2 460 877	R1 723 195	
2037		R5 897 635	R2 863 867		R2 321 582	R1 625 655	
2038		R5 897 635	R2 863 867		R2 190 172	R1 533 637	
2039		R5 897 635	R2 863 867		R2 066 200	R1 446 828	
2040		R5 897 635	R2 863 867		R1 949 245	R1 364 932	
2041		R5 897 635	R2 863 867		R1 838 910	R1 287 671	
2042		R5 897 635	R2 863 867		R1 734 821	R1 214 784	
2043		R5 897 635	R2 863 867		R1 636 624	R1 146 023	
2044		R5 897 635	R2 863 867		R1 543 985	R1 081 154	
2045		R5 897 635	R2 863 867		R1 456 589	R1 019 956	
2046		R5 897 635	R2 863 867		R1 374 141	R962 223	
2047		R5 897 635	R2 863 867		R1 296 359	R907 758	
2048		R5 897 635	R2 863 867		R1 222 980	R856 375	
2049		R5 897 635	R2 863 867		R1 153 755	R807 901	
2050		R5 897 635	R2 863 867		R1 088 448	R762 171	
2051		R5 897 635	R2 863 867		R1 026 838	R719 029	
2052		R5 897 635	R2 863 867		R968 715	R678 329	
2053		R5 897 635	R2 863 867		R913 882	R639 933	
2054		R5 897 635	R2 863 867		R862 153	R603 711	
2055		R5 897 635	R2 863 867		R813 352	R569 538	
2056		R5 897 635	R2 863 867		R767 313	R537 300	
2057		R5 897 635	R2 863 867		R723 880	R506 887	
2058		R5 897 635	R2 863 867		R682 906	R478 195	
2059		R5 897 635	R2 863 867		R644 251	R451 128	
2060		R5 897 635	R2 863 867		R607 784	R425 592	
2061		R5 897 635	R2 863 867		R573 381	R401 502	
2062		R5 897 635	R2 863 867		R540 925	R378 775	
2063		R5 897 635	R2 863 867		R510 307	R357 335	
2064		R5 897 635	R2 863 867		R481 422	R337 109	
2065		R5 897 635	R2 863 867		R454 171	R318 027	
2066		R5 897 635	R2 863 867		R428 464	R300 026	
Totals				R368 001 360	R75 388 407	R52 789 680	
TOTAL						R496 179 447	

BRVAS Cost Calculations for DN1600 Pipeline

Capital Costs

Pipeline	R293 184 000
Pumping Station - Civil	R60 000 000
Pumping Station - M&E	R99 908 000
Total	R453 092 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R90 618 400	R0	R0	R80 650 053	R0	R0
2024	R271 855 200	R0	R0	R228 254 868	R0	R0
2025	R90 618 400	R5 612 240	R3 873 067	R71 778 260	R4 445 420	R3 067 832
2026		R5 612 240	R3 873 067		R4 193 792	R2 894 181
2027		R5 612 240	R3 873 067		R3 956 408	R2 730 359
2028		R5 612 240	R3 873 067		R3 732 460	R2 575 811
2029		R5 612 240	R3 873 067		R3 521 189	R2 430 010
2030		R5 612 240	R3 873 067		R3 321 876	R2 292 462
2031		R5 612 240	R3 873 067		R3 133 846	R2 162 700
2032		R5 612 240	R3 873 067		R2 956 458	R2 040 283
2033		R5 612 240	R3 873 067		R2 789 111	R1 924 796
2034		R5 612 240	R3 873 067		R2 631 237	R1 815 845
2035		R5 612 240	R3 873 067		R2 482 299	R1 713 061
2036		R5 612 240	R3 873 067		R2 341 792	R1 616 095
2037		R5 612 240	R3 873 067		R2 209 237	R1 524 618
2038		R5 612 240	R3 873 067		R2 084 186	R1 438 319
2039		R5 612 240	R3 873 067		R1 966 213	R1 356 905
2040		R5 612 240	R3 873 067		R1 854 918	R1 280 099
2041		R5 612 240	R3 873 067		R1 749 923	R1 207 641
2042		R5 612 240	R3 873 067		R1 650 871	R1 139 284
2043		R5 612 240	R3 873 067		R1 557 425	R1 074 796
2044		R5 612 240	R3 873 067		R1 469 269	R1 013 958
2045		R5 612 240	R3 873 067		R1 386 103	R956 564
2046		R5 612 240	R3 873 067		R1 307 644	R902 419
2047		R5 612 240	R3 873 067		R1 233 627	R851 339
2048		R5 612 240	R3 873 067		R1 163 799	R803 150
2049		R5 612 240	R3 873 067		R1 097 923	R757 689
2050		R5 612 240	R3 873 067		R1 035 777	R714 801
2051		R5 612 240	R3 873 067		R977 148	R674 340
2052		R5 612 240	R3 873 067		R921 838	R636 170
2053		R5 612 240	R3 873 067		R869 658	R600 160
2054		R5 612 240	R3 873 067		R820 432	R566 189
2055		R5 612 240	R3 873 067		R773 993	R534 141
2056		R5 612 240	R3 873 067		R730 182	R503 906
2057		R5 612 240	R3 873 067		R688 851	R475 383
2058		R5 612 240	R3 873 067		R649 859	R448 475
2059		R5 612 240	R3 873 067		R613 075	R423 089
2060		R5 612 240	R3 873 067		R578 372	R399 141
2061		R5 612 240	R3 873 067		R545 634	R376 548
2062		R5 612 240	R3 873 067		R514 749	R355 234
2063		R5 612 240	R3 873 067		R485 613	R335 126
2064		R5 612 240	R3 873 067		R458 125	R316 157
2065		R5 612 240	R3 873 067		R432 193	R298 261
2066		R5 612 240	R3 873 067		R407 730	R281 379
Totals				R380 683 182	R71 740 255	R49 508 717
TOTAL						R501 932 153

BRVAS Cost Calculations for DN1700 Pipeline

Capital Costs

Pipeline	R323 058 000
Pumping Station - Civil	R57 500 000
Pumping Station - M&E	R88 800 000
Total	R469 358 000

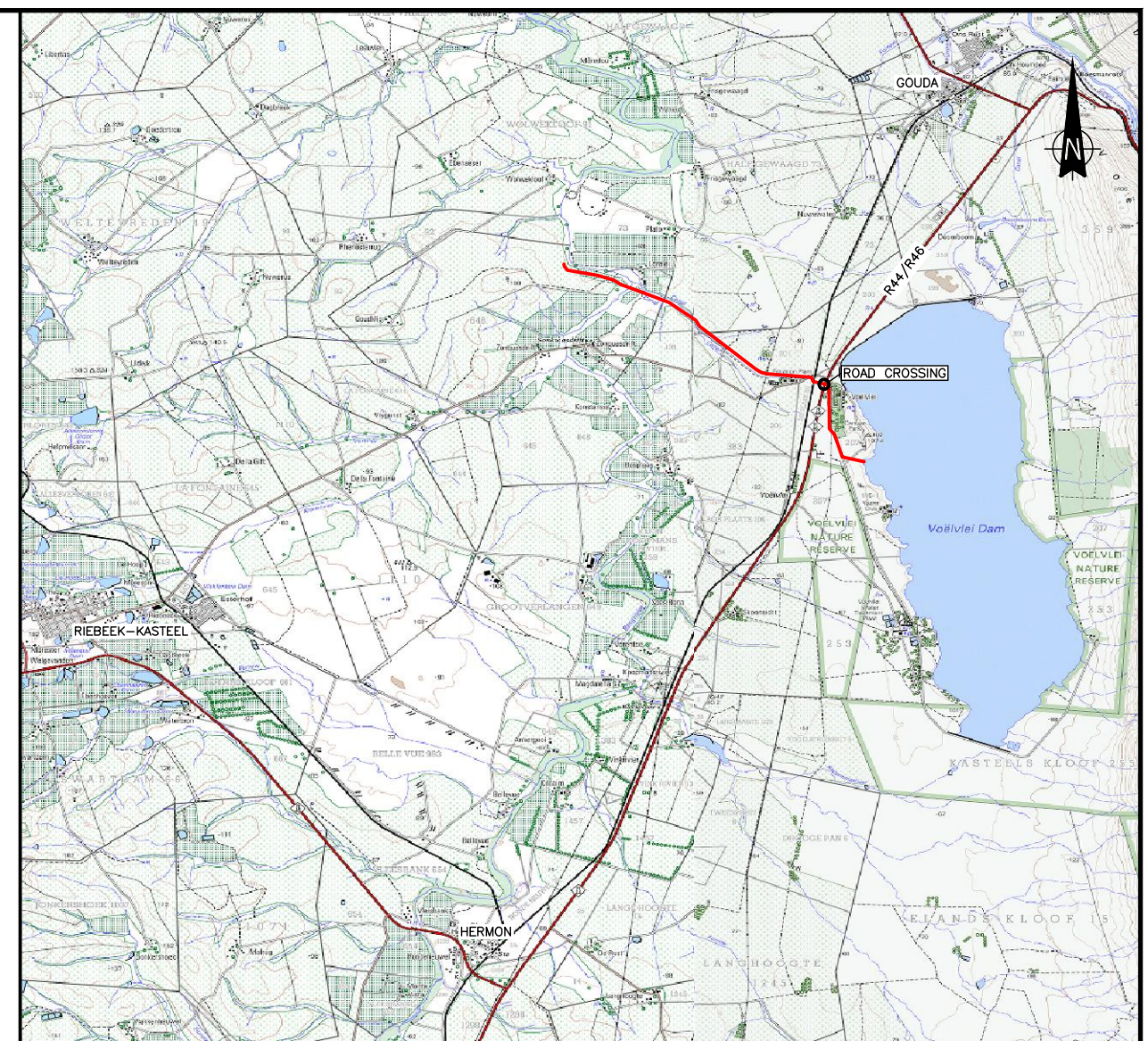
Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R93 871 600	R0	R0	R83 545 390	R0	R0
2024	R281 614 800	R0	R0	R236 449 216	R0	R0
2025	R93 871 600	R5 311 040	R3 712 908	R74 355 100	R4 206 841	R2 940 971
2026		R5 311 040	R3 712 908		R3 968 718	R2 774 501
2027		R5 311 040	R3 712 908		R3 744 074	R2 617 454
2028		R5 311 040	R3 712 908		R3 532 145	R2 469 296
2029		R5 311 040	R3 712 908		R3 332 212	R2 329 524
2030		R5 311 040	R3 712 908		R3 143 596	R2 197 665
2031		R5 311 040	R3 712 908		R2 965 657	R2 073 268
2032		R5 311 040	R3 712 908		R2 797 790	R1 955 914
2033		R5 311 040	R3 712 908		R2 639 424	R1 845 202
2034		R5 311 040	R3 712 908		R2 490 023	R1 740 756
2035		R5 311 040	R3 712 908		R2 349 078	R1 642 223
2036		R5 311 040	R3 712 908		R2 216 111	R1 549 267
2037		R5 311 040	R3 712 908		R2 090 671	R1 461 572
2038		R5 311 040	R3 712 908		R1 972 331	R1 378 842
2039		R5 311 040	R3 712 908		R1 860 690	R1 300 794
2040		R5 311 040	R3 712 908		R1 755 368	R1 227 164
2041		R5 311 040	R3 712 908		R1 656 007	R1 157 702
2042		R5 311 040	R3 712 908		R1 562 271	R1 092 172
2043		R5 311 040	R3 712 908		R1 473 841	R1 030 351
2044		R5 311 040	R3 712 908		R1 390 416	R972 029
2045		R5 311 040	R3 712 908		R1 311 713	R917 009
2046		R5 311 040	R3 712 908		R1 237 465	R865 102
2047		R5 311 040	R3 712 908		R1 167 420	R816 134
2048		R5 311 040	R3 712 908		R1 101 339	R769 938
2049		R5 311 040	R3 712 908		R1 039 000	R726 357
2050		R5 311 040	R3 712 908		R980 188	R685 242
2051		R5 311 040	R3 712 908		R924 706	R646 455
2052		R5 311 040	R3 712 908		R872 364	R609 863
2053		R5 311 040	R3 712 908		R822 985	R575 343
2054		R5 311 040	R3 712 908		R776 401	R542 776
2055		R5 311 040	R3 712 908		R732 454	R512 053
2056		R5 311 040	R3 712 908		R690 994	R483 069
2057		R5 311 040	R3 712 908		R651 881	R455 725
2058		R5 311 040	R3 712 908		R614 982	R429 929
2059		R5 311 040	R3 712 908		R580 172	R405 594
2060		R5 311 040	R3 712 908		R547 332	R382 636
2061		R5 311 040	R3 712 908		R516 351	R360 977
2062		R5 311 040	R3 712 908		R487 124	R340 544
2063		R5 311 040	R3 712 908		R459 550	R321 268
2064		R5 311 040	R3 712 908		R433 538	R303 083
2065		R5 311 040	R3 712 908		R408 998	R285 928
2066		R5 311 040	R3 712 908		R385 847	R269 743
Totals				R394 349 706	R67 890 069	R47 461 435
TOTAL						R509 701 210

BRVAS Cost Calculations for DN1800 Pipeline

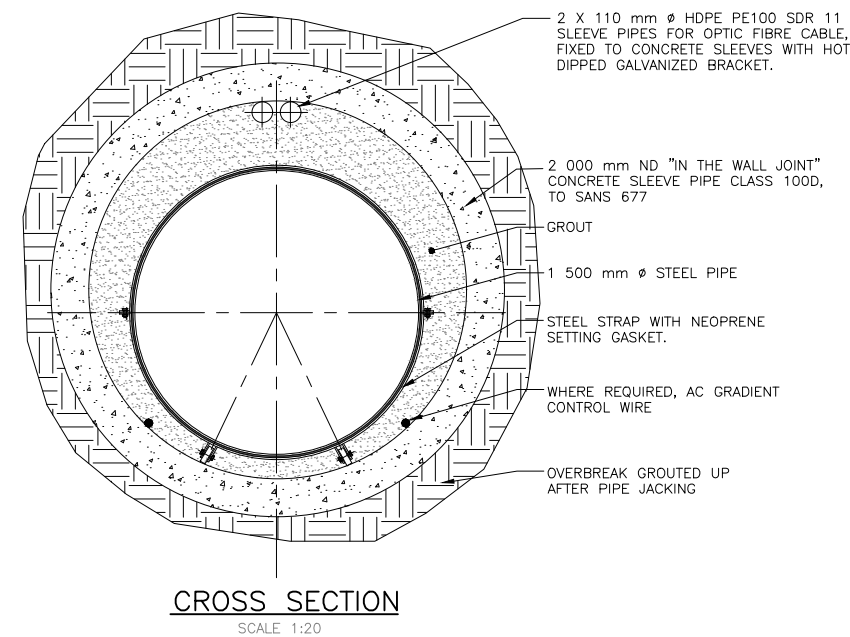
Capital Costs

Pipeline	R349 093 000
Pumping Station - Civil	R55 000 000
Pumping Station - M&E	R80 520 000
Total	R484 613 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R96 922 600	R0	R0	R86 260 769	R0	R0
2024	R290 767 800	R0	R0	R244 134 252	R0	R0
2025	R96 922 600	R5 103 765	R3 564 702	R76 771 777	R4 042 660	R2 823 578
2026		R5 103 765	R3 564 702		R3 813 830	R2 663 753
2027		R5 103 765	R3 564 702		R3 597 953	R2 512 974
2028		R5 103 765	R3 564 702		R3 394 295	R2 370 730
2029		R5 103 765	R3 564 702		R3 202 165	R2 236 538
2030		R5 103 765	R3 564 702		R3 020 911	R2 109 942
2031		R5 103 765	R3 564 702		R2 849 916	R1 990 511
2032		R5 103 765	R3 564 702		R2 688 600	R1 877 841
2033		R5 103 765	R3 564 702		R2 536 415	R1 771 548
2034		R5 103 765	R3 564 702		R2 392 844	R1 671 271
2035		R5 103 765	R3 564 702		R2 257 400	R1 576 671
2036		R5 103 765	R3 564 702		R2 129 623	R1 487 426
2037		R5 103 765	R3 564 702		R2 009 078	R1 403 232
2038		R5 103 765	R3 564 702		R1 895 357	R1 323 803
2039		R5 103 765	R3 564 702		R1 788 072	R1 248 871
2040		R5 103 765	R3 564 702		R1 686 861	R1 178 180
2041		R5 103 765	R3 564 702		R1 591 378	R1 111 491
2042		R5 103 765	R3 564 702		R1 501 300	R1 048 576
2043		R5 103 765	R3 564 702		R1 416 321	R989 223
2044		R5 103 765	R3 564 702		R1 336 152	R933 229
2045		R5 103 765	R3 564 702		R1 260 520	R880 405
2046		R5 103 765	R3 564 702		R1 189 170	R830 571
2047		R5 103 765	R3 564 702		R1 121 859	R783 557
2048		R5 103 765	R3 564 702		R1 058 357	R739 205
2049		R5 103 765	R3 564 702		R998 450	R697 363
2050		R5 103 765	R3 564 702		R941 934	R657 890
2051		R5 103 765	R3 564 702		R888 617	R620 651
2052		R5 103 765	R3 564 702		R838 318	R585 520
2053		R5 103 765	R3 564 702		R790 866	R552 377
2054		R5 103 765	R3 564 702		R746 100	R521 110
2055		R5 103 765	R3 564 702		R703 868	R491 614
2056		R5 103 765	R3 564 702		R664 026	R463 786
2057		R5 103 765	R3 564 702		R626 440	R437 534
2058		R5 103 765	R3 564 702		R590 981	R412 768
2059		R5 103 765	R3 564 702		R557 529	R389 404
2060		R5 103 765	R3 564 702		R525 971	R367 362
2061		R5 103 765	R3 564 702		R496 199	R346 568
2062		R5 103 765	R3 564 702		R468 112	R326 951
2063		R5 103 765	R3 564 702		R441 616	R308 444
2064		R5 103 765	R3 564 702		R416 618	R290 985
2065		R5 103 765	R3 564 702		R393 036	R274 514
2066		R5 103 765	R3 564 702		R370 789	R258 976
Totals				R407 166 798	R65 240 510	R45 566 944
TOTAL						R517 974 252

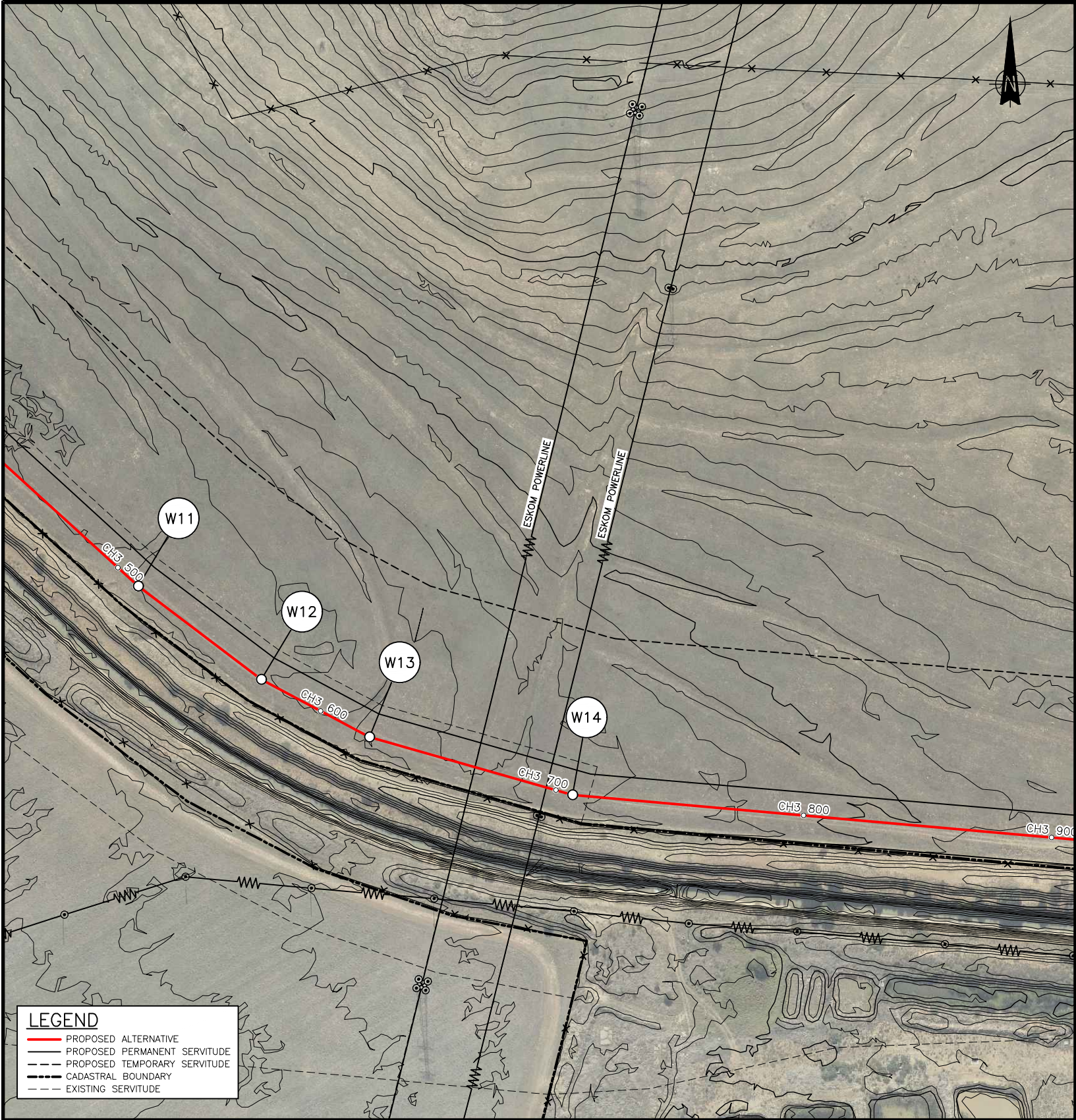


LOCALITY PLAN
SCALE 1:50 000

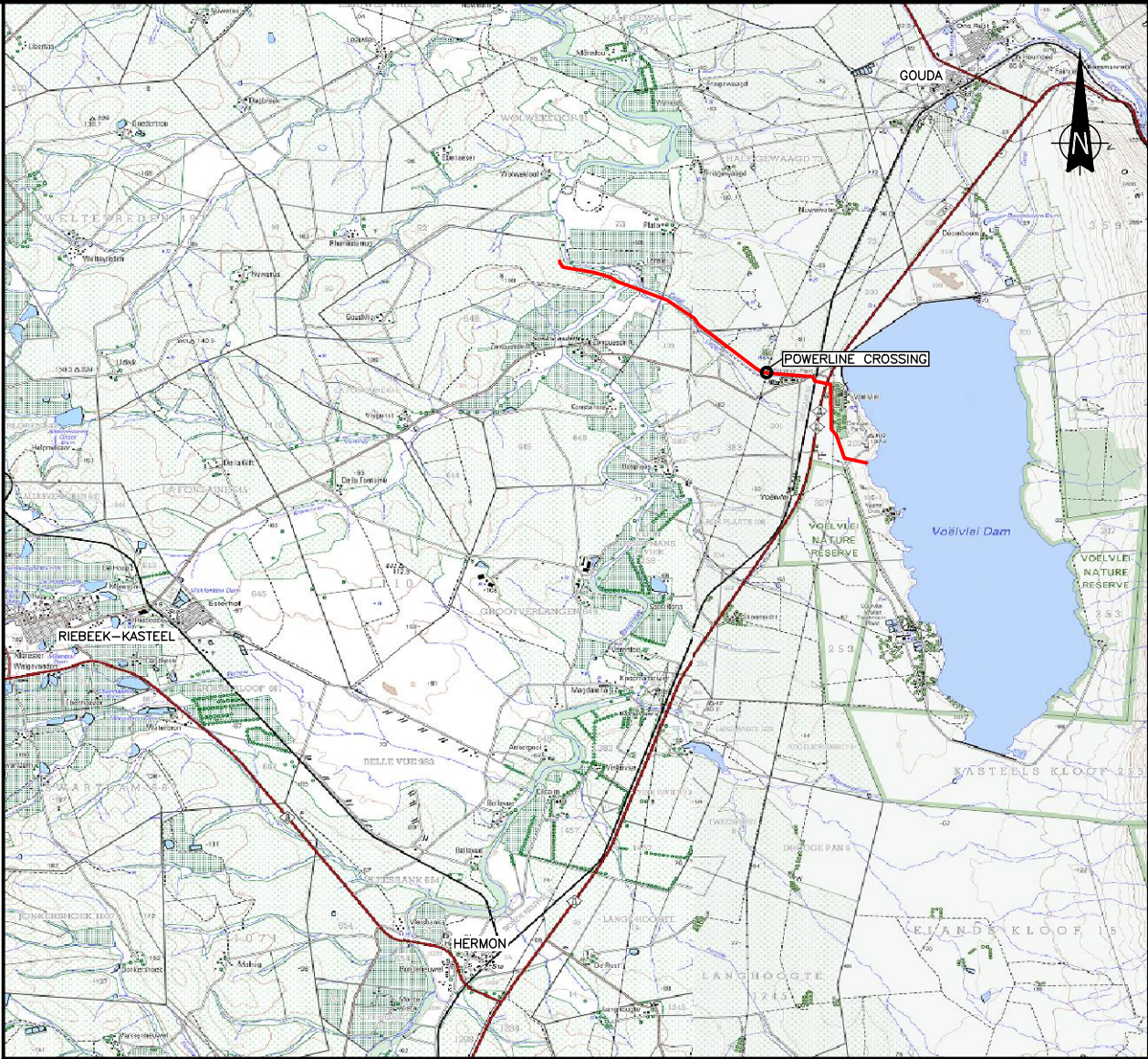


CROSS SECTION
SCALE 1:20

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)												
RISING MAIN												
JACKED ROAD CROSSING												
ROAD R44/R46												
AT PIPELINE CH 4 625												
PROVINCE: WESTERN CAPE		DISTRICT: DRAKENSTEIN/SMARTLAND		KEYCODES:							OTHER NUMBER	XX
LOCALITY No. XXX		TENDER/ CONTRACT No. XXX		SHEET		REG. No.					REV.	
CALC. FILE: XXX				1 OF 1							A	

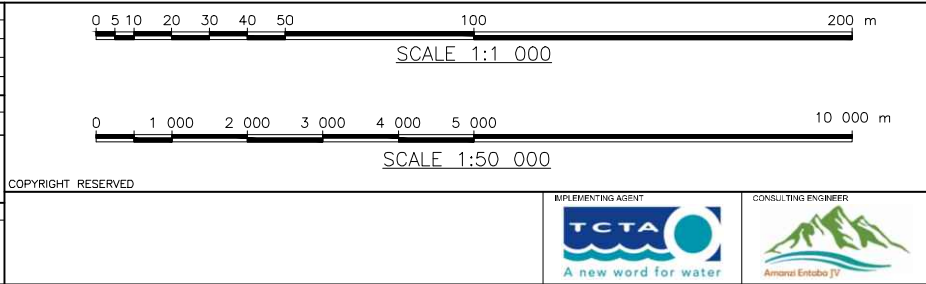


LAYOUT PLAN
SCALE 1:1000



LOCALITY PLAN
SCALE 1:50 000

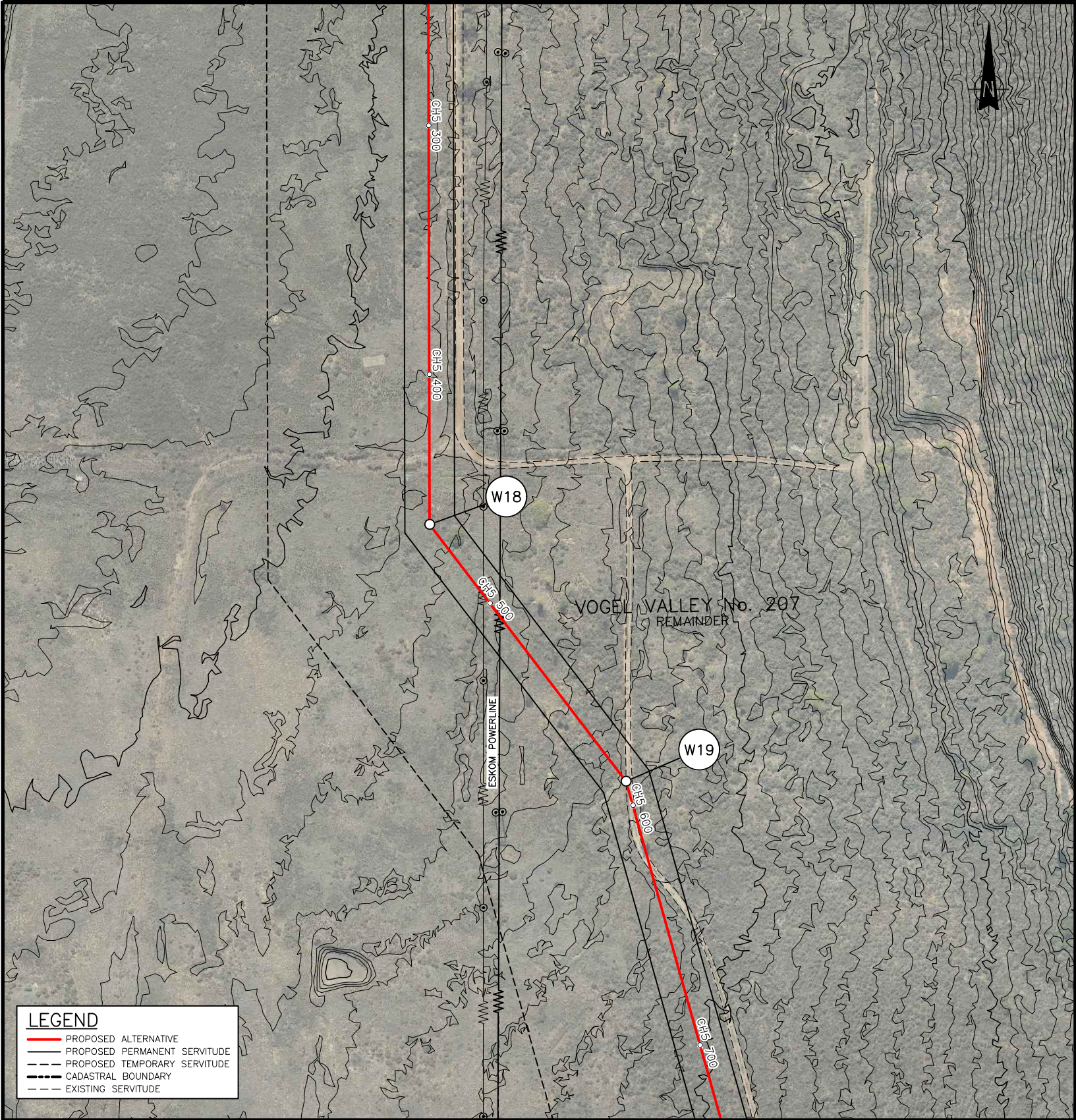
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DESIGNED	P. VAN HEERDEN	N/A
DRAWN	A. STEENBERG	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	A. STEENBERG	N/A
APPROVAL - CONSULTANT		
NAME: P. VAN HEERDEN	REG. No.	DATE:
SIGNATURE:		
JV DRAWING NUMBER		
3177.00.00.GZA.05.A103		



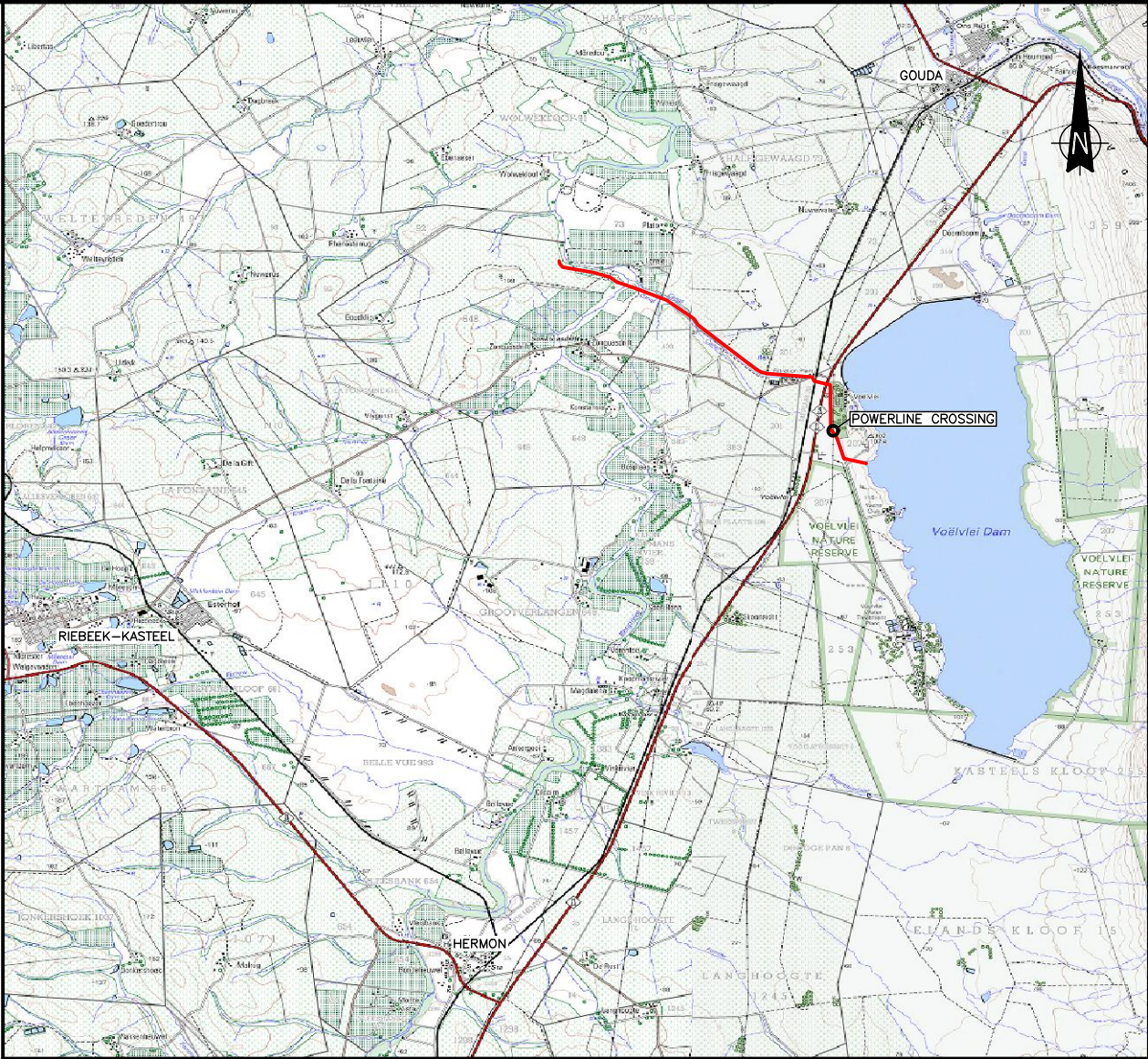
MOD No.	DATE	REVISION DESCRIPTION	FOR	DWA

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

BERG RIVER VOELVLEI 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	REG. No.				REV.		
CALC. FILE. XXX		1 OF 1					A		



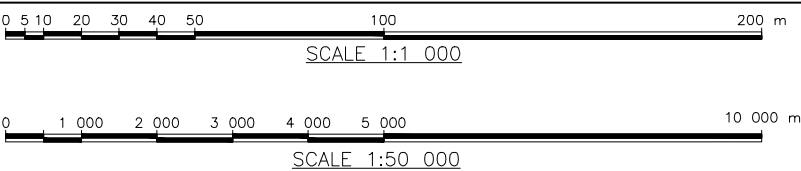
LAYOUT PLAN
SCALE 1:1000



LOCALITY PLAN
SCALE 1:50 000

LEGEND		
—	PROPOSED ALTERNATIVE	
—	PROPOSED PERMANENT SERVITUDE	
---	PROPOSED TEMPORARY SERVITUDE	
---	CADASTRAL BOUNDARY	
---	EXISTING SERVITUDE	

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		
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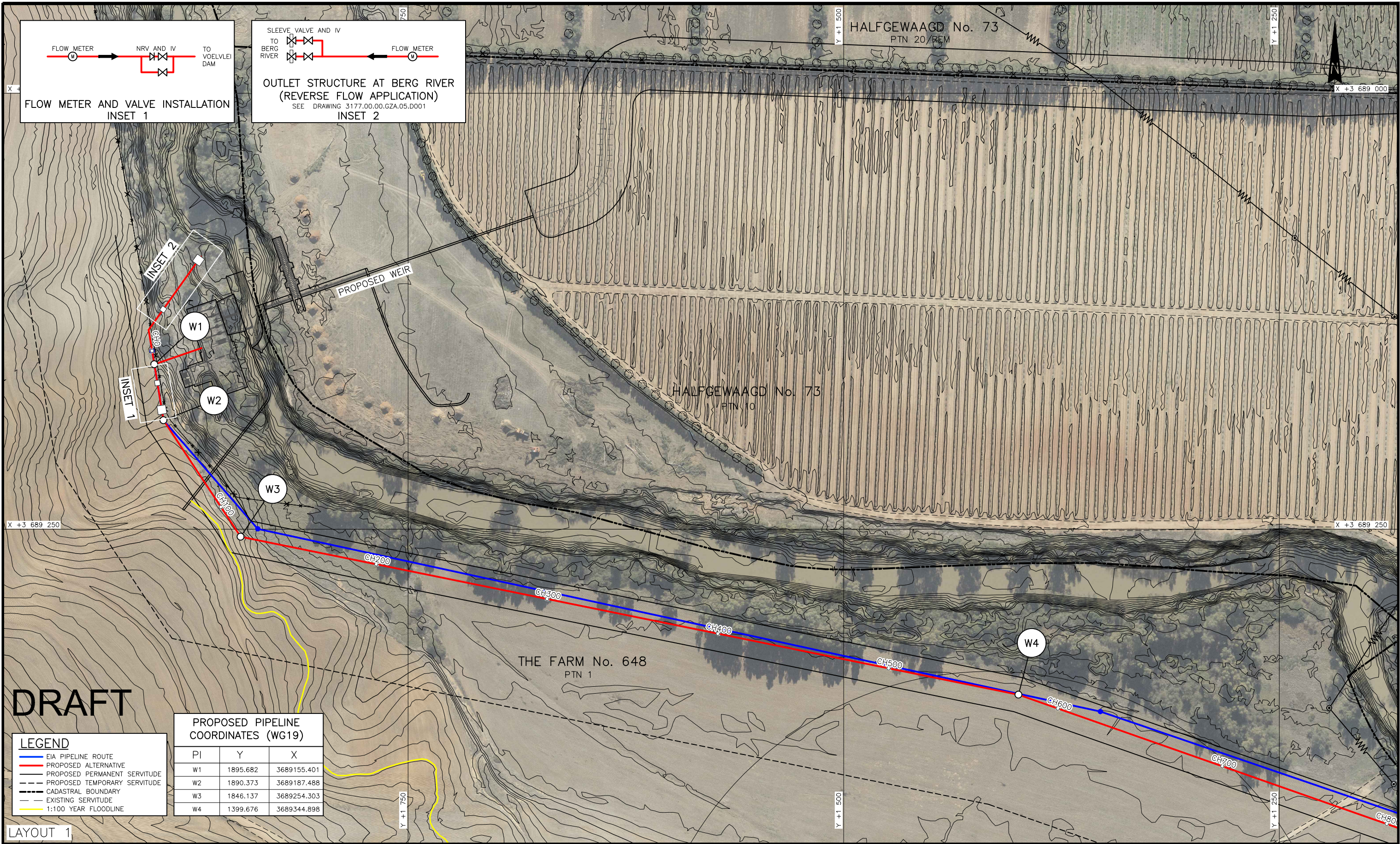
CONSULTING ENGINEER



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				DESCRIPTION					

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

BERG RIVER VOELVLEI 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		SHEET		REV. No.		REV.	
CALC. FILE. XXX		1 OF 1						A	



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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	1895.682	3689155.401	
W2	1890.373	3689187.488	
W3	1846.137	3689254.303	
W4	1399.676	3689344.898	

LAYOUT 1

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:	

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

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Amorisi Entobos JV

MOD No.		DATE		REVISION		FOR		DWA	
				DESCRIPTION					

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PRIVATE BAG X313
PRETORIA 0001

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

CHECKED:

DATE:

DESIGN:

DRAWN: AUTOCAD

ENGINEER:

DATE:

EXTERNAL APPROVAL:

DATE:

CHIEF ENGINEER / APP (Pr. Eng):

DATE:

DIRECTOR (Pr. Eng):

DATE:

BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN

LAYOUT 1

PROVINCE: WESTERN CAPE

DISTRICT: DRAKENSTEIN/SWARTLAND

KEYCODES:

LOCALITY No. XXX

TENDER/ CONTRACT No. XXX

CALC. FILE. XXX

SHEET

REG. No.

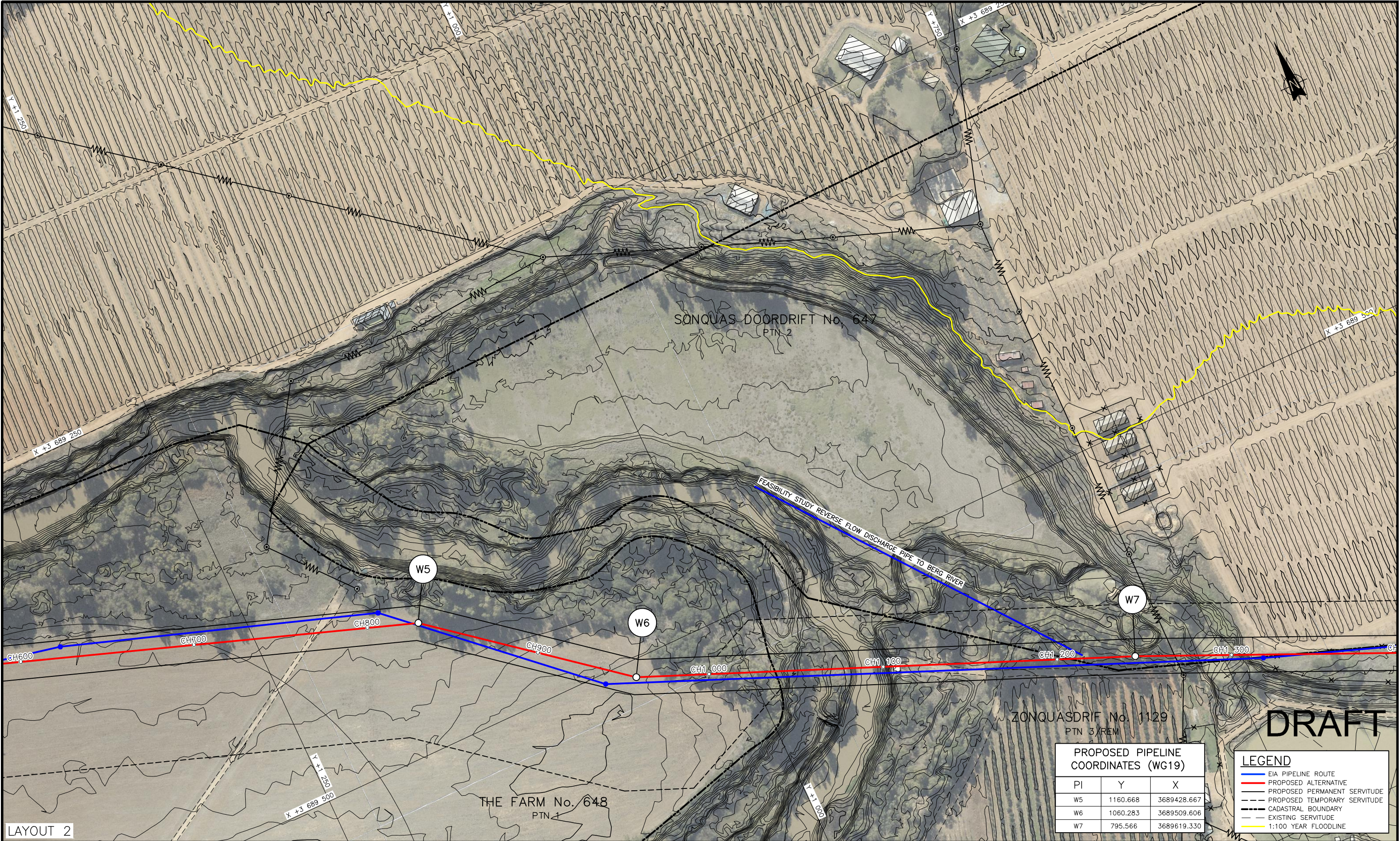
1 OF 6

OTHER NUMBER

REV.

G

3177.00.00.GZA.05.U001



LAYOUT 2

PROPOSED PIPELINE COORDINATES (WG19)		
PI	Y	X
W5	1160.668	3689428.667
W6	1060.283	3689509.606
W7	795.566	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.	DATE:
SIGNATURE:		
JV DRAWING NUMBER		
3177.00.00.GZA.05.U002		

0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

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PRETORIA 0001



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185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

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DRAWN: AUTOCAD

ENGINEER:

DATE:

EXTERNAL APPROVAL:

DATE:

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DATE:

DIRECTOR (Pr. Eng):

DATE:

BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN

LAYOUT 2

PROVINCE: WESTERN CAPE

DISTRICT: DRAKENSTEIN/SWARTLAND

KEYCODES:

LOCALITY No. XXX

TENDER/ CONTRACT No. XXX

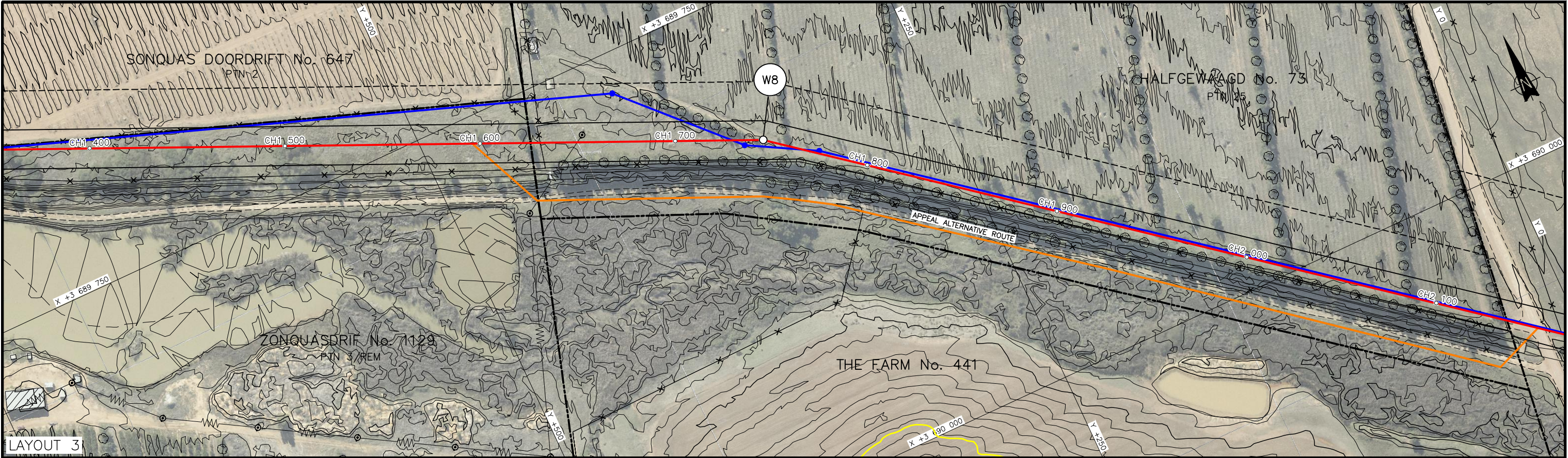
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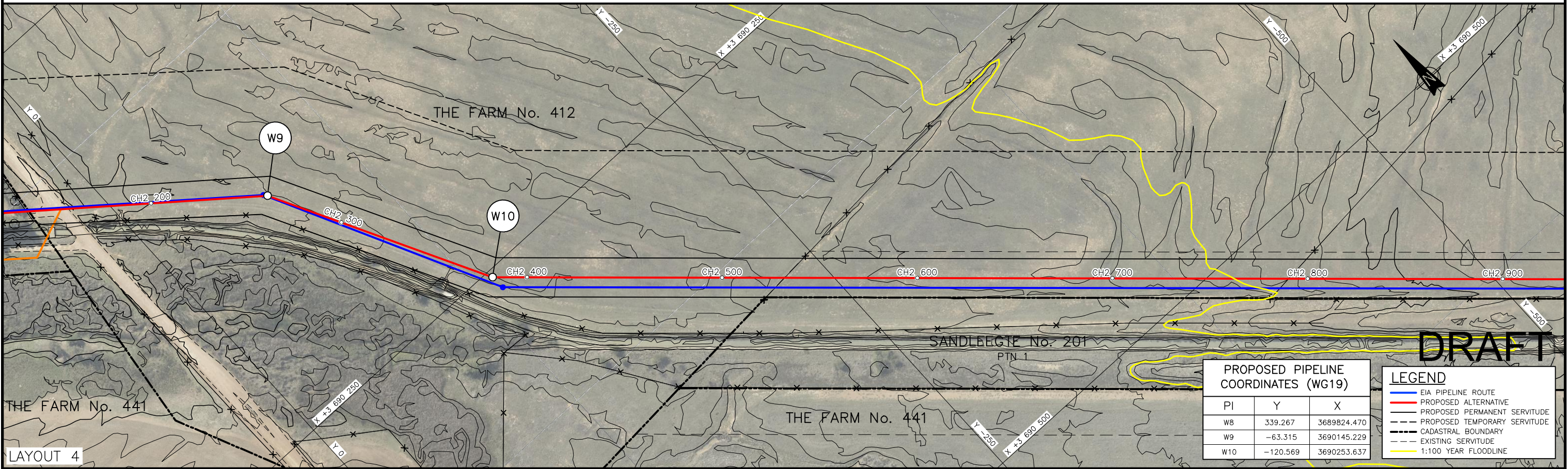
REV. E

SHEET 2 OF 6

REG. No.



LAYOUT 3



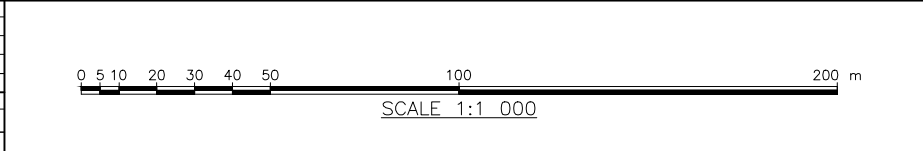
LAYOUT 4

DRAFT

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.	DATE:
SIGNATURE:		

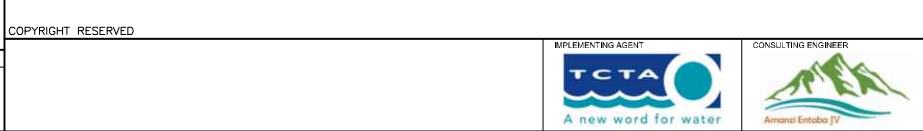


REVISION		FOR	
MOD No.	DATE	DESCRIPTION	DWA

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HEAD OFFICE CIVIL DESIGN PRIVATE BAG X313 PRETORIA 0001	SEDIENG BUILDING 185 FRANCIS BAARD STREET PRETORIA (012) 336-7500
CHECKED:	DESIGN: DATE: DRAWN: AUTOCAD
ENGINEER:	DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng):	DATE: DIRECTOR (Pr. Eng): DATE:

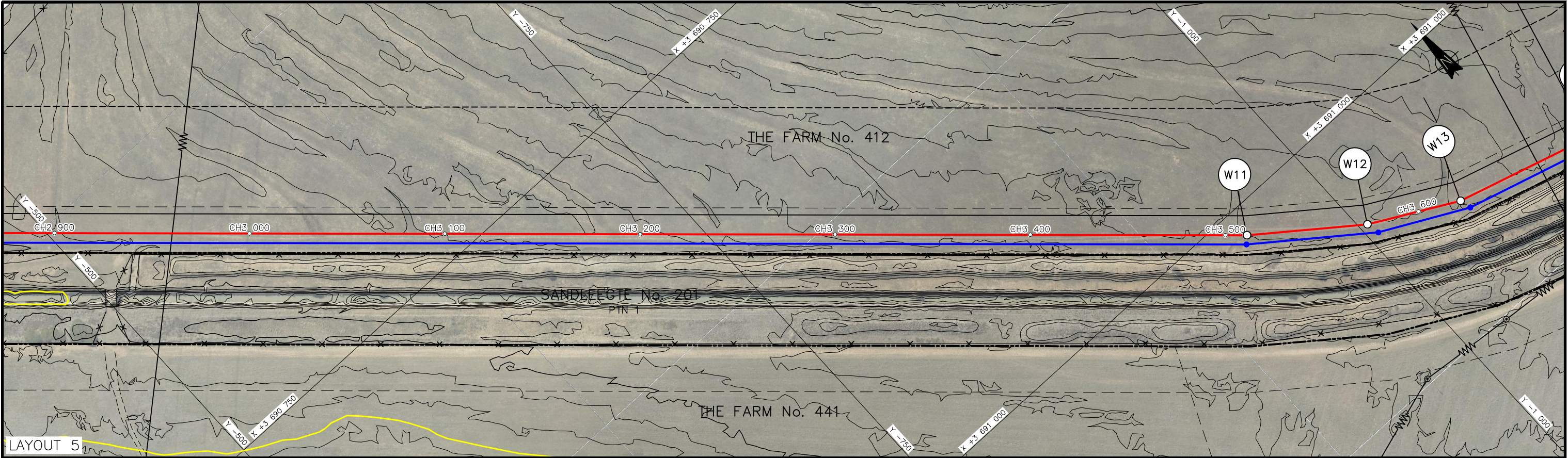
BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)									
RISING MAIN ROUTE PLAN									
LAYOUTS 3 AND 4									

JV DRAWING NUMBER
3177.00.00.GZA.05.U003



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PROVINCE: WESTERN CAPE	DISTRICT: DRAKENSTEIN/SWARTLAND	KEYCODES:				OTHER NUMBER	XX
LOCALITY No. XXX	TENDER/ CONTRACT No. XXX	SHEET	3 OF 6	REG. No.		REV.	E
CALC. FILE. XXX							



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.	DATE:
SIGNATURE:		
JV DRAWING NUMBER		
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0 5 10 20 30 40 50 100 200 m

SCALE 1:1 000

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185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DRAWN: AUTOCAD

ENGINEER: DATE: EXTERNAL APPROVAL: DATE:

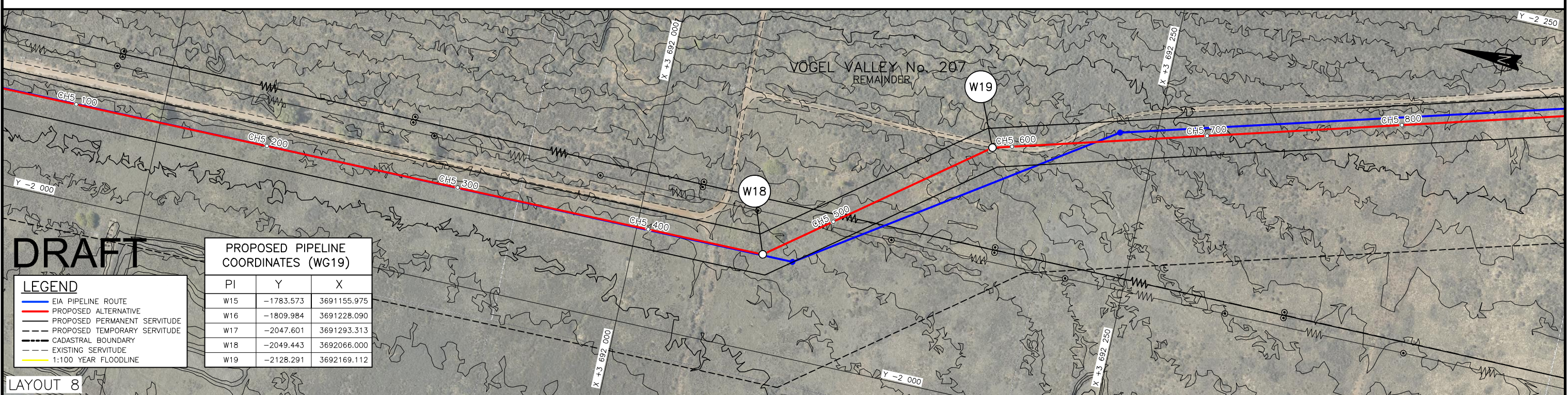
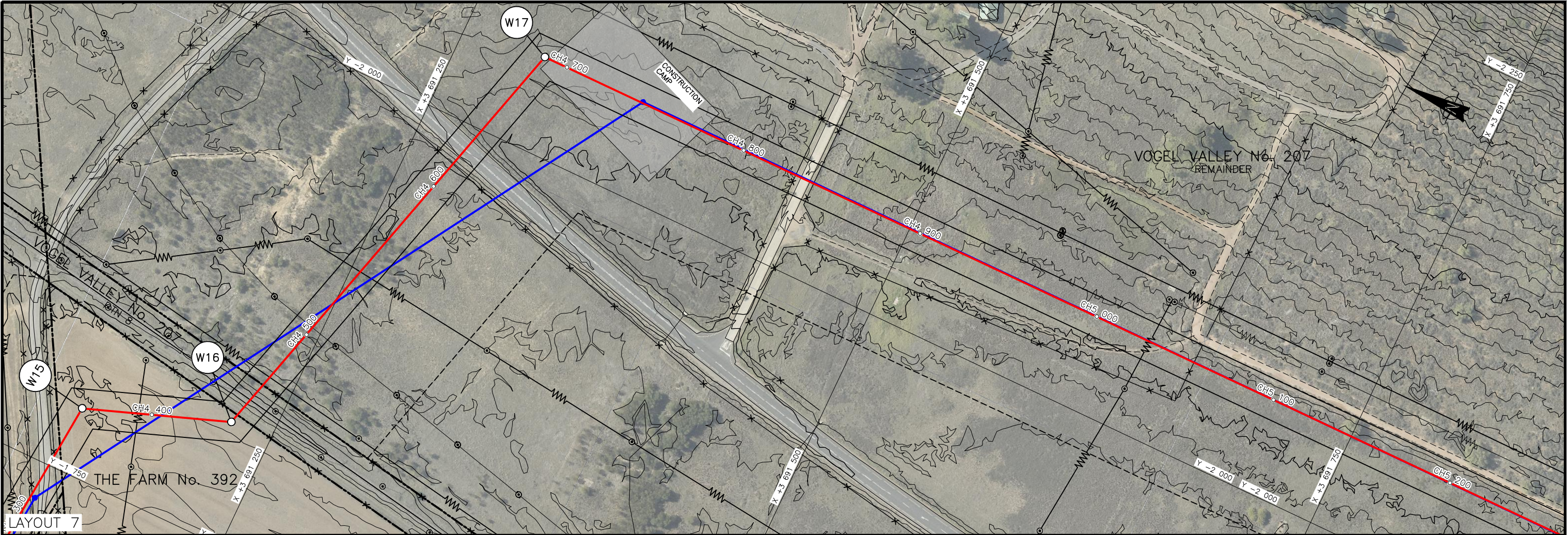
CHIEF ENGINEER / APP. (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN ROUTE PLAN
LAYOUTS 5 AND 6

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

LOCALITY No. XXX TENDER/ CONTRACT No. XXX SHEET 4 OF 6 REG. No. REV. D



DRAFT

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:	
JV DRAWING NUMBER		
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0 5 10 20 30 40 50 100 200 m

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PRETORIA
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CHECKED: DATE: DESIGN: DATE: DRAWN: AUTOCAD

ENGINEER: DATE: EXTERNAL APPROVAL: DATE:

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

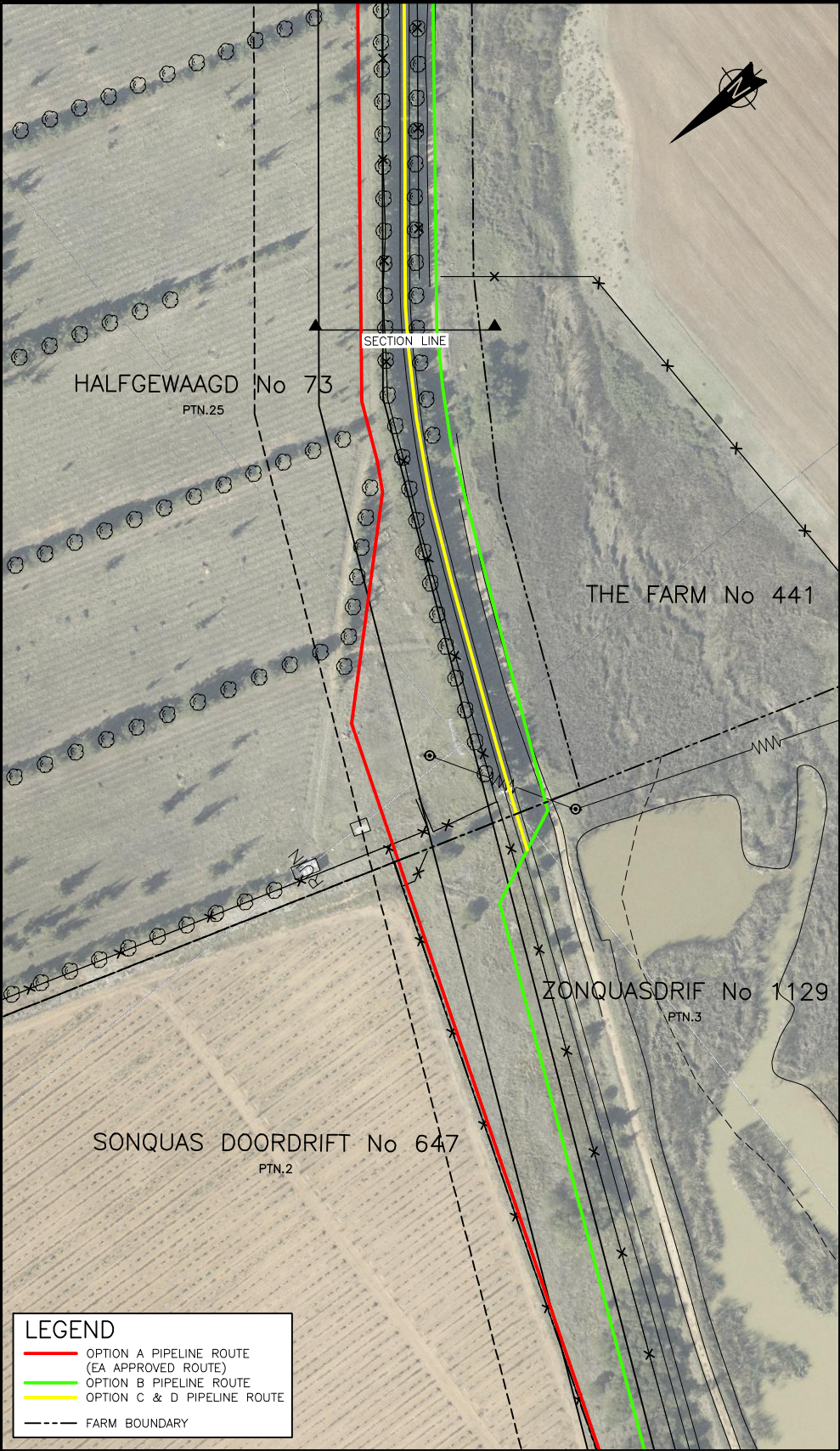
BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

RISEING MAIN ROUTE PLAN
LAYOUTS 7 AND 8

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

LOCALITY No. XXX TENDER/ CONTRACT No. XXX SHEET 5 OF 6 REG. No. REV. D

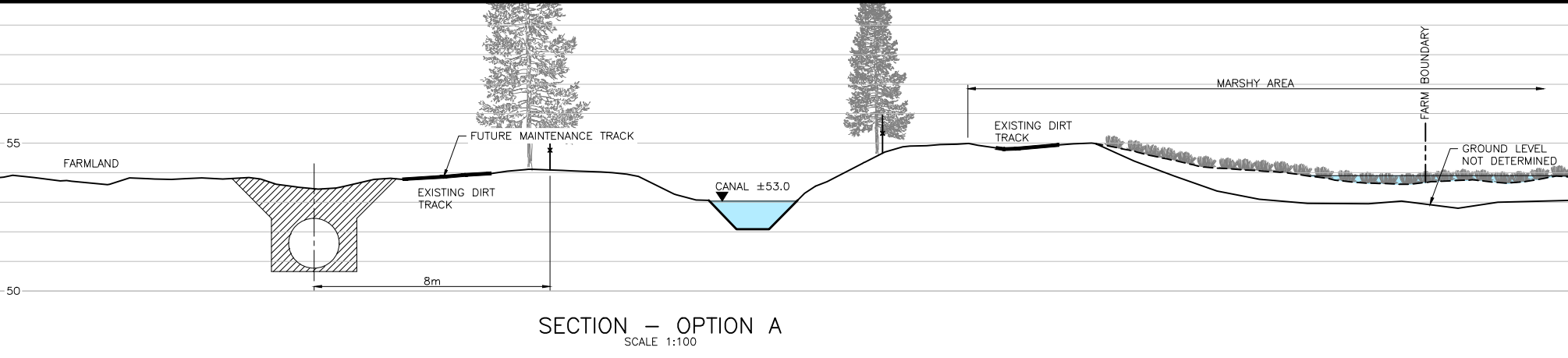
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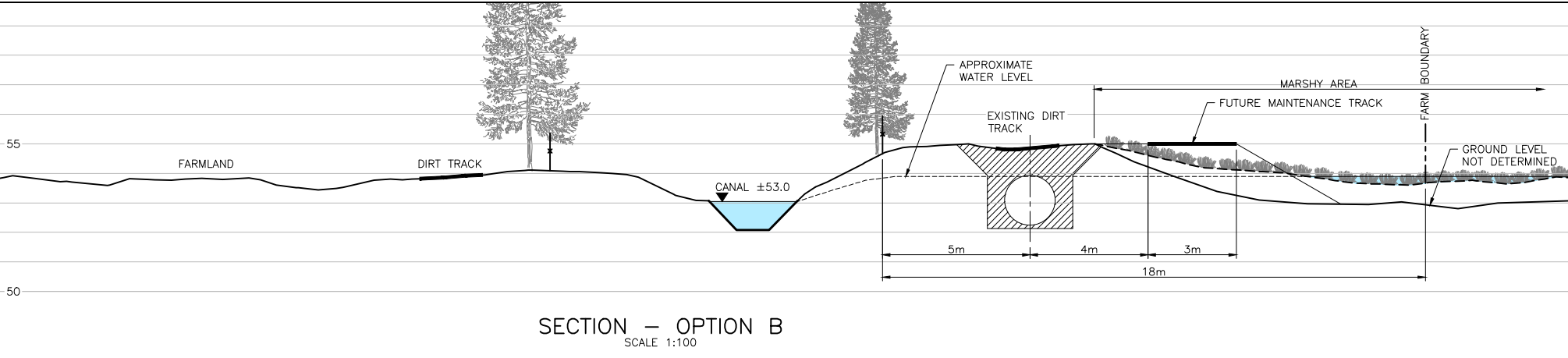
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SCALE 1:1000

LEGEND

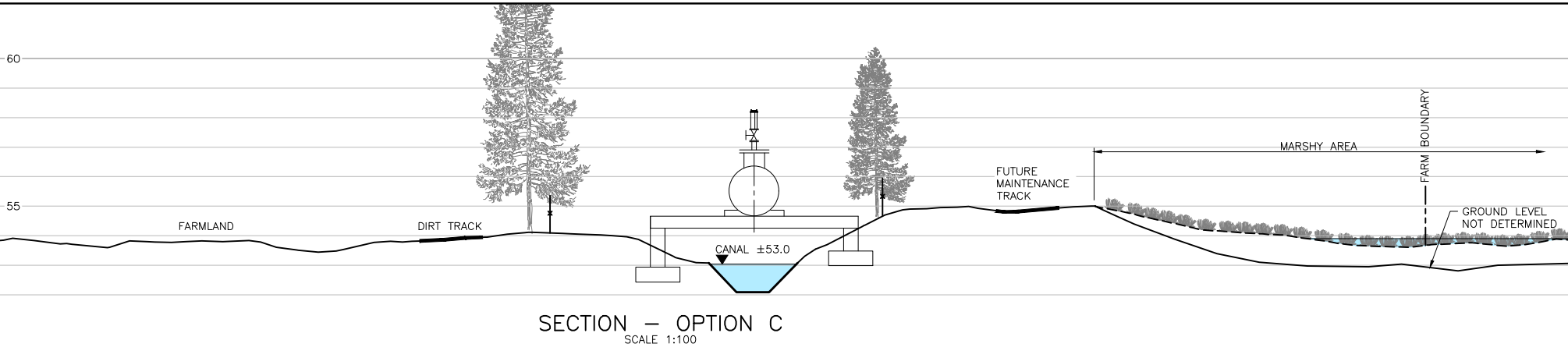
- OPTION A PIPELINE ROUTE (EA APPROVED ROUTE)
- OPTION B PIPELINE ROUTE
- OPTION C & D PIPELINE ROUTE
- FARM BOUNDARY



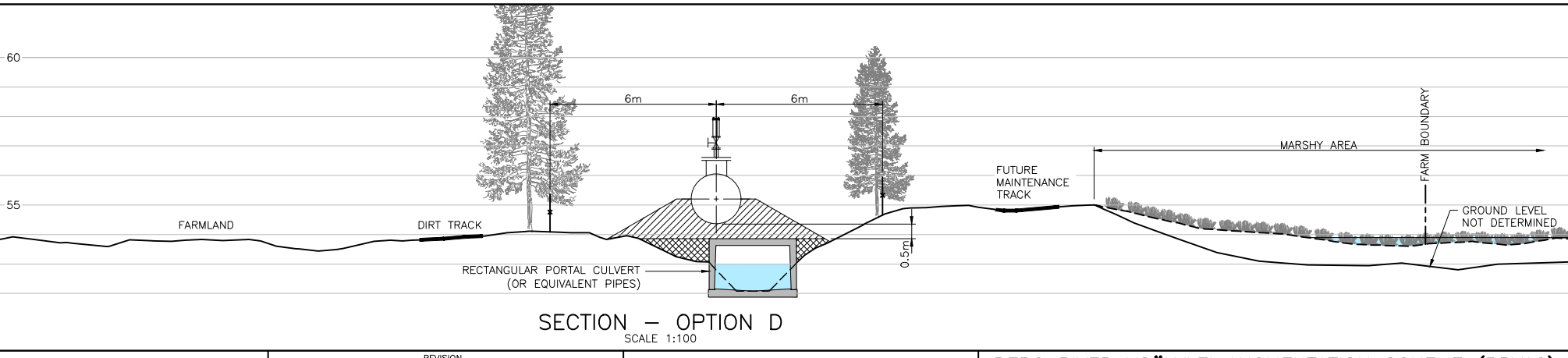
SECTION – OPTION A
SCALE 1:100



SECTION – OPTION B
SCALE 1:100



SECTION – OPTION C
SCALE 1:100



SECTION – OPTION D
SCALE 1:100

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.	DATE:
SIGNATURE:		
JV DRAWING NUMBER		
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PRETORIA 0001

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

CHECKED: DATE: DESIGN: AUTOCAD

ENGINEER: DATE: EXTERNAL APPROVAL: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: 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 SHEET 1 OF 1 REG. No. REV. D

CALC. FILE. XXX

BRVAS: Assessment of Impacts during the Construction and Future Operations of the BRVAS Pipeline on the Farm Halfgwaagd 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.	



Consulting Analytical & Industrial Chemists
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After Hours (083-3263887)
e-Mail Address :
info@alabbott.co.za



T0276

Doc.No. 7.8 # 1 Rev.4

No. 1, Vine Park
Vine Road
7925
P.O. Box 483
WOODSTOCK, CAPE
7915

Certificate of Analysis

BIGEN (HENK AARTSMA)

ANALYSES

ZONQUASDRIFT RIVER AFTER RAIN

DATE SAMPLED : 2021/07/30

DATE RECEIVED : 2021/07/30

DATE ANALYSIS

COMMENCED : 2021/07/30

OUR REF. : 2021/07/30/20583

REPORT NO. : 4213

	Sample Number	20583		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
9	Conductivity (mS/m) (at 25 °C)	30.5	≤170 Aesthetic	4.5
7	Total Dissolved Solids (mg/l)	202	≤1200 Aesthetic	-
19	pH (at 25 °C) Field	7.40	≥5 - ≤ 9.7 Operational	-
19	pH (at 25 °C) Field	7.51	≥5 - ≤ 9.7 Operational	-
6A	Total Suspended Solids (mg/l)	31	N/A	18
27	Turbidity (NTU)	39.3	≤1 Operational : ≤5 Aesthetic	11
Calc	Langelier Saturation Index (at 25 °C)	-1.7	N/A	-
19	pH (at 25 °C)	7.23	≥5 - ≤ 9.7 Operational	1.5
N/A	Temperature (°C) (Field)	15.2	N/A	-
Calc	Ryznar Index	-7.2	N/A	-
100	Nitrate & Nitrite Nitrogen (mg/l as N)	2.1	≤12 Acute Health	10.2
Calc	Nitrate Nitrogen (mg/l as N)	1.9	≤11 Acute Health	3.4
99	Nitrite Nitrogen (mg/l as N)	<0.20	≤0.9 Acute Health	4
102	Sulphate (mg/l as SO ₄)	14.6	≤250 Aesthetic ≤500 Acute Health	8.3
95	Ammonia Nitrogen (mg/l as N)	<0.10	≤1.5 Aesthetic	5.2
96	Chloride (mg/l as Cl)	54.1	≤300 Aesthetic	10
94	Total Alkalinity (mg/l as CaCO ₃)	32.7	N/A	4
92a	Sodium (mg/l as Na)	38.9	≤200 Aesthetic	5.1
Calc	Total Hardness (mg/l as CaCO ₃)	49.3	N/A	-
92a	Calcium (mg/l as Ca)	9.7	N/A	5.6
Calc	Calcium Hardness (mg/l as CaCO ₃)	24.3	N/A	-

Sampler : Eden van Eyssen (ALA)

This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.



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	Sample Number	20583		
Mthd ALA No.	Analyses	Results	SANS 241-1:2015	% Uncertainty of Measurement
92a	Magnesium (mg/l as Mg)	6.1	N/A	5.1
Calc	Magnesium Hardness (mg/l as CaCO ₃)	25.0	N/A	-
Calc	Carbonate (mg/l)	39.1	N/A	-
11	Total Phosphate (mg/l as P)	0.60	N/A	-
Calc	CaCO ₃ Precipitation Potential (mg/l)	-11.0	N/A	-
92a	Potassium (mg/l as K)	4.9	N/A	4.5
19	pH (at 25 °C) Field	7.40	≥5 - ≤ 9.7 Operational	-
19	pH (at 25 °C) Field	7.51	≥5 - ≤ 9.7 Operational	-

Notes:

- Test marked with an asterisk (*) on attached Appendix 1 (Doc. 7.8#3) are SANAS Accredited and are included in the SANAS Schedule of Accreditation for this laboratory.
- Schedule of Accreditation excludes sampling. Where applicable pH and Free & Total Chlorine Residual results are supplied by the sampling officer and will be indicated on the Certificate of Analysis. This is marked as "Field".
- Sampling plans are as requested by the customer. Sampling is done according to A.L. Abbott and Associates (Pty) Ltd sampling procedures which are available on request.
- Uncertainty of Measurement and Method Description will be provided upon request.
- Results are reported at the 95% Confidence Interval with a Coverage Factor K = 2.
- The laboratory does not normally issue any statement of conformity, unless by prior arrangement.
Decision Rule: Results reflecting on the Certificate of Analysis are actual results as obtained at the time of testing and do not include any uncertainty consideration.
- The quality and integrity of samples submitted has a direct correlation on the results reported. Results reflected on this report therefore relate only to the sample as received.
- In the absence of customer specified limits, SANS 241-1:2015 or General Limits will appear, as applicable.
- This report may not be reproduced, except in full, without the prior written approval of the laboratory.
- Opinions and interpretations are not included in the Certificate of Analysis.

Sampler : Eden van Eyssen (ALA)

This report relates only to the samples tested and is issued subject to the company's standard terms and conditions of business.



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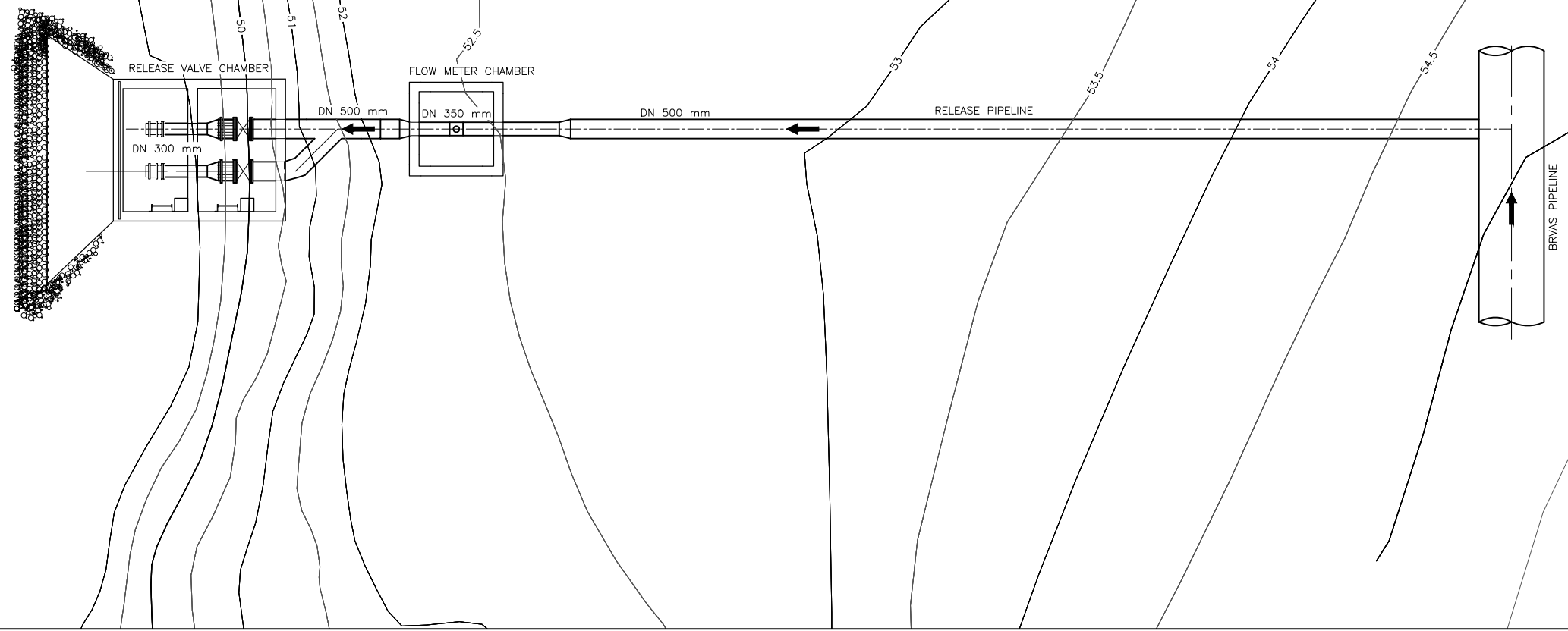
COMMENCED : 2021/07/30

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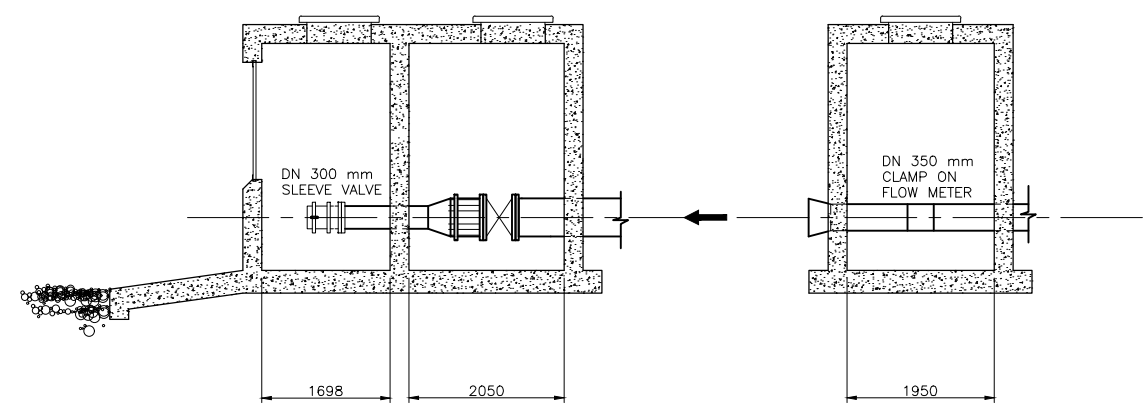
REPORT NO. : 4213

J.L. DA SILVA (Cert.Sci.Nat.)
TECHNICAL MANAGER
13 August 2021

TO: BIGEN GROUP
Attention: Henk Aartsma <Henk.Aartsma@bigengroup.com>



PLAN
SCALE 1:75



SECTION
SCALE 1:50

FUNCTION	NAME	SIGNATURE
DESIGNED	P. VAN HEERDEN	N/A
DRAWN	N. MSELENI	N/A
DESIGN CHECKED	P. VAN HEERDEN	N/A
DRAWING CHECKED	N. MSELENI	N/A
APPROVAL — CONSULTANT		
NAME: P. VAN HEERDEN	REG. No.	DATE:
SIGNATURE:		
JV DRAWING NUMBER		
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A new word for water

CONSULTING ENGINEER



Amorisi Entolus 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

CHECKED: DATE: DRAWN: AUTOCAD

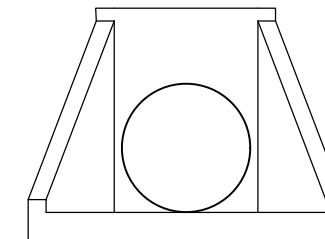
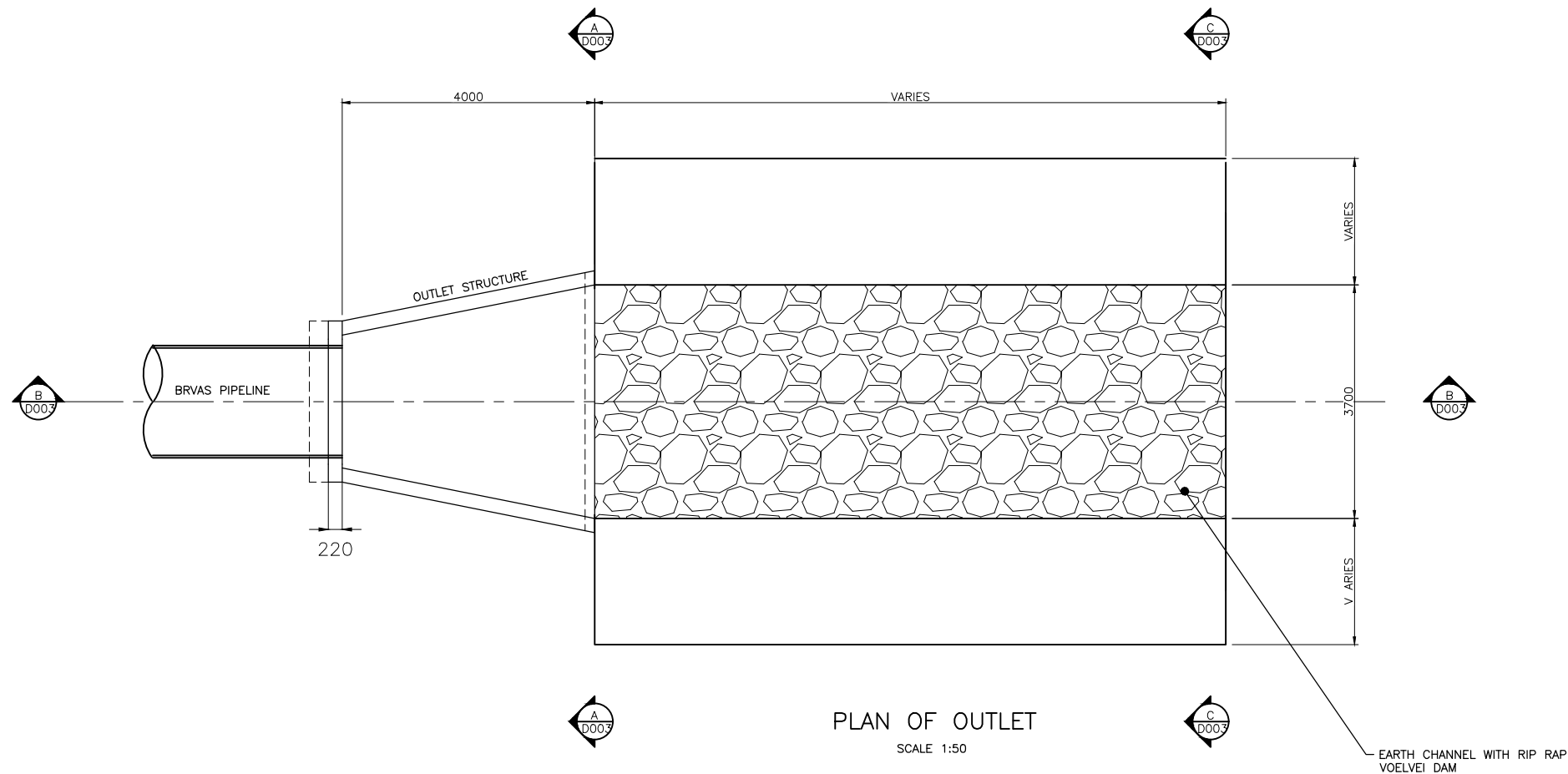
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CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

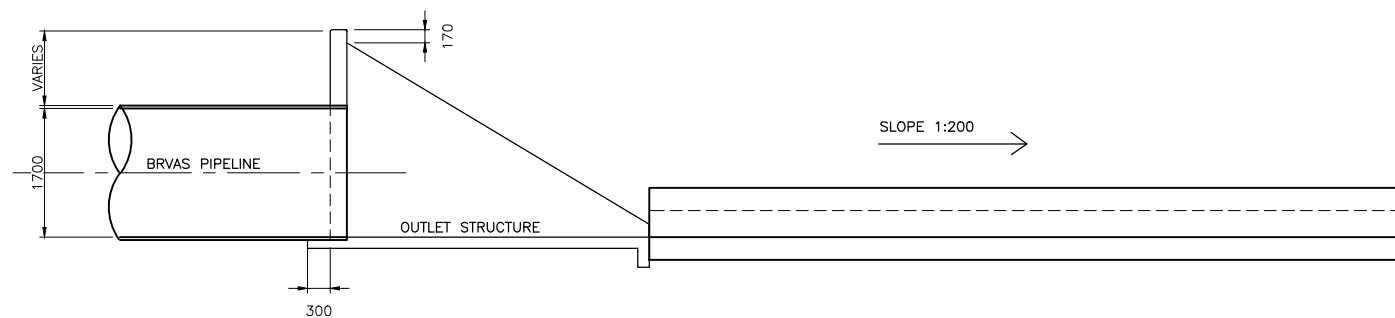
BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

RISING MAIN
OUTLET STRUCTURE AT BERG RIVER

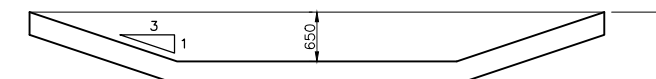
PROVINCE: WESTERN CAPE	DISTRICT: DRAKENSTEIN/SWARTLAND	KEYCODES:				OTHER NUMBER	XX
LOCALITY No. XXX	TENDER/ CONTRACT No. XXX	SHEET	REG. No.			REV.	
CALC. FILE. XXX		1 OF 1				A	



SECTION A-A
SCALE 1:50



SECTION B-B
SCALE 1:50



SECTION C-C
SCALE 1:50

<table><tr><td>FUNCTION</td><td>NAME</td><td>SIGNATURE</td></tr><tr><td>DESIGNED</td><td>P. VAN HEERDEN</td><td>N/A</td></tr><tr><td>DRAWN</td><td>N. MSELENI</td><td>N/A</td></tr><tr><td>DESIGN CHECKED</td><td>P. VAN HEERDEN</td><td>N/A</td></tr><tr><td>DRAWING CHECKED</td><td>N. MSELENI</td><td>N/A</td></tr><tr><td colspan="3">APPROVAL – CONSULTANT</td></tr><tr><td>NAME: P. VAN HEERDEN</td><td>REG. No.</td><td>DATE:</td></tr><tr><td colspan="3">SIGNATURE:</td></tr></table>			FUNCTION	NAME	SIGNATURE	DESIGNED	P. VAN HEERDEN	N/A	DRAWN	N. MSELENI	N/A	DESIGN CHECKED	P. VAN HEERDEN	N/A	DRAWING CHECKED	N. MSELENI	N/A	APPROVAL – CONSULTANT			NAME: P. VAN HEERDEN	REG. No.	DATE:	SIGNATURE:			<table><tr><td colspan="3">MOD No.</td><td colspan="3">DATE</td><td colspan="3">REVISION</td><td colspan="3">FOR</td><td colspan="3">DWA</td></tr><tr><td colspan="3"></td><td colspan="3"></td><td colspan="3">DESCRIPTION</td><td colspan="3"></td><td colspan="3"></td></tr><tr><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr></table>			MOD No.			DATE			REVISION			FOR			DWA									DESCRIPTION																								<table><tr><td colspan="3">DEPARTMENT OF WATER AFFAIRS REPUBLIC OF SOUTH AFRICA</td></tr><tr><td colspan="3"> HEAD OFFICE CIVIL DESIGN PRIVATE BAG X313 PRETORIA 0001 SEDIBENG BUILDING 185 FRANCIS BAARD STREET PRETORIA (012) 336-7500 </td></tr><tr><td colspan="3">CHECKED: DATE: DRAWN: AUTOCAD</td></tr><tr><td colspan="3">ENGINEER: DATE: EXTERNAL APPROVAL: DATE:</td></tr><tr><td colspan="3">CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:</td></tr></table>			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			CHECKED: DATE: DRAWN: AUTOCAD			ENGINEER: DATE: EXTERNAL APPROVAL: DATE:			CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:			<table><tr><td colspan="12">BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)</td></tr><tr><td colspan="12">RISING MAIN OUTLET AT VOELVLEI DAM</td></tr><tr><td colspan="3">PROVINCE: WESTERN CAPE</td><td colspan="3">DISTRICT: DRAKENSTEIN/SWARTLAND</td><td colspan="3">KEYCODES:</td><td colspan="3">OTHER NUMBER</td><td colspan="3">XX</td></tr><tr><td colspan="3">LOCALITY No. XXX</td><td colspan="3">TENDER/ CONTRACT No. XXX</td><td colspan="3">SHEET 1 OF 1</td><td colspan="3">REV. A</td></tr><tr><td colspan="3">CALC. FILE. XXX</td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr></table>												BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)												RISING MAIN OUTLET AT VOELVLEI DAM												PROVINCE: WESTERN CAPE			DISTRICT: DRAKENSTEIN/SWARTLAND			KEYCODES:			OTHER NUMBER			XX			LOCALITY No. XXX			TENDER/ CONTRACT No. XXX			SHEET 1 OF 1			REV. A			CALC. FILE. XXX														
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BRVAS Cost Calculations for DN1400 Pipeline

Capital Costs

Pipeline	R240 277 000
Pumping Station - Civil	R65 000 000
Pumping Station - M&E	R134 338 000
Total	R439 615 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R87 923 000	R0	R0	R78 251 157	R0	R0
2024	R263 769 000	R0	R0	R221 465 539	R0	R0
2025	R87 923 000	R6 737 405	R4 516 267	R69 643 251	R5 336 656	R3 577 306
2026		R6 737 405	R4 516 267		R5 034 581	R3 374 817
2027		R6 737 405	R4 516 267		R4 749 605	R3 183 790
2028		R6 737 405	R4 516 267		R4 480 759	R3 003 576
2029		R6 737 405	R4 516 267		R4 227 131	R2 833 562
2030		R6 737 405	R4 516 267		R3 987 860	R2 673 172
2031		R6 737 405	R4 516 267		R3 762 132	R2 521 860
2032		R6 737 405	R4 516 267		R3 549 181	R2 379 113
2033		R6 737 405	R4 516 267		R3 348 284	R2 244 446
2034		R6 737 405	R4 516 267		R3 158 758	R2 117 402
2035		R6 737 405	R4 516 267		R2 979 961	R1 997 549
2036		R6 737 405	R4 516 267		R2 811 284	R1 884 480
2037		R6 737 405	R4 516 267		R2 652 154	R1 777 812
2038		R6 737 405	R4 516 267		R2 502 032	R1 677 181
2039		R6 737 405	R4 516 267		R2 360 408	R1 582 246
2040		R6 737 405	R4 516 267		R2 226 800	R1 492 685
2041		R6 737 405	R4 516 267		R2 100 755	R1 408 193
2042		R6 737 405	R4 516 267		R1 981 844	R1 328 484
2043		R6 737 405	R4 516 267		R1 869 664	R1 253 287
2044		R6 737 405	R4 516 267		R1 763 834	R1 182 346
2045		R6 737 405	R4 516 267		R1 663 995	R1 115 421
2046		R6 737 405	R4 516 267		R1 569 806	R1 052 284
2047		R6 737 405	R4 516 267		R1 480 949	R992 721
2048		R6 737 405	R4 516 267		R1 397 122	R936 529
2049		R6 737 405	R4 516 267		R1 318 040	R883 518
2050		R6 737 405	R4 516 267		R1 243 433	R833 508
2051		R6 737 405	R4 516 267		R1 173 050	R786 328
2052		R6 737 405	R4 516 267		R1 106 651	R741 819
2053		R6 737 405	R4 516 267		R1 044 011	R699 829
2054		R6 737 405	R4 516 267		R984 916	R660 216
2055		R6 737 405	R4 516 267		R929 166	R622 845
2056		R6 737 405	R4 516 267		R876 572	R587 590
2057		R6 737 405	R4 516 267		R826 954	R554 330
2058		R6 737 405	R4 516 267		R780 146	R522 953
2059		R6 737 405	R4 516 267		R735 986	R493 352
2060		R6 737 405	R4 516 267		R694 327	R465 426
2061		R6 737 405	R4 516 267		R655 025	R439 081
2062		R6 737 405	R4 516 267		R617 948	R414 228
2063		R6 737 405	R4 516 267		R582 970	R390 781
2064		R6 737 405	R4 516 267		R549 972	R368 661
2065		R6 737 405	R4 516 267		R518 841	R347 794
2066		R6 737 405	R4 516 267		R489 473	R328 107
Totals				R369 359 947	R86 123 036	R57 730 629
TOTAL						R513 213 612

BRVAS Cost Calculations for DN1500 Pipeline

Capital Costs

Pipeline	R265 101 000
Pumping Station - Civil	R62 500 000
Pumping Station - M&E	R110 397 000
Total	R437 998 000

Year	Annual Costs			Present Value (2021) @ 6% DR			
	Capital	O&M	Energy	Capital	O&M	Energy	
2021		R0		R0	R0	R0	R0
2022		R0		R0	R0		R0
2023	R87 599 600	R0		R77 963 332	R0		R0
2024	R262 798 800	R0		R220 650 940	R0		R0
2025	R87 599 600	R5 897 635	R2 863 867	R69 387 088	R4 671 479	R3 271 138	
2026		R5 897 635	R2 863 867		R4 407 056	R3 085 979	
2027		R5 897 635	R2 863 867		R4 157 600	R2 911 301	
2028		R5 897 635	R2 863 867		R3 922 264	R2 746 511	
2029		R5 897 635	R2 863 867		R3 700 249	R2 591 048	
2030		R5 897 635	R2 863 867		R3 490 801	R2 444 385	
2031		R5 897 635	R2 863 867		R3 293 209	R2 306 023	
2032		R5 897 635	R2 863 867		R3 106 801	R2 175 494	
2033		R5 897 635	R2 863 867		R2 930 944	R2 052 353	
2034		R5 897 635	R2 863 867		R2 765 041	R1 936 182	
2035		R5 897 635	R2 863 867		R2 608 530	R1 826 586	
2036		R5 897 635	R2 863 867		R2 460 877	R1 723 195	
2037		R5 897 635	R2 863 867		R2 321 582	R1 625 655	
2038		R5 897 635	R2 863 867		R2 190 172	R1 533 637	
2039		R5 897 635	R2 863 867		R2 066 200	R1 446 828	
2040		R5 897 635	R2 863 867		R1 949 245	R1 364 932	
2041		R5 897 635	R2 863 867		R1 838 910	R1 287 671	
2042		R5 897 635	R2 863 867		R1 734 821	R1 214 784	
2043		R5 897 635	R2 863 867		R1 636 624	R1 146 023	
2044		R5 897 635	R2 863 867		R1 543 985	R1 081 154	
2045		R5 897 635	R2 863 867		R1 456 589	R1 019 956	
2046		R5 897 635	R2 863 867		R1 374 141	R962 223	
2047		R5 897 635	R2 863 867		R1 296 359	R907 758	
2048		R5 897 635	R2 863 867		R1 222 980	R856 375	
2049		R5 897 635	R2 863 867		R1 153 755	R807 901	
2050		R5 897 635	R2 863 867		R1 088 448	R762 171	
2051		R5 897 635	R2 863 867		R1 026 838	R719 029	
2052		R5 897 635	R2 863 867		R968 715	R678 329	
2053		R5 897 635	R2 863 867		R913 882	R639 933	
2054		R5 897 635	R2 863 867		R862 153	R603 711	
2055		R5 897 635	R2 863 867		R813 352	R569 538	
2056		R5 897 635	R2 863 867		R767 313	R537 300	
2057		R5 897 635	R2 863 867		R723 880	R506 887	
2058		R5 897 635	R2 863 867		R682 906	R478 195	
2059		R5 897 635	R2 863 867		R644 251	R451 128	
2060		R5 897 635	R2 863 867		R607 784	R425 592	
2061		R5 897 635	R2 863 867		R573 381	R401 502	
2062		R5 897 635	R2 863 867		R540 925	R378 775	
2063		R5 897 635	R2 863 867		R510 307	R357 335	
2064		R5 897 635	R2 863 867		R481 422	R337 109	
2065		R5 897 635	R2 863 867		R454 171	R318 027	
2066		R5 897 635	R2 863 867		R428 464	R300 026	
Totals				R368 001 360	R75 388 407	R52 789 680	
TOTAL						R496 179 447	

BRVAS Cost Calculations for DN1600 Pipeline

Capital Costs

Pipeline	R293 184 000
Pumping Station - Civil	R60 000 000
Pumping Station - M&E	R99 908 000
Total	R453 092 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R90 618 400	R0	R0	R80 650 053	R0	R0
2024	R271 855 200	R0	R0	R228 254 868	R0	R0
2025	R90 618 400	R5 612 240	R3 873 067	R71 778 260	R4 445 420	R3 067 832
2026		R5 612 240	R3 873 067		R4 193 792	R2 894 181
2027		R5 612 240	R3 873 067		R3 956 408	R2 730 359
2028		R5 612 240	R3 873 067		R3 732 460	R2 575 811
2029		R5 612 240	R3 873 067		R3 521 189	R2 430 010
2030		R5 612 240	R3 873 067		R3 321 876	R2 292 462
2031		R5 612 240	R3 873 067		R3 133 846	R2 162 700
2032		R5 612 240	R3 873 067		R2 956 458	R2 040 283
2033		R5 612 240	R3 873 067		R2 789 111	R1 924 796
2034		R5 612 240	R3 873 067		R2 631 237	R1 815 845
2035		R5 612 240	R3 873 067		R2 482 299	R1 713 061
2036		R5 612 240	R3 873 067		R2 341 792	R1 616 095
2037		R5 612 240	R3 873 067		R2 209 237	R1 524 618
2038		R5 612 240	R3 873 067		R2 084 186	R1 438 319
2039		R5 612 240	R3 873 067		R1 966 213	R1 356 905
2040		R5 612 240	R3 873 067		R1 854 918	R1 280 099
2041		R5 612 240	R3 873 067		R1 749 923	R1 207 641
2042		R5 612 240	R3 873 067		R1 650 871	R1 139 284
2043		R5 612 240	R3 873 067		R1 557 425	R1 074 796
2044		R5 612 240	R3 873 067		R1 469 269	R1 013 958
2045		R5 612 240	R3 873 067		R1 386 103	R956 564
2046		R5 612 240	R3 873 067		R1 307 644	R902 419
2047		R5 612 240	R3 873 067		R1 233 627	R851 339
2048		R5 612 240	R3 873 067		R1 163 799	R803 150
2049		R5 612 240	R3 873 067		R1 097 923	R757 689
2050		R5 612 240	R3 873 067		R1 035 777	R714 801
2051		R5 612 240	R3 873 067		R977 148	R674 340
2052		R5 612 240	R3 873 067		R921 838	R636 170
2053		R5 612 240	R3 873 067		R869 658	R600 160
2054		R5 612 240	R3 873 067		R820 432	R566 189
2055		R5 612 240	R3 873 067		R773 993	R534 141
2056		R5 612 240	R3 873 067		R730 182	R503 906
2057		R5 612 240	R3 873 067		R688 851	R475 383
2058		R5 612 240	R3 873 067		R649 859	R448 475
2059		R5 612 240	R3 873 067		R613 075	R423 089
2060		R5 612 240	R3 873 067		R578 372	R399 141
2061		R5 612 240	R3 873 067		R545 634	R376 548
2062		R5 612 240	R3 873 067		R514 749	R355 234
2063		R5 612 240	R3 873 067		R485 613	R335 126
2064		R5 612 240	R3 873 067		R458 125	R316 157
2065		R5 612 240	R3 873 067		R432 193	R298 261
2066		R5 612 240	R3 873 067		R407 730	R281 379
Totals				R380 683 182	R71 740 255	R49 508 717
TOTAL						R501 932 153

BRVAS Cost Calculations for DN1700 Pipeline

Capital Costs

Pipeline	R323 058 000
Pumping Station - Civil	R57 500 000
Pumping Station - M&E	R88 800 000
Total	R469 358 000

Year	Annual Costs			Present Value (2021) @ 6% DR			
	Capital	O&M	Energy	Capital	O&M	Energy	
2021		R0	R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0	R0
2023	R93 871 600	R0	R0	R83 545 390	R0	R0	R0
2024	R281 614 800	R0	R0	R236 449 216	R0	R0	R0
2025	R93 871 600	R5 311 040	R3 712 908	R74 355 100	R4 206 841	R2 940 971	
2026		R5 311 040	R3 712 908		R3 968 718	R2 774 501	
2027		R5 311 040	R3 712 908		R3 744 074	R2 617 454	
2028		R5 311 040	R3 712 908		R3 532 145	R2 469 296	
2029		R5 311 040	R3 712 908		R3 332 212	R2 329 524	
2030		R5 311 040	R3 712 908		R3 143 596	R2 197 665	
2031		R5 311 040	R3 712 908		R2 965 657	R2 073 268	
2032		R5 311 040	R3 712 908		R2 797 790	R1 955 914	
2033		R5 311 040	R3 712 908		R2 639 424	R1 845 202	
2034		R5 311 040	R3 712 908		R2 490 023	R1 740 756	
2035		R5 311 040	R3 712 908		R2 349 078	R1 642 223	
2036		R5 311 040	R3 712 908		R2 216 111	R1 549 267	
2037		R5 311 040	R3 712 908		R2 090 671	R1 461 572	
2038		R5 311 040	R3 712 908		R1 972 331	R1 378 842	
2039		R5 311 040	R3 712 908		R1 860 690	R1 300 794	
2040		R5 311 040	R3 712 908		R1 755 368	R1 227 164	
2041		R5 311 040	R3 712 908		R1 656 007	R1 157 702	
2042		R5 311 040	R3 712 908		R1 562 271	R1 092 172	
2043		R5 311 040	R3 712 908		R1 473 841	R1 030 351	
2044		R5 311 040	R3 712 908		R1 390 416	R972 029	
2045		R5 311 040	R3 712 908		R1 311 713	R917 009	
2046		R5 311 040	R3 712 908		R1 237 465	R865 102	
2047		R5 311 040	R3 712 908		R1 167 420	R816 134	
2048		R5 311 040	R3 712 908		R1 101 339	R769 938	
2049		R5 311 040	R3 712 908		R1 039 000	R726 357	
2050		R5 311 040	R3 712 908		R980 188	R685 242	
2051		R5 311 040	R3 712 908		R924 706	R646 455	
2052		R5 311 040	R3 712 908		R872 364	R609 863	
2053		R5 311 040	R3 712 908		R822 985	R575 343	
2054		R5 311 040	R3 712 908		R776 401	R542 776	
2055		R5 311 040	R3 712 908		R732 454	R512 053	
2056		R5 311 040	R3 712 908		R690 994	R483 069	
2057		R5 311 040	R3 712 908		R651 881	R455 725	
2058		R5 311 040	R3 712 908		R614 982	R429 929	
2059		R5 311 040	R3 712 908		R580 172	R405 594	
2060		R5 311 040	R3 712 908		R547 332	R382 636	
2061		R5 311 040	R3 712 908		R516 351	R360 977	
2062		R5 311 040	R3 712 908		R487 124	R340 544	
2063		R5 311 040	R3 712 908		R459 550	R321 268	
2064		R5 311 040	R3 712 908		R433 538	R303 083	
2065		R5 311 040	R3 712 908		R408 998	R285 928	
2066		R5 311 040	R3 712 908		R385 847	R269 743	
Totals				R394 349 706	R67 890 069	R47 461 435	
TOTAL						R509 701 210	

BRVAS Cost Calculations for DN1800 Pipeline

Capital Costs

Pipeline	R349 093 000
Pumping Station - Civil	R55 000 000
Pumping Station - M&E	R80 520 000
Total	R484 613 000

Year	Annual Costs			Present Value (2021) @ 6% DR		
	Capital	O&M	Energy	Capital	O&M	Energy
2021		R0	R0	R0	R0	R0
2022	R0	R0	R0	R0	R0	R0
2023	R96 922 600	R0	R0	R86 260 769	R0	R0
2024	R290 767 800	R0	R0	R244 134 252	R0	R0
2025	R96 922 600	R5 103 765	R3 564 702	R76 771 777	R4 042 660	R2 823 578
2026		R5 103 765	R3 564 702		R3 813 830	R2 663 753
2027		R5 103 765	R3 564 702		R3 597 953	R2 512 974
2028		R5 103 765	R3 564 702		R3 394 295	R2 370 730
2029		R5 103 765	R3 564 702		R3 202 165	R2 236 538
2030		R5 103 765	R3 564 702		R3 020 911	R2 109 942
2031		R5 103 765	R3 564 702		R2 849 916	R1 990 511
2032		R5 103 765	R3 564 702		R2 688 600	R1 877 841
2033		R5 103 765	R3 564 702		R2 536 415	R1 771 548
2034		R5 103 765	R3 564 702		R2 392 844	R1 671 271
2035		R5 103 765	R3 564 702		R2 257 400	R1 576 671
2036		R5 103 765	R3 564 702		R2 129 623	R1 487 426
2037		R5 103 765	R3 564 702		R2 009 078	R1 403 232
2038		R5 103 765	R3 564 702		R1 895 357	R1 323 803
2039		R5 103 765	R3 564 702		R1 788 072	R1 248 871
2040		R5 103 765	R3 564 702		R1 686 861	R1 178 180
2041		R5 103 765	R3 564 702		R1 591 378	R1 111 491
2042		R5 103 765	R3 564 702		R1 501 300	R1 048 576
2043		R5 103 765	R3 564 702		R1 416 321	R989 223
2044		R5 103 765	R3 564 702		R1 336 152	R933 229
2045		R5 103 765	R3 564 702		R1 260 520	R880 405
2046		R5 103 765	R3 564 702		R1 189 170	R830 571
2047		R5 103 765	R3 564 702		R1 121 859	R783 557
2048		R5 103 765	R3 564 702		R1 058 357	R739 205
2049		R5 103 765	R3 564 702		R998 450	R697 363
2050		R5 103 765	R3 564 702		R941 934	R657 890
2051		R5 103 765	R3 564 702		R888 617	R620 651
2052		R5 103 765	R3 564 702		R838 318	R585 520
2053		R5 103 765	R3 564 702		R790 866	R552 377
2054		R5 103 765	R3 564 702		R746 100	R521 110
2055		R5 103 765	R3 564 702		R703 868	R491 614
2056		R5 103 765	R3 564 702		R664 026	R463 786
2057		R5 103 765	R3 564 702		R626 440	R437 534
2058		R5 103 765	R3 564 702		R590 981	R412 768
2059		R5 103 765	R3 564 702		R557 529	R389 404
2060		R5 103 765	R3 564 702		R525 971	R367 362
2061		R5 103 765	R3 564 702		R496 199	R346 568
2062		R5 103 765	R3 564 702		R468 112	R326 951
2063		R5 103 765	R3 564 702		R441 616	R308 444
2064		R5 103 765	R3 564 702		R416 618	R290 985
2065		R5 103 765	R3 564 702		R393 036	R274 514
2066		R5 103 765	R3 564 702		R370 789	R258 976
Totals				R407 166 798	R65 240 510	R45 566 944
TOTAL						R517 974 252