TRANS-CALEDON TUNNEL AUTHORITY

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT №: 21-041

FACTUAL REPORT

FOR

CONTRACT 1A-C-211-01: ADDITIONAL GEOTECHNICAL INVESTIGATION

February 2022

AMANZI ENTABA JOINT VENTURE

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

BERG RIVER VOËLVLEI AUGMENTATION SCHEME

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DRAFT FACTUAL REPORT FOR CONTRACT 1A-C-211-01: ADDITIONAL GEOTECHNICAL INVESTIGATION

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BERG RIVER VOËLVLEI AUGMENTATION SCHEME

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FACTUAL REPORT FOR CONTRACT 1A-C-211-01: ADDITIONAL GEOTECHNICAL INVESTIGATION

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1 INTRODUCTION

The Amanzi Entaba Joint Venture (AEJV) was appointed by the Trans-Caledon Tunnel Authority (TCTA) for consulting services for the Berg River Voëlvlei Augmentation Scheme (BRVAS). The project is situated in the Western Cape in the Drakenstein Local Municipality of the Cape Winelands District Municipality. The project entails the abstraction of surplus winter water from a proposed low level diversion weir across the Berg River and the pumping of the water via a 6.3 km long rising main into the existing Voëlvlei Dam.

Previous geotechnical investigations have been conducted at a feasibility level and comprised mapping of the exposed bedrock, the exploratory drilling of eight rotary core boreholes at the Berg River weir site, the excavation of nine trial pits along the pipeline (rising main), and basic laboratory testing of soils and groundwater samples obtained from the trial pits. Based on the findings of the previous investigation the weir location was found to be favourable, however more investigation was required to determine any potential geotechnical constraints that might affect the design and construction of the proposed development.

The current study commenced with a gap analysis of the previous geotechnical studies. The findings of the gap analysis formed the basis of the scope of work for the current study. The JV then recommended that further investigation was required as detailed below. These aspects formed the basis of the additional geotechnical investigation. The following components required further investigation:

- The optimum position for a pump station at the proposed Berg River weir site.
- The condition of the bedrock at the pipeline river crossings.
- Detailed trial pitting along the pipeline route.
- Investigating the suitability of the in-situ materials for construction purposes.
- Geophysical investigation to determine depth of alluvium, bedrock level and quality of rock, and to identify any potential faults or areas of weak ground along all the structures.
- Evaluate the permeability and groutability of the material(s) below the various concrete structures.
- Detailed trial pitting on the right flank of the Berg River along the centreline of the proposed earth embankment, to assess the type and quality of the in-situ materials and assess the in-situ permeability of the material(s) below the proposed earth embankment.
- Determine the susceptibility of the alluvium beneath the proposed earth embankment to liquefaction and piping at various depths.
- Seismic surveys or deep test pits (>6m depth) on both sides of the river and infrastructure crossings where pipe jacking will be required, such as under the railway line, Road R44, and at the Voëlvlei outlet.
- Identify specific sources at or adjacent to the proposed weir/abstraction and works/pump station, and along or adjacent to the pipeline route for bedding material and material suitable for the construction of the earth embankment.
- In case there is insufficient suitable material for re-use on site, the identification of potential borrow areas within the project area or from commercial sources.
- Determine soil corrosivity/resistivity for cathodic protection of the proposed steel pipeline.
- The identification of potential spoil sites within the project area for the disposal of unsuitable material, including registered landfill sites.

- Undertake a materials investigation along a portion of the existing Provincial road and a new access road in the vicinity of Voëlvlei Dam.
- Carrying out soil fertility testing.

The format of the contract for this project is intended to be design and construct. As such, no Geotechnical Interpretive Report will be produced, as the successful bidder(s) will be required to do their own interpretation of the geotechnical data to suit the eventual design. This Geotechnical Factual Report collates all the data collected from the Additional Geotechnical Investigation.

1.1 Terms of Reference

The following reports have relevance in terms of the geotechnical information for the study area:

- Berg River Voëlvlei Augmentation Scheme – Pre-feasibility and Feasibility Studies for Augmentation of the Western Cape Water Supply System by means of further surface water developments: Report No 3: Feasibility Studies, Volume 1: First Phase Augmentation of Voëlvlei Dam, Prepared by Western Cape Water Consultants for the Department of Water Affairs in 2012. Report No. P WMA 19/G10/00/2413/5.
- Berg River Voëlvlei Augmentation Scheme – Pre-feasibility and Feasibility Studies for Augmentation of the Western Cape Water Supply System by means of further surface water developments: Report No. 3 Volume 2: Breede-Berg (Michell's Pass) Water Transfer Scheme, Appendix No. 8: Geotechnical Investigations for the Berg River – Voëlvlei Augmentation Scheme, and the Breede-Berg (Michell's Pass) Water Transfer Scheme, Prepared by Western Cape Water Consultants for the Department of Water Affairs in 2012. Report No. P WMA 19/G10/00/2413/6.

1.2 Objectives and Scope of Work

The purpose of the geotechnical investigation was to assess the underlying geological setting of the proposed study area and to determine any potential geotechnical constraints that might affect the design and construction of the proposed development. The additional geotechnical investigation was planned to be carried out in two (2) phases (Phase 1A and Phase 1B) where each subsequent phase builds on the information gained during the previous phases in order to allow the investigation to be optimised and be cost effective.

The Phase 1A investigations were essential and a minimum requirement to understand the stratigraphy on site, while Phase 1B components were only executed if deemed required. This report presents the findings of the additional geotechnical investigation carried out at the proposed study area for Phase 1A only, which consisted of the following:

- Excavation of test pits (along sections of the pipeline route, for ancillary works and for material source),
- Profiling and soil sampling,
- DCP testing,
- Geophysical investigation (resistivity and seismic surveys),
- Identification of suitable construction materials,
- Laboratory soil testing, and
- Preparation of the geotechnical factual report.

At the time of writing this report, no Phase 1B investigations had been carried out. It is planned to carry out a portion of the Phase 1B investigations at the weir in order to better understand the stratigraphy and consistency of the deep subsoils in this area, and also at the Berg River crossing in order to better understand the stratigraphy in the area to better inform the location of the river diversion.

1.3 Proposed Development

The proposed development includes a water pipeline with a diameter of 1,500 mm with minimum cover of 1,000 mm and more at river and road/rail crossing as may be dictated by geotechnical conditions and authority requirements. The proposed pipeline will traverse a total distance of approximately 6.3 km from Swartland Municipality to Drakenstein Municipality and includes the following key components:

- Construction of a low-level diversion weir and abstraction works in the Berg River including a crump weir, a soil embankment on the right bank, a canoe chute and a pumping station.
- Construction of a water transfer system consisting of a pump station and a 6.3 km long pipeline. The system must allow for releases in summer from the Voëlvlei Dam to the Berg River and downstream users, including the West Coast District Municipality Water Treatment Works.
- Construction of the appurtenant works which will include river, road and power line crossings, access roads, the outlet at the dam, network infrastructure, etc.

2 SITE DESCRIPTION

2.1 Site Locality

The project is situated in the Western Cape in the Drakenstein Local Municipality of the Cape Winelands District Municipality about 30 km North East of Malmesbury. The weir and the associated structures are located 5 km North West of the Voëlvlei Dam. The pipeline route traverses towards the south east approximately 6.3 km from the pump station to the existing Voëlvlei Dam. Figure 1 below shows the proposed pipeline route.

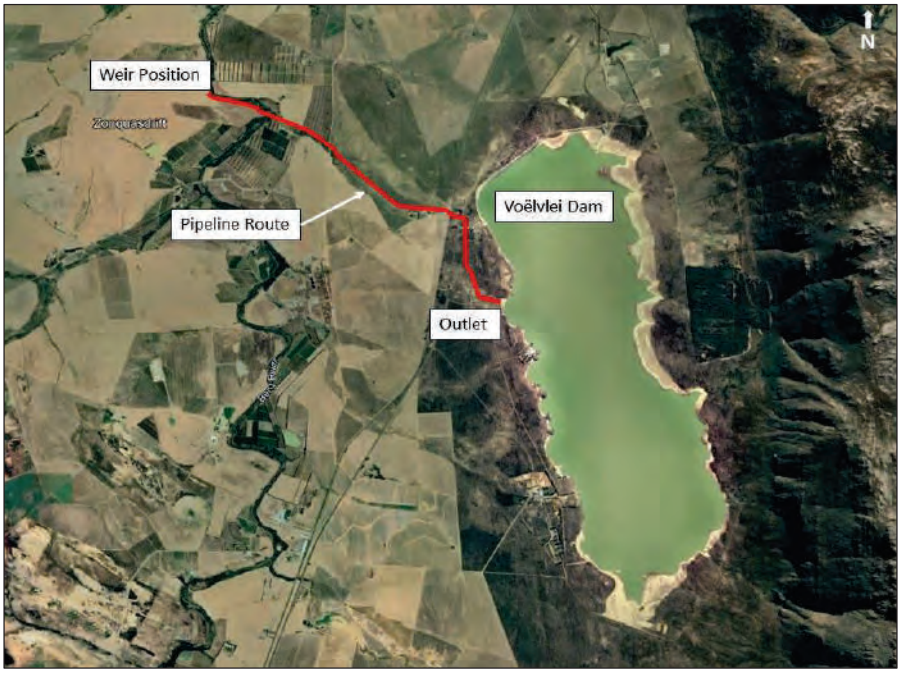


Figure 1:Locality Map

2.2 Topography

Most of the land through which the pipeline will traverse includes greenfield sites mainly comprising farming lands. The pipeline is underlain by slightly undulating slopes dipping towards the north west with the highest point at the outlet at 81 m above sea level and the lowest point at the weir position approximately 55 m above sea level.

The proposed pipeline will have a few crosses including one under a major road namely the R44. The pipeline also crosses a district road (DR01145) and as well as a railway line. The pipeline alignment crosses the Berg River which spans over 100 m at this location. The pipeline runs parallel to the existing canal for approximately 1.5 m. The locality of the pipeline is shown in both 3318BD and 3319AC 1:50 000 Topographic map in Figure 2 below.

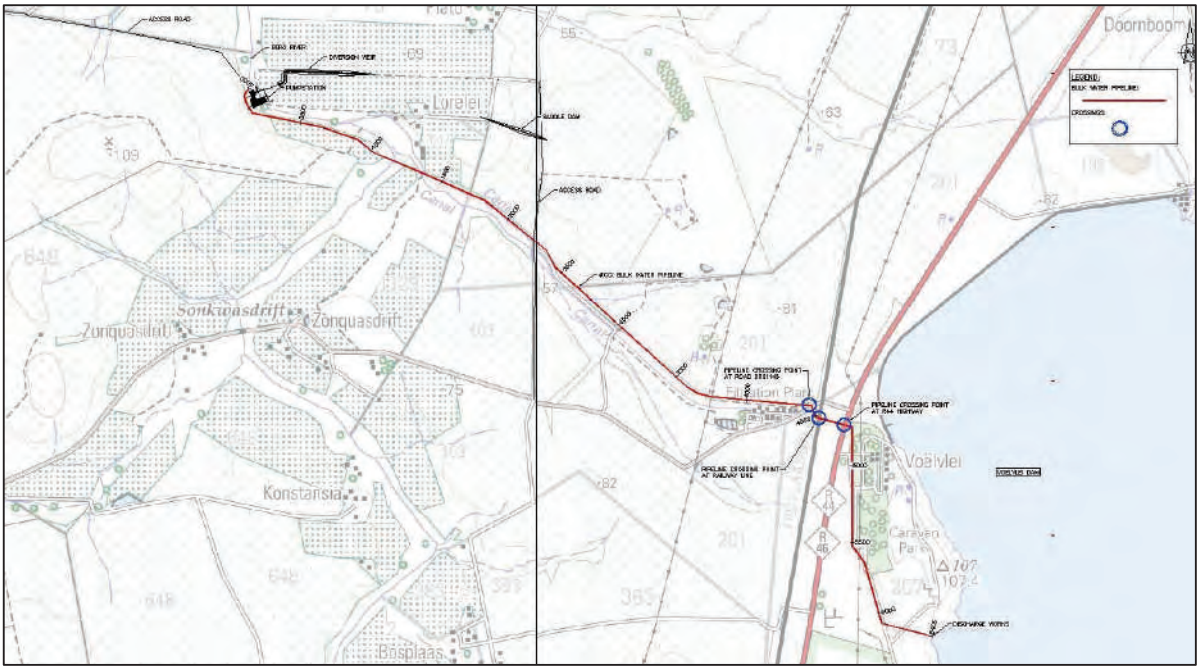


Figure 2: 1:50 000 Topographic Maps 3318BD & 3319AC

2.3 Climate Weathering

Weinert developed an N-value which is the ratio of the annual evaporation versus annual precipitation of a region and has been defined for Southern Africa region (Weinert, 1980). Climatic regime of the present and recent past plays an important role in the soil profile below the earth's surface (Brink, Vol 1, 1979). The N-values are therefore used to characterize the mode of weathering of the rocks within the subcontinent.

Weinert demonstrated that chemical decomposition is the predominant mode of rock weathering in areas where the climatic "N-value" is less than 5. In areas where the climatic N-value is between 5 and 10, disintegration is the predominant form of weathering, although some chemical decomposition of the primary rock minerals still takes place. Where the climatic N-value is greater than 10, secondary minerals do not develop to an appreciable extent and all weathering takes place by mechanical disintegration of the rock.

The Weinert's N value for this site is <5 which indicates that chemical decomposition will be the predominant form of weathering, with the residual soil(s) probably being deeply developed (Brink, Vol 1,1979). Figure 3 shows the N-Value map with the proposed site indicated in red.

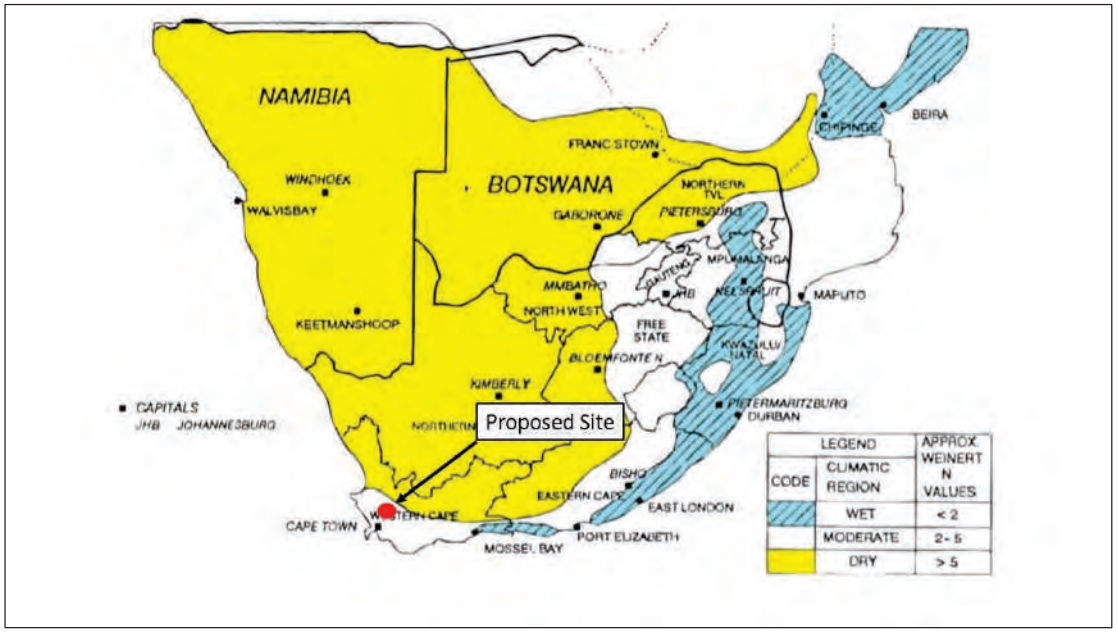


Figure 3: Weinert N-Value Map (Weinert,1980)

2.4 Seismicity

Seismic hazard can be the physical effects of an earthquake or earth tremor. Examples of such phenomenon include surface faulting, ground shaking and ground liquefaction (Kijko et al, 2004). The peak ground acceleration (PGA) is the maximum acceleration of the ground shaking during an earthquake. The seismic hazard map of South Africa indicates that the proposed site lies within an area where there is a 10% probability that Peak Ground Acceleration (PGA), ranging from 0.12 g to 0.18 g, will be exceeded in 50 years which indicates a medium risk. The proposed study area is shown in white in Figure 4 below.

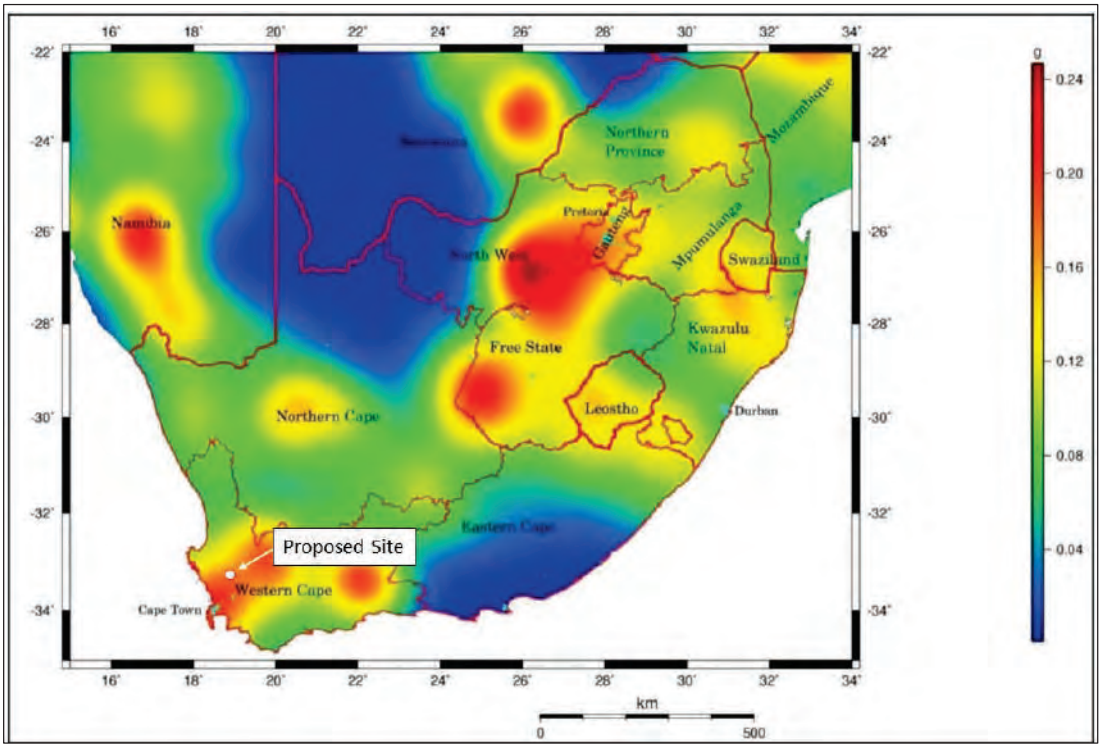


Figure 4: Seismic Hazard Map of South Africa 10% in 50 Years Nominal Peak Ground Acceleration (PGA), Expressed in Earth Gravity acceleration (g) (9, 81 m/s^2) (SANS 10160-4)

3 GEOLOGY

3.1 Regional Geology

The regional geology for the proposed study area is shown on an extract of the 1:250 000 geological maps 3318 Cape Town and 3319 Worcester as indicated below in Figure 5. The proposed study area is underlain by Malmesbury Group which includes both Porterville and Noree Formations. Malmesbury Group underlies the recent quaternary deposits which includes alluvium and soils of the Springfontyn Formation comprising light grey pale red sandy soils. Dolerite dykes of the Cambrian era have intruded the site and outcrops occur towards the south east near the outlet of the pipeline.

3.1.1 Malmesbury Group

Malmesbury Group is further divided into the Swartland and Boland Subgroups with the later outcropping on site. The Porterville and Noree Formations indicated as (Npo) and (Nn) respectively on the geological maps, outcrop on site. The Porterville Formation comprising phyllite shale, schist, and greywacke with dark grey limestone outcrops mainly along the central section of the pipeline. The southern section of the pipeline is underlain by the Noree Formation comprising phyllite, medium grained to gritty greywacke, felspathic and sericitic quartzite, limestone, dolomite, and gritstone rocks.

3.1.2 Quaternary

Quaternary deposits include recent alluvium deposits and include the Springfontyn formation indicated as Qs on the geological map. These deposits are shown in pale yellow on the geological

map and cover the majority of the northern section of the pipeline with small outcrops in the central section.

3.1.3 Dolerite Dyke

Dolerite from the Cambrian era indicated as (£d) on the Worcester geological map, has intruded the Malmesbury Group and occurs as dykes. The southernmost section of the pipeline is underlain by dolerite trending in a north-east south-west direction.

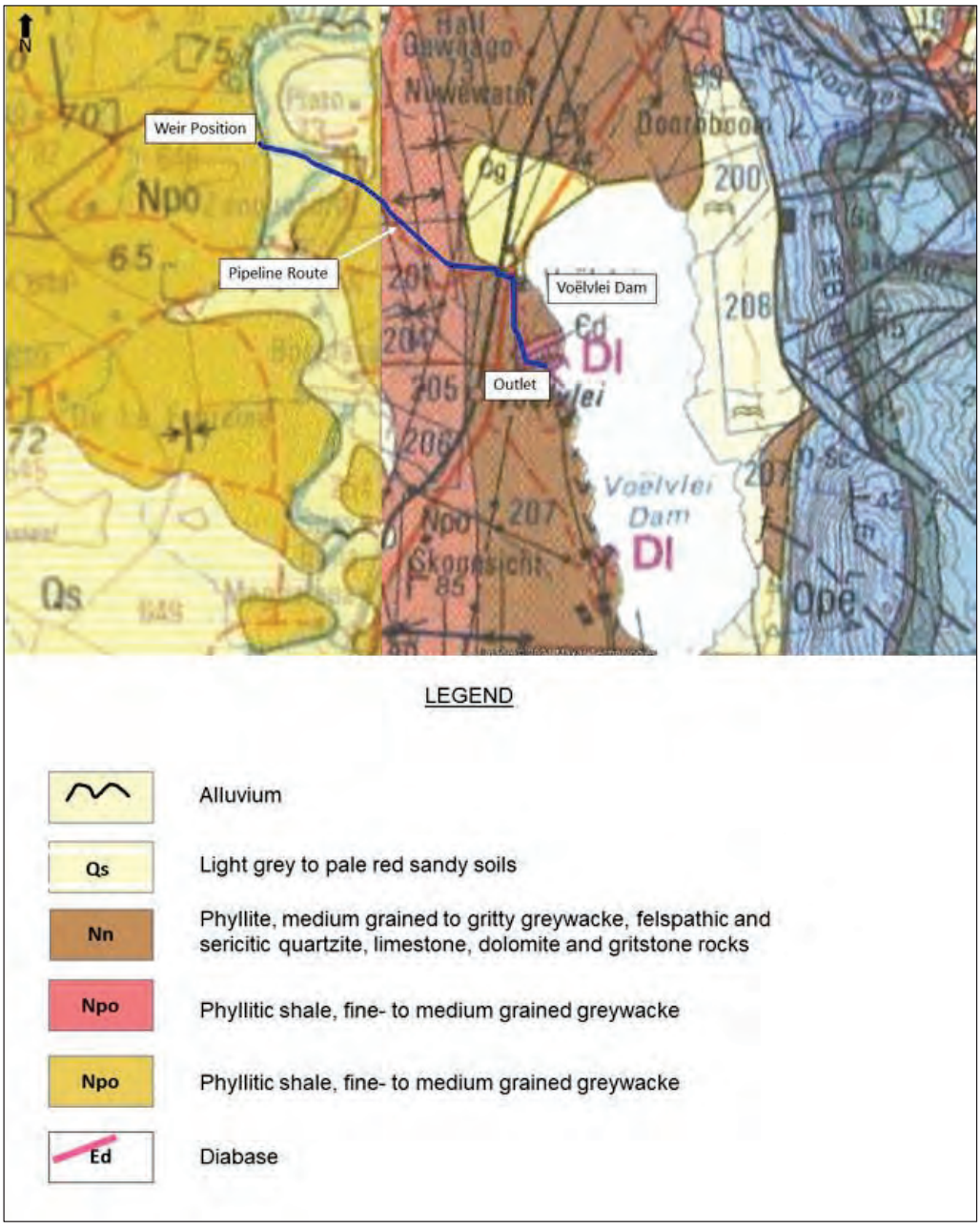


Figure 5: Geological Maps 3318 Cape Town and 3319 Worcester

4 GEOTECHNICAL INVESTIGATION

The sections to follow present a summary of the various components to the fieldwork and laboratory testing program carried out as part of the additional geotechnical investigation for the BRVAS Project. About 98% of the field investigation was carried out in the September/October 2021 period. The remainder of the work was completed in December 2021, after which the lab testing was done.

4.1 Test pits

The test pits were excavated using a Tractor Loader Backhoe (TLB) as well as a 30-ton excavator. The test pits were excavated to either the limit of reach (i.e.: 3 m or 6 m) or TLB/excavator refusal. The soil profiles of the test pits were logged according to current guidelines (Brink & Bruin, 2002). The test pits were positioned using a hand-held GPS and representative soil samples were taken for laboratory testing. The location of the test pits is presented in the drawings included in Annexure A. The test pit soil profiles are presented in Annexure B and testpit photographs are presented as Annexure C to this report.

4.1.1 Weir Abstraction

A total of four (4) test pits were planned to be excavated at the weir location. Three (3) on the right bank and one (1) on the wing wall along the right bank. Testpits TPD 01 and TPD 03 were excavated with a TLB and when rock was not encountered in these testpits an excavator was used and TPDE 01, TPDE 02, TPDE 03 and TPDE 04A were excavated to 6 m. No rock was encountered in any of the test pits excavated within the weir location. Table 1 below indicates the test pits excavated at the weir location showing the end depth of the test pits and Figure 6 shows the location of the testpits. The reason for stopping the hole short is given in the comment's column.

Table 1:Weir Testpit Summary

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
TPD 01	-	2.80	Collapse	-33.327901	18.980548
TPD E01	-	5.10	Collapse	-33.327901	18.980548
TPD E02	-	4.50	Collapse	-33.327793	18.980958
TPD 03	-	2.20	Collapse	-33.328469	18.981370
TPD E03	-	4.52	Collapse	-33.328469	18.981370
TPD E04A	-	6.00	Maxim Depth Reached	-33.327596	18.981487

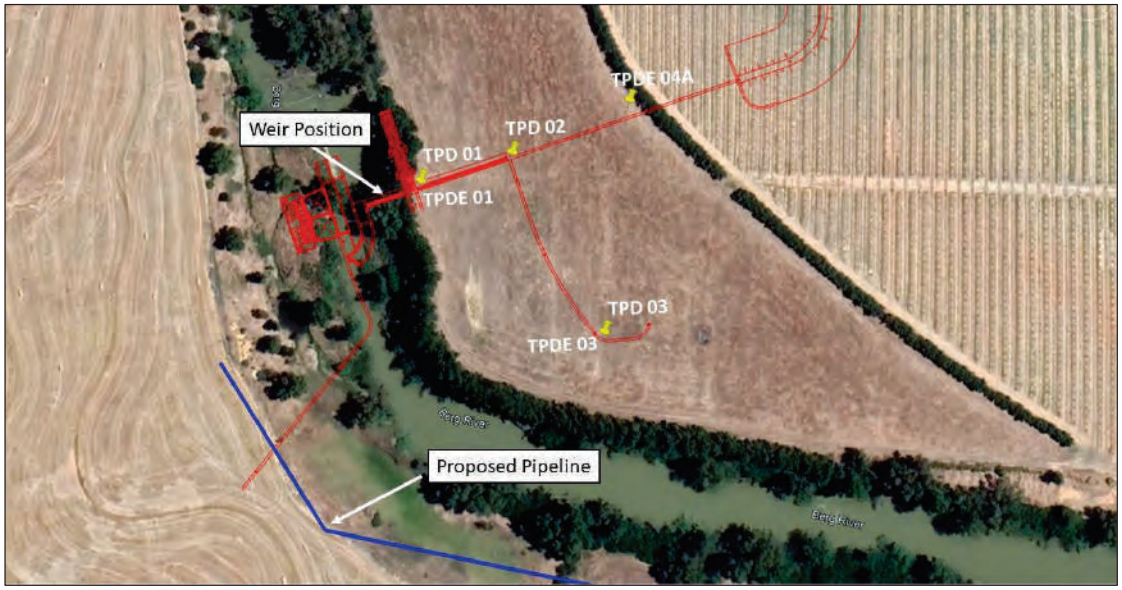


Figure 6: Weir Testpit Positions

4.1.2 Earth Embankment Dam

A total of eight (8) test pits (PT D04 to TP D12) were excavated along the proposed earth embankment with a TLB. When the excavator was available on site it was deemed necessary to excavate two (2) more testpits (TPDE 04 B and TPDE 05A) with an excavator as some of the tespits did not refuse with a TLB. Table 2 below indicates the test pits excavated at the proposed embankment wall showing the depth to bedrock and test pit end depth. Figure 7 shows the location of the testpits along the proposed embankment.

Table 2:Earth Embankment Dam Testpits

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
TPD04	-	2.50	Terminated due to space. Excavated in orchard	-33.32749609	18.98197836
TPDE 04 A	-	6.00	No refusal with excavator	-33.32759600	18.98148702
TPDE 04 B	-	6.00	No refusal with excavator	-33.32752199	18.98189597
TPD05	-	1.70	Slow advance in stiff clay	-33.32669696	18.98200996
TPDE 05A	-	5.30	Slow advance	-33.32672202	18.98207702
TPD06	-	2.30	Slow advance in stiff clay	-33.32673904	18.98304496
TPD07	-	2.10	Slow advance in stiff clay	-33.32675597	18.98410896
TPD08	-	2.70	Slow advance in stiff clay	-33.32680601	18.98516499
TPD09	-	3.00	No refusal	-33.32682202	18.98624400
TPD10	*1.30	2.70	Refusal on shale bedrock	-33.32686099	18.98738704
TPD11	*0.20	1.40	Refusal on shale bedrock	-33.32691698	18.98826797
TPD12	*1.50	3.00	No refusal	-33.32694104	18.98966901

*depth to soft/very soft rock

Figure 7: Embankment Testpit Positions

4.1.3 Saddle Dam

A total of three (3) test pits (PTE 01 to TPE 03) were excavated at the proposed saddle dam location. Table 3 below indicates the test pits excavated showing the depth to bedrock and testpit end depth. Figure 8 shows the location of the testpits.

Table 3: Saddle Dam Testpits

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
TPE 01	*2.20	2.50	Refusal on shale bedrock	-33.329557	18.996647
TPE 02	-	1.70	Slow advance in stiff clay	-33.330160	18.998686
TPE 03	*0.40	2.20	Refusal on shale bedrock	-33.330595	19.000223

*depth to soft/very soft rock

Figure 8: Saddle Dam Testpit Positions

4.1.4 Pipeline

The proposed pipeline is approximately 6 km long and testpits were excavated at 200 m intervals along the alignment. From the pump station, approximately 1 km of the pipeline traverses along the left bank of the river. After crossing the river, the pipeline alignment runs along the right flank of the current canal. Two of the tespits were close to crossings and it was not deemed necessary to excavate them as the information from the crossing was considered to be sufficient for the pipeline route. A total of 31 testpits were excavated along the proposed pipeline route. Table 4 below shows the testpit coordinates and Figure 9 shows the testpit locations.

Table 4: Pipeline Testpits

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
TPP 01	*1.4	1.80	Slow advance on shale bedrock	-33.32820327	18.97962296
TPP 02		3.50	No refusal	-33.32929669	18.98095183
TPP 03		3.60	No refusal	-33.32965057	18.98303138
TPP 04		3.50	No refusal	-33.33006925	18.98512736
TPP 05		3.70	No refusal	-33.33061181	18.98717640
TPP 06		3.70	No refusal	-33.33161915	18.98896200
TPP 07	not excavated too close to a crossing				
TPP 08	-	3.00	No refusal	-33.33304105	18.99288783
TPP 09	*1.80	2.10	Slow advance on shale bedrock	-33.33378352	18.99485112
TPP 10	*0.90	1.70	Refusal on shale bedrock	-33.33456798	18.99679547
TPP 11	*1.10	1.50	Refusal on shale bedrock	-33.33568932	18.99846925
TPP 12	*1.00	3.00	No refusal	-33.33679589	19.00017455
TPP 13	*0.90	2.40	Refusal on shale bedrock	-33.33825116	19.00140820
TPP 14	*0.90	2.20	Refusal on shale bedrock	-33.33946486	19.00300696
TPP 15	*1.10	1.80	Refusal on shale bedrock	-33.34069985	19.00457530
TPP 16	*1.00	2.20	Refusal on shale bedrock	-33.34190483	19.00616988
TPP 17	*0.90	2.20	Refusal on shale bedrock	-33.34312046	19.00777241
TPP 18	*1.00	3.00	No refusal	-33.34432972	19.00936590
TPP 19	*1.60	3.10	No refusal	-33.34547678	19.01103037
TPP 20	*1.60	3.10	No refusal	-33.34585145	19.01310070
TPP 21	*1.30	3.10	No refusal	-33.34601331	19.01524245
TPP 22	*1.40	2.60	Refusal on shale bedrock	-33.34617357	19.01738629
TPP 23	-	2.90	No refusal	-33.34654313	19.01927557
TPP 24	not excavated too close to a crossing				
TPP 25	-	2.90	No refusal	-33.34869065	19.02202215
TPP 26	*1.30	3.10	No refusal	-33.35045219	19.02200363
TPP 27	-	3.10	No refusal	-33.35229345	19.02202232
TPP 28	*1.60	3.20	No refusal	-33.35408424	19.02203011
TPP 29	-	3.00	No refusal	-33.35562609	19.02293100
TPP 30	-	3.00	No refusal	-33.35736592	19.02349385
TPP 31	-	2.90	No refusal	-33.35904440	19.02409005
TPP 32	-	3.00	No refusal	-33.35949627	19.02616591
TPP 33	*1.00	2.00	Slow advance on schist bedrock	-33.35980522	19.02755714

*depth to soft/very soft rock

Figure 9: Pipeline Testpit Positions

4.1.5 Crossings

The proposed pipeline will have four (4) major crossings which will include district and provincial roads, a railway line, and a river crossing. One (1) testpit was excavated on each side of the crossing using a 30-ton excavator to the limit of reach of the machine (6 m) or refusal. Table 5 below shows the testpits coordinates and Figure 10 shows the testpit locations.

Table 5: Crossings Testpits

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
TPC01	-	4.90	Terminated due to space	-33.331917	18.989278
TPC04	-	5.00	Terminated due to collapse	-33.332064	18.990487
TPC05	*4.80	5.40	Slow advance on shale bedrock	-33.347487	19.021548
TPC07	-	6.00	No refusal	-33.346298	19.018870
TPC09	*5.00	5.30	Refusal on shale bedrock	-33.346997	19.019460
TPC11	*5.30	5.60	Slow advance on shale bedrock	-33.347104	19.019891
TPC13	*2.60	6.00	No refusal	-33.347319	19.021187
TPC15	*4.10	5.50	Refusal on shale bedrock	-33.347487	19.021548

*depth to soft/very soft rock

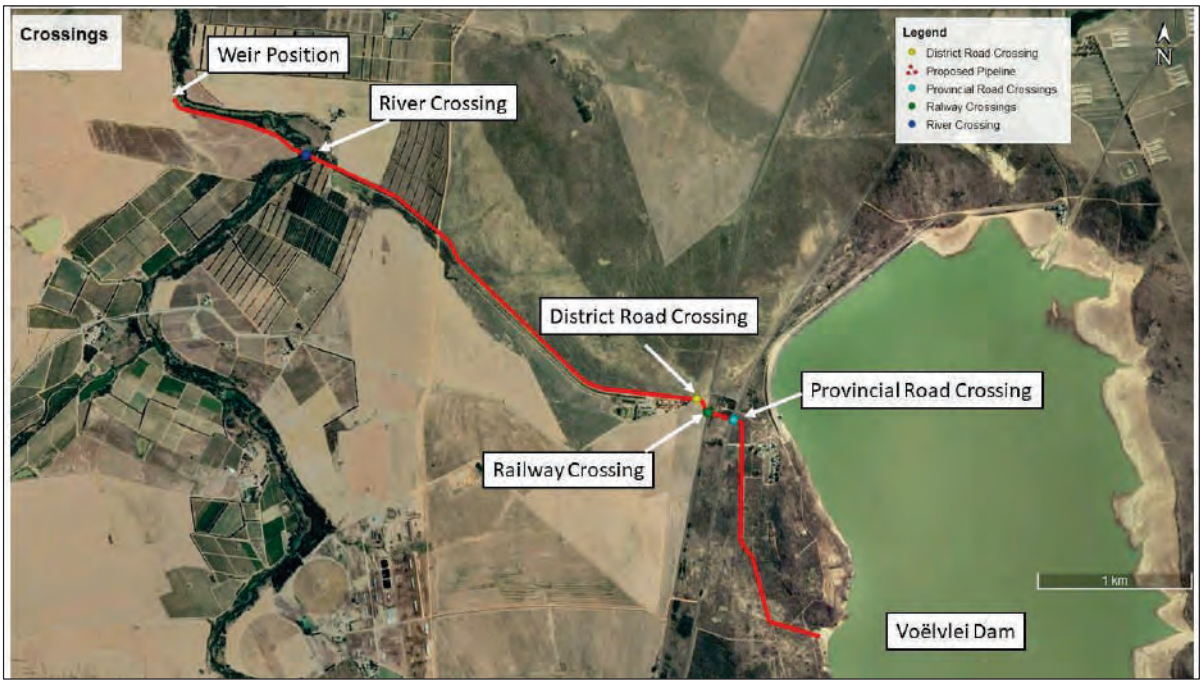


Figure 10: Pipeline Crossing Locations

4.1.6 Access Roads

A few roads have been selected as proposed access roads for the project, including farm roads and public roads (refer to Figure 11 below). Along the public roads, testpits were excavated at 500 m intervals for sampling of the gravel wearing course for foundation indicator testing. The public roads are indicated in blue on Figure 11. Trial pits to 1.5 m depth at 100 m intervals for sampling of in-situ material were carried out along the farm roads leading to the weir and earth embankment location. Table 6 below shows the tespits coordinates

Table 6: Roads Testpits

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
Farm Access Road Left Bank					
TPR01	*0.70	1.70	Maximum investigation depth reached	-33.32353799	18.96472698
TPR02	*0.50	1.50	Maximum investigation depth reached	-33.32368702	18.96590296
TPR03	*0.60	1.60	Maximum investigation depth reached	-33.32383504	18.96698196
TPR04	*1.10	1.50	Maximum investigation depth reached	-33.32398198	18.96806801
TPR05	-	1.50	Maximum investigation depth reached	-33.32412899	18.96913704
TPR06	-	1.50	Maximum investigation depth reached	-33.32430703	18.97036800
TPR07	*1	1.60	Maximum investigation depth reached	-33.32445304	18.97138196
TPR08	*0.70	1.50	Maximum investigation depth reached	-33.32459302	18.97247404
TPR09	*0.80	1.50	Maximum investigation depth reached	-33.32474800	18.97354499
TPR10	*0.90	1.70	Maximum investigation depth reached	-33.32488102	18.97459298
TPR11	*0.80	1.50	Maximum investigation depth reached	-33.32504396	18.97571096
TPR12	*0.70	1.50	Maximum investigation depth reached	-33.32517900	18.97680203
TPR13	*0.60	1.50	Maximum investigation depth reached	-33.32534001	18.97785002

*depth to soft/very soft rock

Table 7: Roads Testpits Continues

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
Farm Access Road Right Bank					
TPRE01	*0.80	1.50	Maximum investigation depth reached	-33.32697700	18.99071599
TPRE02	-	1.50	Maximum investigation depth reached	-33.32699896	18.99180003
TPRE03	*0.80	1.50	Maximum investigation depth reached	-33.32703802	18.99283896
TPRE04	-	1.60	Maximum investigation depth reached	-33.32708001	18.99398301
TPRE05	*0.60	1.50	Maximum investigation depth reached	-33.32714899	18.99504500
TPRE06	*0.60	1.50	Maximum investigation depth reached	-33.32715796	18.99579501
TPRE07	*0.20	1.50	Maximum investigation depth reached	-33.32715604	18.99623397
TPRE08	*0.70	0.90	Refusal on sandstone bedrock	-33.32721404	18.99726201
TPRE09	*0.30	1.50	Maximum investigation depth reached	-33.32725201	18.99834604
TPRE10	-	1.50	Maximum investigation depth reached	-33.32729098	18.99942001
TPRE11	-	1.50	Maximum investigation depth reached	-33.32732367	19.00022342
TPRE12	*0.20	1.20	Refusal on shale bedrock	-33.33184286	19.00036373
TPRE13	-	1.50	Maximum investigation depth reached	-33.33629357	18.99981254
TPRE14	*0.40	1.30	Refusal on shale bedrock	-33.34081409	18.99984548
TPRE15	*0.70	1.50	Maximum investigation depth reached	-33.34549866	18.99984774

*depth to soft/very soft rock

Table 8: Roads Testpits Continues

Test Pit ID	Bedrock Depth (m)	Final Depth (m)	Comments	Coordinates	
				Latitude	Longitude
Public Access Roads					
TPRA1	*0.40	1.00	Refusal on shale bedrock	-33.36052800	18.94400298
TPRA02	*1.00	1.20	Refusal on shale bedrock	-33.35625800	18.94232500
TPRA03	*0.20	1.30	Refusal on shale bedrock	-33.35159699	18.94347802
TPRA04	*0.10	0.50	Refusal on shale bedrock	-33.34715400	18.94241503
TPRA05	*0.30	1.50	Maximum investigation depth reached	-33.34286498	18.94070101
TPRA06	-	1.60	Maximum investigation depth reached	-33.34013700	18.93636798
TPRA07	-	1.70	Maximum investigation depth reached	-33.33580004	18.93496100
TPRA08	*0.60	1.00	Refusal on shale bedrock	-33.33158302	18.93692496
TPRA09	*0.50	1.30	Refusal on shale bedrock	-33.32743197	18.93966802
TPRA10	*0.50	1.20	Refusal on shale bedrock	-33.32442898	18.94365999
TPRA11	*0.00	0.60	Refusal on shale bedrock	-33.32390302	18.94931501
TPRA12	*0.20	1.00	Refusal on shale bedrock	-33.32580898	18.95418498
TPRA13	*0.60	1.20	Refusal on shale bedrock	-33.32442697	18.95937799
TPRA14	*0.70	1.70	Maximum investigation depth reached	-33.32341900	18.963944°
TPRA15	*1.00	1.30	Refusal on shale bedrock	-33.32707699	18.93931598
TPRA16	*0.10	0.50	Refusal on shale bedrock	-33.32702603	18.93389197
TPRA17	*0.20	1.30	Refusal on shale bedrock	-33.32708001	18.92849696
TPRA18	*1.30	1.70	Maximum investigation depth reached	-33.32679897	18.92310496
TPRA19	*0.70	0.90	Refusal on mudstone bedrock	-33.32591602	18.91778204
TPRA20	-	1.70	Maximum investigation depth reached	-33.32662504	18.91243497
TPRA21	*1.00	1.50	Maximum investigation depth reached	-33.32618197	18.90705496
TPRA22	*0.20	1.60	Maximum investigation depth reached	-33.32512803	18.90183597
TPRA23	*0.30	1.00	Refusal on shale bedrock	-33.32237802	18.89765298

*depth to soft/very soft rock

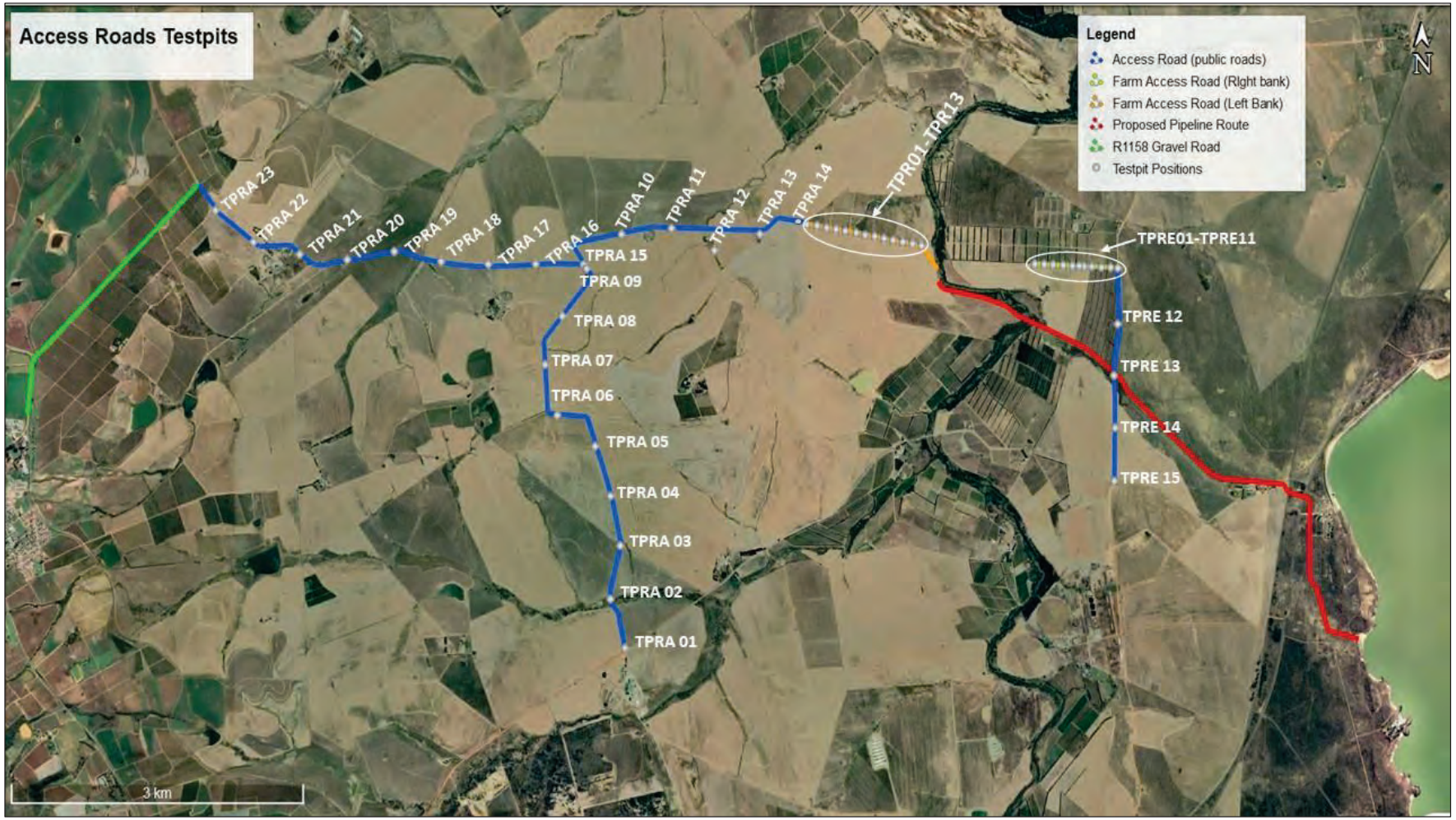


Figure 11:Access Roads Testpit Locations

4.2 DCP (Dynamic Cone Penetrometer)

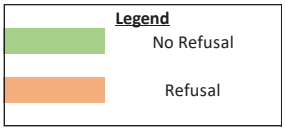
The DCP test is a penetration test for the evaluation of the mechanical strength of the in-situ materials. The California Bearing Ratio (CBR) is derived from DCP test data to assess the strength of the underlying structural layers. DCP testing was carried out along the proposed access roads at 100 m intervals. The test was carried out to 1.0 m or refusal of the machine, DCP tests along gravel road 1158 were carried out at 200 m instead of the 100 m due to the nature of the road being hard and resulting in the DCP breaking. The DCP test results are included in Annexure D of this report and are summarised in Table 9 and Table 10. Refer to the drawings in Annexure A for the location of the DCPs along the access roads.

Table 9: DCP Tests

DCP ID	Final Depth (mm)	Final Depth (m)	Refused	Coordinates		DCP ID	Final Depth (mm)	Final Depth (m)	Refused	Coordinates	
				Latitude	Longitude					Latitude	Longitude
DCP 1	1000.00	1.00	NO	-33.32708999	18.99400103	DCP 31	146.00	0.15	Yes	-33.35709100	18.94286597
DCP 2	1000.00	1.00	No	-33.32712896	18.99512001	DCP 32	1000.00	1.00	No	-33.35621299	18.94232400
DCP 3	710.00	0.71	Yes	-33.32717200	18.99625200	DCP 33	985.00	0.99	Yes	-33.35532300	18.94234101
DCP 4	195.00	0.20	Yes	-33.32720800	18.99729897	DCP 34	330.00	0.33	Yes	-33.35444801	18.94261703
DCP 5	1000.00	1.00	No	-33.32724798	18.99836901	DCP 35	610.00	0.61	Yes	-33.35356800	18.94287502
DCP 6	130.00	0.13	Yes	-33.32728200	18.99946100	DCP 36	552.00	0.55	Yes	-33.35272696	18.94316202
DCP 7	1000.00	1.00	No	-33.32766700	19.00021303	DCP 37	353.00	0.35	Yes	-33.35186698	18.94341599
DCP 8	45.00	0.05	Yes	-33.32943097	19.00026198	DCP 38	545.00	0.55	Yes	-33.35095402	18.94340702
DCP 9	1000.00	1.00	No	-33.33030101	19.00027597	DCP 39	648.00	0.65	Yes	-33.35009596	18.94319597
DCP 10	930.00	0.93	Yes	-33.33117901	19.00030598	DCP 40	527.00	0.53	Yes	-33.34923699	18.94297502
DCP 11	760.00	0.76	Yes	-33.33215400	19.00032702	DCP 41	222.00	0.22	Yes	-33.34837600	18.94277302
DCP 12	80.00	0.08	Yes	-33.33303099	19.00024404	DCP 42	607.00	0.61	Yes	-33.34744502	18.94251703
DCP 13	620.00	0.62	Yes	-33.33392903	19.00007799	DCP 43	147.00	0.15	Yes	-33.34654204	18.94217002
DCP 14	1000.00	1.00	No	-33.33479899	18.99997900	DCP 44	355.00	0.36	Yes	-33.34571097	18.94182402
DCP 15	1000.00	1.00	No	-33.33568697	18.99984799	DCP 45	1000.00	1.00	No	-33.34486096	18.94148597
DCP 16	1000.00	1.00	No	-33.33655500	18.99981304	DCP 46	650.00	0.65	Yes	-33.34403903	18.94114399
DCP 17	1000.00	1.00	No	-33.33744599	18.99982100	DCP 47	679.00	0.68	Yes	-33.34320604	18.94082699
DCP 18	1000.00	1.00	No	-33.33831503	18.99985503	DCP 48	182.00	0.18	Yes	-33.34237698	18.94050403
DCP 19	1000.00	1.00	No	-33.33916403	18.99981698	DCP 49	512.00	0.51	Yes	-33.34154801	18.94017303
DCP 20	1000.00	1.00	No	-33.34002301	18.99979896	DCP 50	732.00	0.73	Yes	-33.34069901	18.93984698
DCP 21	1000.00	1.00	No	-33.34097402	18.99981304	DCP 51	72.00	0.07	Yes	-33.34030397	18.93885900
DCP 22	430.00	0.43	Yes	-33.34184499	18.99980600	DCP 52	75.00	0.08	Yes	-33.34023298	18.93782099
DCP 23	915.00	0.92	Yes	-33.34269801	18.99981103	DCP 53	1000.00	1.00	No	-33.34014304	18.93671298
DCP 24	470.00	0.47	Yes	-33.34353503	18.99980097	DCP 54	1000.00	1.00	No	-33.34005998	18.93560900
DCP 25	665.00	0.67	Yes	-33.34443902	18.99980097	DCP 55	880.00	0.88	Yes	-33.33922296	18.93521598
DCP 26	1000.00	1.00	No	-33.34534401	18.99982000	DCP 56	1000.00	1.00	No	-33.33832802	18.93515202
DCP 27	1000.00	1.00	No	-33.36049698	18.94399200	DCP 57	1000.00	1.00	No	-33.33743200	18.93508698
DCP 28	65.00	0.07	Yes	-33.35964002	18.94375303	DCP 58	1000.00	1.00	No	-33.33651703	18.93501900
DCP 29	210.00	0.21	Yes	-33.35878900	18.94353996	DCP 59	1000.00	1.00	No	-33.33560902	18.93496603
DCP 30	745.00	0.75	Yes	-33.35794603	18.94329596	DCP 60	410.00	0.41	Yes	-33.33470704	18.93490199

Table 10: DCP Tests Continue

DCP ID	Final Depth (mm)	Final Depth (m)	Refused	Coordinates		DCP ID	Final Depth (mm)	Final Depth (m)	Refused	Coordinates	
				Latitude	Longitude					Latitude	Longitude
DCP 61	142.00	0.14	Yes	-33.33381898	18.93489604	DCP 91	525.00	0.53	Yes	-33.32672403	18.95599597
DCP 62	1000.00	1.00	No	-33.33307198	18.93553700	DCP 92	535.00	0.54	Yes	-33.32615800	18.95683198
DCP 63	565.00	0.57	Yes	-33.33235399	18.93623698	DCP 93	110.00	0.11	Yes	-33.32560102	18.95768300
DCP 64	920.00	0.92	Yes	-33.33154798	18.93697198	DCP 94	62.00	0.06	Yes	-33.32503902	18.95849302
DCP 65	1000.00	1.00	No	-33.33085396	18.93767104	DCP 95	117.00	0.12	Yes	-33.32438397	18.95941302
DCP 66	1000.00	1.00	No	-33.33018299	18.93833899	DCP 96	170.00	0.17	Yes	-33.32381803	18.96025398
DCP 67	1000.00	1.00	No	-33.32948201	18.93900602	DCP 97	370.00	0.37	Yes	-33.32319701	18.96106702
DCP 68	517.00	0.52	Yes	-33.32878397	18.93967104	DCP 98	392.00	0.39	Yes	-33.32312903	18.96216304
DCP 69	353.00	0.35	Yes	-33.32793203	18.94005602	DCP 99	970.00	0.97	Yes	-33.32327002	18.96321497
DCP 70	211.00	0.21	Yes	-33.32714103	18.93951204	DCP 100	1000.00	1.00	No	-33.32350496	18.96476503
DCP 71	535.00	0.54	Yes	-33.32643301	18.93886797	DCP 101	1000.00	1.00	No	-33.32367796	18.96591101
DCP 72	875.00	0.88	Yes	-33.32566498	18.93829297	DCP 102	1000.00	1.00	No	-33.32381803	18.96703703
DCP 73	312.00	0.31	Yes	-33.32509300	18.93916201	DCP 103	1000.00	1.00	No	-33.32397502	18.96811201
DCP 74	948.00	0.95	Yes	-33.32492201	18.94024998	DCP 104	1000.00	1.00	No	-33.32411399	18.96915397
DCP 75	363.00	0.36	Yes	-33.32475403	18.94130099	DCP 105	1000.00	1.00	No	-33.32430803	18.97046800
DCP 76	1000.00	1.00	No	-33.32458497	18.94239700	DCP 106	1000.00	1.00	No	-33.32443904	18.97143099
DCP 77	136.00	0.14	Yes	-33.32442303	18.94348204	DCP 107	912.00	0.91	Yes	-33.32459796	18.97253799
DCP 78	935.00	0.94	Yes	-33.32427501	18.94457404	DCP 108	1000.00	1.00	No	-33.32473400	18.97361004
DCP 79	858.00	0.86	Yes	-33.32409899	18.94563401	DCP 109	1000.00	1.00	No	-33.32487297	18.97469298
DCP 80	877.00	0.88	Yes	-33.32388701	18.94672098	DCP 110	852.00	0.85	Yes	-33.32504497	18.97579000
DCP 81	555.00	0.56	Yes	-33.32386103	18.94778104	DCP 111	1000.00	1.00	No	-33.32518302	18.97686096
DCP 82	507.00	0.51	Yes	-33.32388198	18.94884998	DCP 112	1000.00	1.00	No	-33.32535200	18.97789604
DCP 83	565.00	0.57	Yes	-33.32389497	18.94991197	DCP 113	100.00	0.10	Yes	-33.32708001	18.93875004
DCP 84	250.00	0.25	Yes	-33.32393797	18.95099801	DCP 114	625.00	0.63	Yes	-33.32699996	18.93767498
DCP 85	125.00	0.13	Yes	-33.32411500	18.95204499	DCP 115	240.00	0.24	Yes	-33.32695504	18.93656001
DCP 86	137.00	0.14	Yes	-33.32481002	18.95267397	DCP 116	365.00	0.37	Yes	-33.32697398	18.93549199
DCP 87	130.00	0.13	Yes	-33.32523197	18.95362004	DCP 117	130.00	0.13	Yes	-33.32700298	18.93445004
DCP 88	142.00	0.14	Yes	-33.32591400	18.95431800	DCP 118	1000.00	1.00	No	-33.32702997	18.93338696
DCP 89	490.00	0.49	Yes	-33.32943097	19.00026198	DCP 119	1000.00	1.00	No	-33.32705797	18.93236001
DCP 90	135.00	0.14	Yes	-33.32665597	18.95494304	DCP 120	275.00	0.28	Yes	-33.32708403	18.93129299
DCP 121	624.00	0.62	Yes	-33.32704296	18.93012397	DCP 151	61.00	0.06	Yes	-33.33093300	18.88264501
DCP 122	1000.00	1.00	No	-33.32705503	18.92903399	DCP 152	120.00	0.12	Yes	-33.32964596	18.88419399
DCP 123	695.00	0.70	Yes	-33.32708102	18.92798600	DCP 153	102.00	0.10	Yes	-33.32836898	18.88574699
DCP 124	82.00	0.08	Yes	-33.32710298	18.92691496	DCP 154	100.00	0.10	Yes	-33.32708001	18.88728398
DCP 125	553.00	0.55	Yes	-33.32705696	18.92590201	DCP 155	370.00	0.37	Yes	-33.32579196	18.88881904
DCP 126	62.00	0.06	Yes	-33.32695504	18.92486902	DCP 156	230.00	0.23	Yes	-33.32450702	18.89034899
DCP 127	150.00	0.15	Yes	-33.32684699	18.92379697	DCP 157	1000.00	1.00	No	-33.32320799	18.89191498
DCP 128	560.00	0.56	Yes	-33.32675203	18.92274697	DCP 158	230.00	0.23	Yes	-33.32197401	18.89347997
DCP 129	188.00	0.19	Yes	-33.32663803	18.92167401	DCP 159	137.00	0.14	Yes	-33.32073902	18.89499701
DCP 130	50.00	0.05	Yes	-33.32643100	18.92063800	DCP 160	168.00	0.17	Yes	-33.32546398	18.90477299
DCP 131	103.00	0.10	Yes	-33.32617904	18.91962497	DCP 161	62.00	0.06	Yes	-33.32547303	18.90370396
DCP 132	338.00	0.34	Yes	-33.32584896	18.91858100	DCP 162	890.00	0.89	Yes	-33.32552701	18.90259604
DCP 133	592.00	0.59	Yes	-33.32594301	18.91752102	DCP 163	358.00	0.36	Yes	-33.32504103	18.90170798
DCP 134	1000.00	1.00	No	-33.32608298	18.91646700	DCP 164	525.00	0.53	Yes	-33.32447500	18.90085696
DCP 135	108.00	0.11	Yes	-33.32622497	18.91542496	DCP 165	537.00	0.54	Yes	-33.32392297	18.90002497
DCP 136	385.00	0.39	Yes	-33.32636001	18.91438100	DCP 166	378.00	0.38	Yes	-33.32334504	18.89916801
DCP 137	180.00	0.18	Yes	-33.32648498	18.91335798	DCP 167	772.00	0.77	Yes	-33.32280097	18.89832303
DCP 138	372.00	0.37	Yes	-33.32662202	18.91224001	DCP 168	270.00	0.27	Yes	-33.32218104	18.89755198
DCP 139	905.00	0.91	Yes	-33.32686502	18.91091499	DCP 169	1000.00	1.00	No	-33.32136900	18.89698100
DCP 140	150.00	0.15	Yes	-33.32705604	18.90949904	DCP 170	259.00	0.26	Yes	-33.32069904	18.89630098
DCP 141	132.00	0.13	Yes	-33.32689997	18.90841300						
DCP 142	118.00	0.12	Yes	-33.32644098	18.90749702						
DCP 143	458.00	0.46	Yes	-33.32590898	18.90667601						
DCP 144	560.00	0.56	Yes	-33.32538201	18.90583296						
DCP 145	1000.00	1.00	No	-33.33982696	18.87655598						
DCP 146	107.00	0.11	Yes	-33.33806399	18.87672203						
DCP 147	305.00	0.31	Yes	-33.33625400	18.87688103						
DCP 148	64.00	0.06	Yes	-33.33469799	18.87793900						
DCP 149	74.00	0.07	Yes	-33.33349301	18.87958202						
DCP 150	123.00	0.12	Yes	-33.33220596	18.88112697						



4.3 Laboratory Testing

Representative samples of the materials encountered in the trial pits were retrieved for laboratory testing. The material was tested to determine the suitability of the materials excavated from the pipeline trench for bedding and selected backfill and the corrosive potential of the materials towards the pipeline and concrete structures. The tests were carried out for foundation purposes also. A list of all the tests carried out is given below.

- Foundation Indicator;
- Mod AASHTO;
- CBR;
- Compactability;
- pH;
- Conductivity;
- Chloride content (SABS 830); and
- Water soluble sulphates (TMH1 B17T/BS1377).

On receiving the initial laboratory results for the above testing, it was noticed that certain of the Unified Soil Classification System results were incorrect according to USCS – ASTM Designation D 2487. These classifications were corrected and the corrected classifications are reflected in the summary table of results included in Annexure E. In addition, some check tests were carried out to ensure that the soil samples were assigned the correct classifications. These check tests are also included in the summary table of results. A corrected set of laboratory results will be included in Annexure E when these are received.

In addition, it was intended that soil fertility testing was to be carried out which would have included the following:

- Plant available nutrients – P, K, Mg, Ca;
- pH (TMH1 A20);
- %C;
- Soil particle size;
- %N – indicative of microbial activity in soils planted to leguminous crops and /or nitrogen from incorporated organic materials rich in N;
- Cation Exchange Capacity (CEC); and
- Electric conductivity (TMH1 A21T).

However, this testing was not carried out as all attempts to communicate with the laboratory that carried out previous fertility testing failed.

It is understood that the embankment dam structure will require a substantial amount of material and that a portion of this may have to be sourced from commercial sources. During the investigation potential commercial sources were identified and material from their stockpile was sampled for testing. The following tests were carried out:

- Grading;
- Maximum dry density;
- Optimum moisture content; and
- California Bearing Ratio (CBR).

4.4 Geophysical Survey

Three methods of surface geophysical survey have been utilised as part of the investigation including electrical resistivity, seismic refraction, and soil corrosivity.

Electrical Resistivity Imaging is a method to measure the electrical resistivity of soils and rocks with increasing depth. Electrical resistivity profiling is particularly useful in providing an indication of the depth of weathering or depth to bedrock, as well as providing information on the presence of features such as faults/shear zones and intrusive dykes. The electrical resistivity was carried out at the proposed weir position, wing walls, along the embankment dam and saddle dam as well as the river crossing. A total of 12 electrical resistivity imaging traverses where surveyed amounting to a length of 3070 m.

Seismic refraction is a method to measure the velocity of compressional waves (P-waves) of soils and rocks with increasing depth. Seismic refraction survey is required to determine the depth of weathering and depth to bedrock. The seismic refraction survey was carried out at the proposed weir position, wing wall, along the embankment dam and saddle dam as well as at the river crossing. Due to the heavy rains that occurred just before the time of the investigation, the river crossing area was inundated and therefore the seismic lines were posing difficulty in-terms of placing the geophones. It was therefore suggested that the survey be carried out on the banks of the river and not across the high flowing river. A total of 14 seismic refraction traverses where surveyed amounting to a length of 4141 m.

Soil Resistivity Surveys/Soil Corrosivity Surveys were carried out along the pipeline route. This included a detailed soil resistivity survey undertaken at nominal intervals of 100 m, using the 4-pin Wenner method. A deep soil resistivity survey at the crossing of the pipeline with the high voltage power line(s) and soil sampling and analysis for chemical and bacterial (i.e., Sulphate Reducing Bacteria) activities at nominal intervals of 1000 m. Soil acts as the electrolyte in the electrochemical corrosion cell formed during the external electrochemical corrosion of a pipeline. Soil resistivity is an electrical characteristic of the soil (and groundwater) which affects the ability of corrosion currents to flow through the electrolyte. Soil resistivity is a function of soil moisture and the concentrations of ionic soluble salts and is the most comprehensive indicator of a soil's corrosivity.

The position of the electrical resistivity and seismic investigation carried out at on site is given below in Figure 12 and Figure 13 respectively. The results of the geophysical surveys are included in the reports presented as Annexure F. The investigation points for the soil corrosivity survey are indicated in Figure 14 below and the results of the survey is included as Annexure G to this report

Figure 12: Electrical Resistivity Imaging

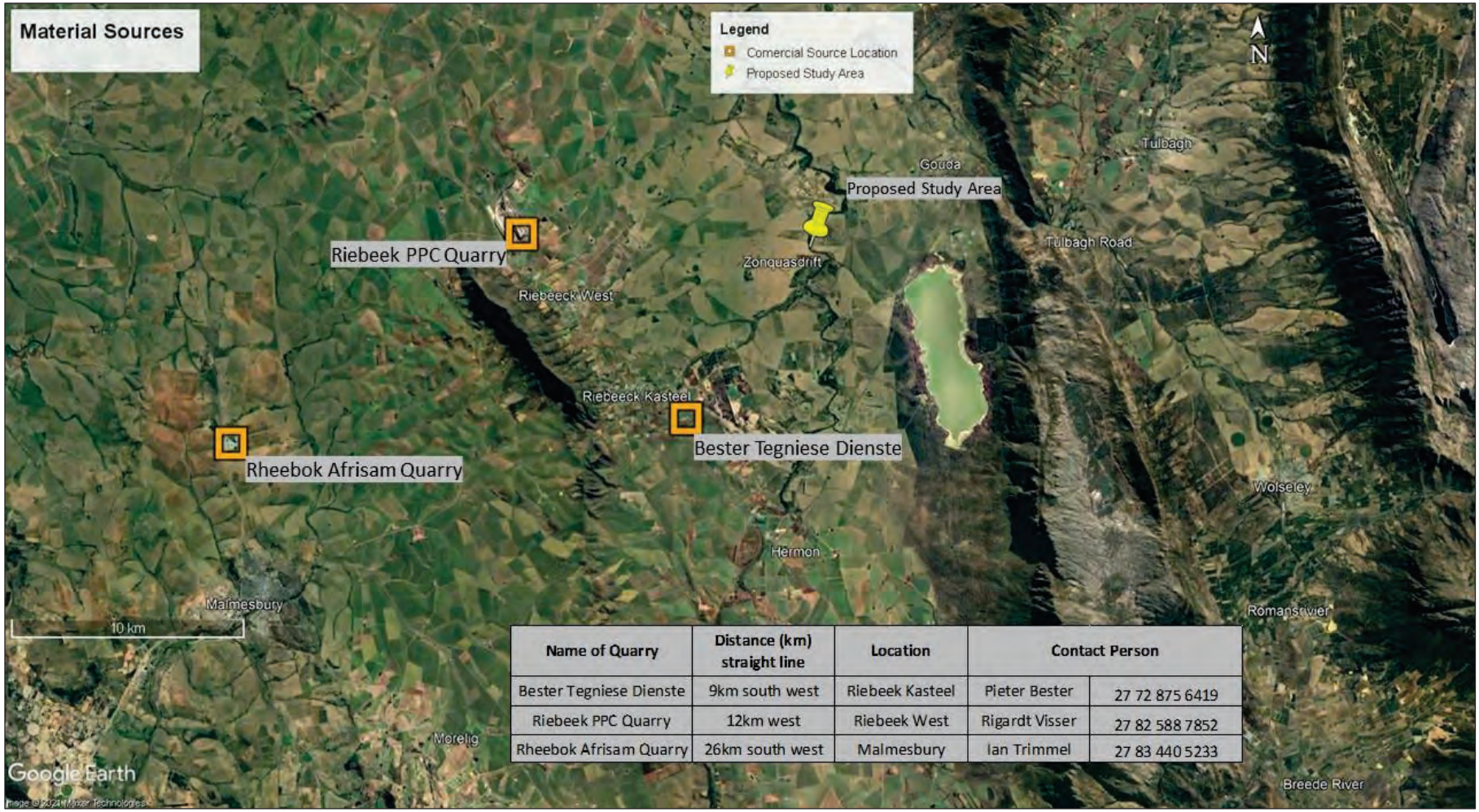
Figure 13: Seismic Refraction Survey

Figure 14: Soil Resistivity Survey Points

4.5 Materials Investigation

Materials will be required during construction for the pipeline including bedding (which consists of the bed, bedding cradle, selected fill blanket and bedding material) and the main backfill. Several samples were collected during the investigation to check the suitability of the soils encountered on site along the pipeline route. The material that was excavated during the construction of the canal that runs parallel to the proposed pipeline was also sampled for testing.

It is also understood that the embankment dam structure will require a substantial amount of material and that a portion of this may have to be sourced from commercial sources. During the investigation potential commercial sources were identified and material from their stockpile was sampled for testing. Figure 15 below details some of the commercial sources that were visited during the investigation and their location with reference to the study area.



Name of Quarry	Distance (km) straight line	Location	Contact Person	
Bester Tegniese Dienste	9km south west	Riebeek Kasteel	Pieter Bester	27 72 875 6419
Riebeek PPC Quarry	12km west	Riebeek West	Rigardt Visser	27 82 588 7852
Rheebok Afrisam Quarry	26km south west	Malmesbury	Ian Trimmel	27 83 440 5233

Figure 15:Potential Commercial Sources Location

5 CONCLUSION

The current investigation follows a feasibility geotechnical investigation carried out in 2012 for the BRVAS project. The current study commenced with a gap analysis of the previous geotechnical studies. The findings of the gap analysis formed the basis of the scope of work for the current study. The additional geotechnical investigation was planned in two phases including Phase 1A and Phase1B. Phase 1A was considered to be essential, while the components for Phase 1B would only be executed if required. This report presents the study carried out for Phase1A only, as no further Phase 1B investigations was required. The field work was carried between September and October 2021, with the final work being done in December 2021 due to access restrictions on certain areas of the site. The purpose of this factual report is to present the findings of the current BRVAS additional geotechnical investigation.

At the time of writing this report, no Phase 1B investigations had been carried out. It is planned to carry out a portion of the Phase 1B investigations at the weir in order to better understand the stratigraphy and consistency of the deep subsoils in this area, and also at the Berg River crossing in order to better understand the stratigraphy in the area to better inform the location of the river diversion.

6 REFERENCES

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ANNEXURE A

DRAWINGS

ANNEXURE B

TESTPIT PROFILES

ANNEXURE C

TESTPIT PHOTOGRAPHS

ANNEXURE D

DCP TESTS RESULTS

ANNEXURE E

LABORATORY TEST RESULTS

ANNEXURE F

GEOPHYSICAL REPORT