

Ref: CC169700/2019/11/01/DJH

01 November 2019

Black Orchid Farming (Pty) Ltd
Office 201
30 Hudson Street
De Waterkant
Cape Town
8001

Attention: Mr Werner Stears

Dear Sir,

PROJECT NO. CC169700: ENLARGEMENT OF ZWARTFONTEIN DAM, WELLINGTON

We refer to your request for us to report on the above.

1. Introduction and background

Black Orchid Farming (Pty) Ltd appointed Ingerop South Africa (Pty) Ltd to undertake an investigation into enlarging the storage capacity (Zwartfontein Dam 12/2/G101/DB) on Properties Portion 8 and Restant of Farm 792. This would provide insurance of supply for irrigation of the existing irrigation areas. The recent drought in the Western Cape and the uncertainties of the impact of Climate Change are the major drivers of this project.

Zwartfontein Farms are managed by the UFF Agri Asset Management Trust, for the owner, Black Orchid Farming (Pty) Ltd. Refer to **Table 1** below for a summary of properties owned by Black Orchid Farming (Pty) Ltd.

The existing Zwartfontein Dam consists of a storage capacity of 150 000 m³ and a wall height of 11.7m (as measured from a survey completed by Douw Willemse in 2018).

The proposed scheme includes the enlargement of Zwartfontein dam to a maximum storage capacity of 915 000 m³ (increased storage capacity of 765 000 m³, to a wall height of 22.5 m). The proposed dam will be filled with water from the Berg River (from an existing abstraction point with existing water rights enlisted under the Berg River Irrigation Board).



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Company Registration No. 1995/002049/07

Directors • N Daya (MD) • N Pather • D Booyse • C Blanc



Table 1: Zwartfontein Farm properties owned by Black Orchid Farming (Pty) Ltd

Property description	Property owner
Portion 7 of farm 792	Black Orchid Farming (Pty) Ltd
Portion 8 of farm 792	Black Orchid Farming (Pty) Ltd
Portion Re of farm 792	Black Orchid Farming (Pty) Ltd

The site is located approximately 15 km north west of Wellington (within the Western Cape). Refer to the locality map in **Figure 1** below, also included in **Appendix C**.

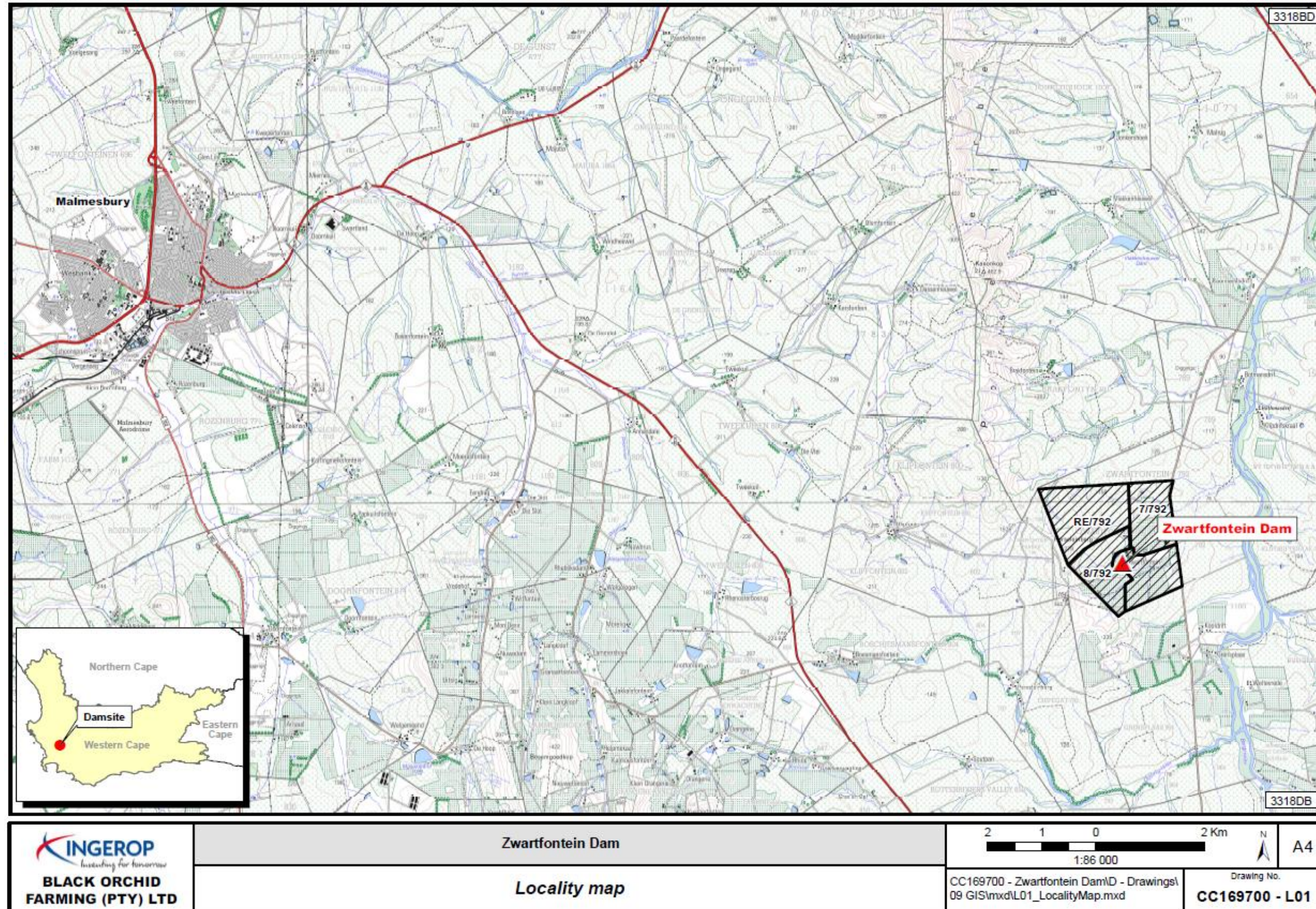


Figure 1: Locality map

2. Existing water rights

The Berg River Irrigation Board confirmed that the properties listed in the tables below have a total enlistment area of 258.5 ha for water uses on properties listed under Zwartfontein Farm owned by Black Orchid Farming (Pty) Ltd (refer to **Appendix A**). Table 2 contains a summary of the existing water rights on the Zwartfontein Farm properties.

The water enlistment volumes are calculated based on 6 000 m³/ha/a, which equates to a total of 1 551 000 m³/a.

Table 2: Summary of Zwartfontein Farm existing water rights

Property description: Zwartfontein Farms	Existing water rights (ha) 21a)	Total Enlistment @ 6000 m ³ /ha/a (m ³ /a)	Existing Storage (m ³) 21b)	Proposed storage (m ³) 21b)	Total storage (m ³) 21b)
Portion 7 of farm 792	80	480 000			
Portion 8 of farm 792	43.5	261 000		765 000	915 000
Portion RE of farm 792	135	810 000	150 000 (160 000) ¹⁾		
Total	258.5	1 551 000	150 000	765 000	915 000

1) Existing dam capacity surveyed as 150 000 m³ in 2018, although registered as 160 000 m³

The proposed enlarged storage of Zwartfontein farm properties (915 000 m³) amounts to approx. 59% of the owners existing water rights.

To summarise the Water Use License Applications must include the following:

- **Section 21 (b) – storing of water with a volume of 765 000 m³ (to the amount of 915 000 m³);**
- **Section 21 (c) & (i) – impeding or diverting/altering the bed, banks of a watercourse for all associated infrastructure of the proposed scheme summarized in Section 4.**

3. Available surface water from dam catchments

The existing catchment supplying the farm is located in the quaternary catchment G10D with a catchment area of 688 km² and a Mean Annual Precipitation (MAP) of 691 mm. The dam's catchment area of 0.6 km² and weighted MAP's from WRC 2012 study (Bailey & Pitman, 2015) of 450 mm and wide Area Augmentation System (WAAS, 2007) Satellites of 622mm are shown in **Figure 2** below.

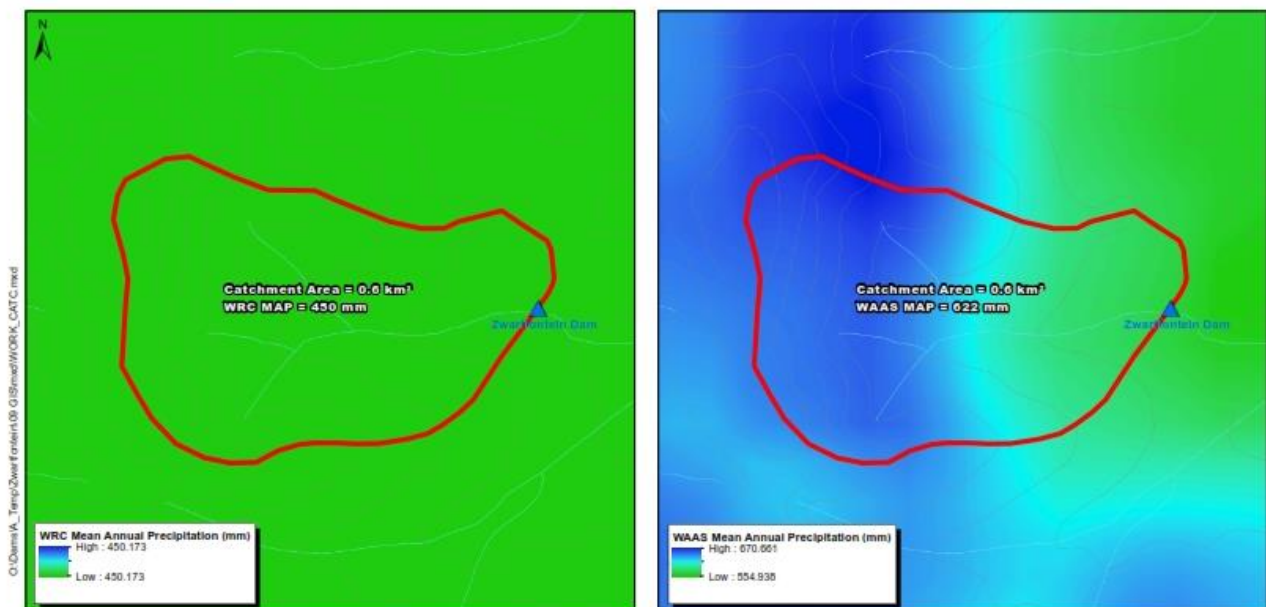


Figure 2: Dam catchment area and weighted MAP's (WRC - left and WAAS - right)

The WAAS MAP is considered more representative due to the nature and location of the Dam site and will therefore be used for the determination of the estimated Mean Annual Runoff (MAR).

Table 3: Estimated runoff of Zwartfontein Dam catchment

Dam Site	Catchment (km ²)	MAP (mm)	Runoff %	Natural MAR (million m ³)
G10D	688	691	26.3	124.95
Zwartfontein Dam	0.6	622	25	0.093

A MAR of approx. 93 000 m³/a was calculated, however, the existing dam already impede this flow and it should be confirmed by the freshwater specialist whether EWR releases should be made from the enlarged dam.

It was also noted that upstream embankments do exist in the catchment area of Zwartfontein Dam and it is expected that these are operated as evaporation ponds due to low quality water provided by the runoff from the catchment area.

4. Proposed scheme

The project is proposed to include the following developments:

- The enlargement of the existing Zwartfontein Dam from a storage capacity of 150 000 m³ with a wall height of 11.9 m (2018 Survey statistics) to a total storage capacity of 915 000 m³ with a 22.5 m wall height (along with the construction of a new 500mm dia outlet pipe through the embankment and the construction of an open channel spillway on the dam's right abutment);
- Relocating the existing pump station as shown in **Figure 5** to downstream of the raised embankment footprint on the left abutment of the river section, along with the relocation of associated irrigation infrastructure and pipelines to downstream of the raised embankment footprint (pipelines sizes varying between 110mm and 250mm dia, relocations to be performed by Bergrivier Besproeiing);
- Relocation of Eskom electrical infrastructure (as shown on **Figure 5**) located directly below the existing dam embankment to downstream of the raised embankment footprint; and
- Allowance for a maximum 10m road width along the raised dam embankment and full supply level footprint.

The existing storage volume based on the survey completed in 2018 (by Douw Willemse) is calculated at 150 000 m³, with the existing dams' registration volume as 160 000 m³. The proposed enlargement of Zwartfontein Dam is to a storage capacity of 915 000 m³ to a wall height of 22.5m and is shown in **Figure 3** below and Drawing CC169700-L03 included in **Appendix C**.

The existing abstraction point from the Berg River is shown in **Figure 4** below and will remain as is.

The existing pumpstation and Eskom infrastructure downstream of the embankment is proposed to be relocated with the proposed position of the relocated pumpstation and irrigation pipelines around the dam indicated in **Figure 3** below.

Allowance should be made for a 10m access road between the proposed raised full supply level and embankment and the irrigation areas around the dam basin.

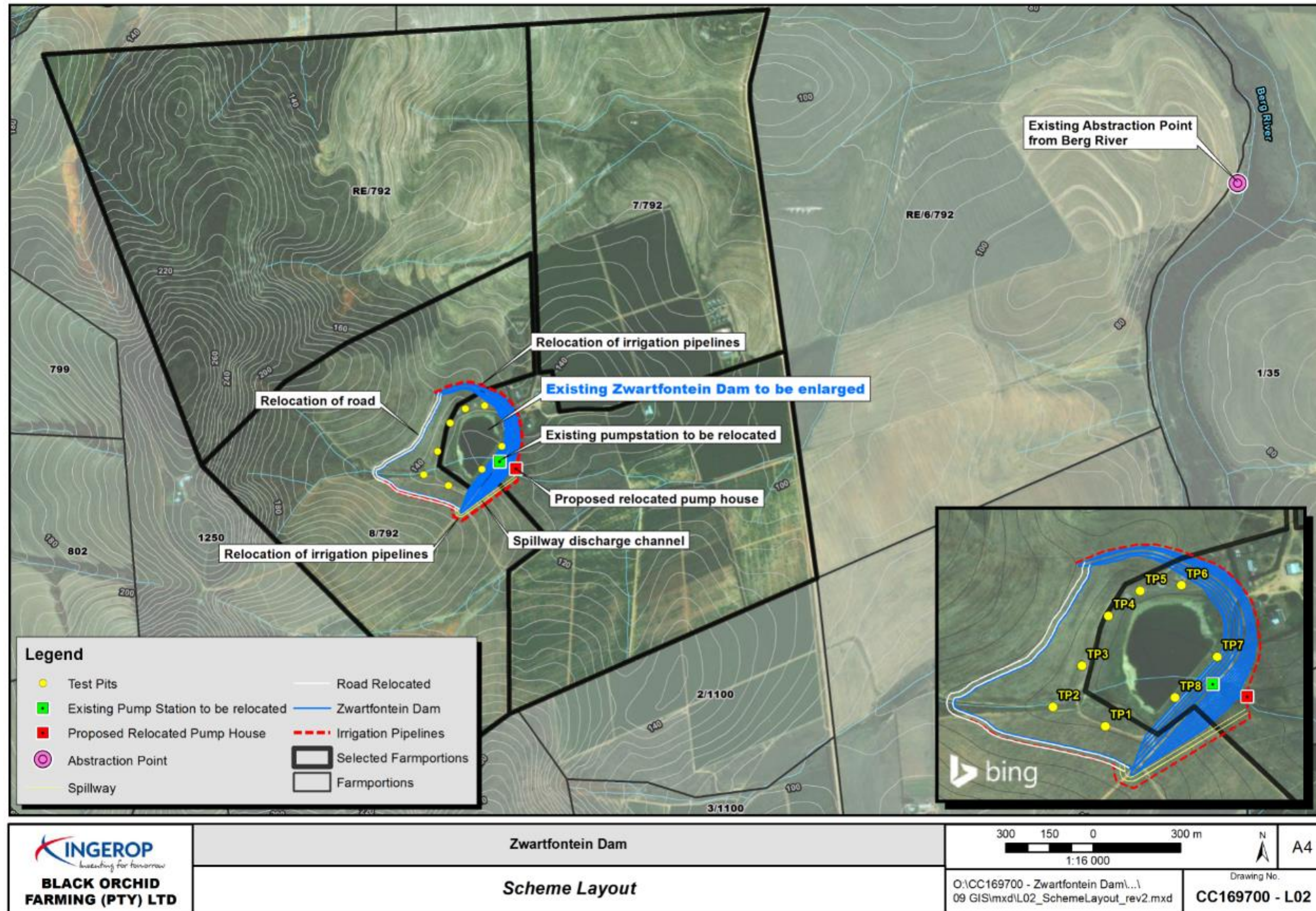


Figure 3: Proposed scheme layout of the Enlarged Zwartfontein Dam

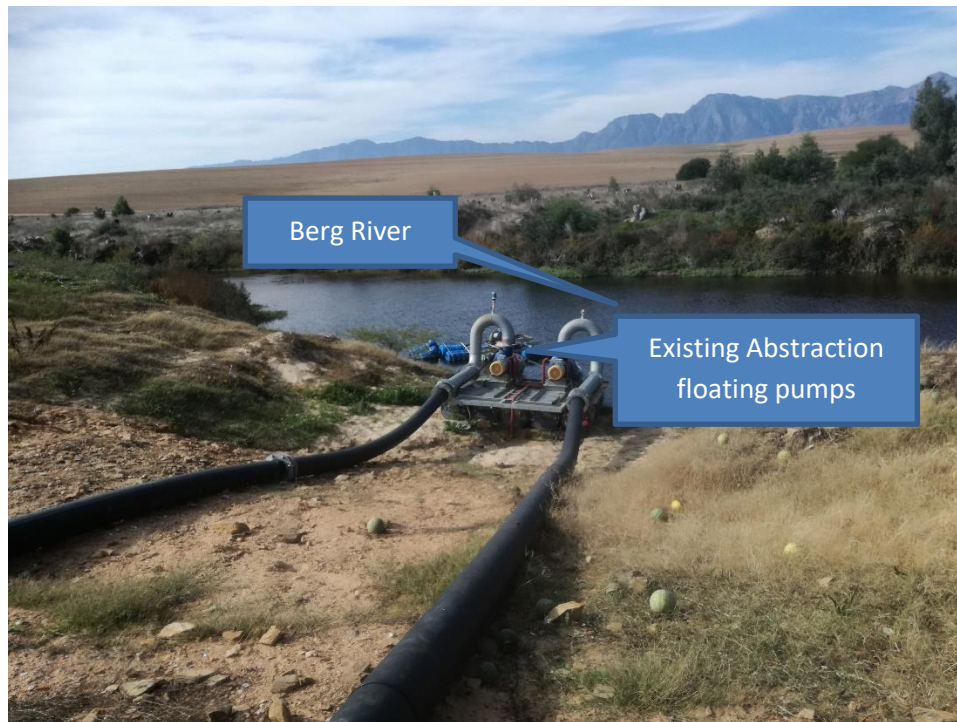


Figure 4: Existing abstraction located on the Berg River (to remain as is)

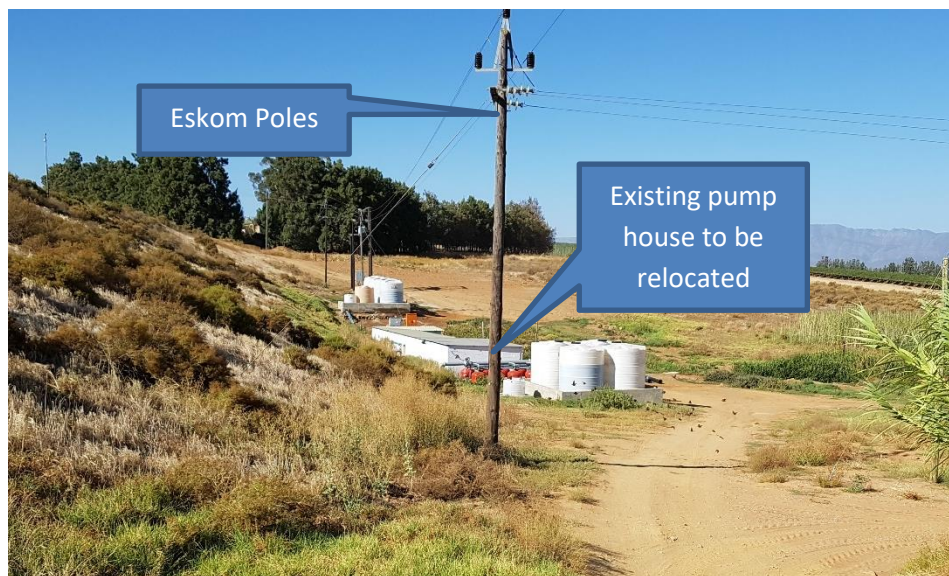


Figure 5: Existing Pump House and Eskom infrastructure downstream of the existing embankment to be relocated

5. Geotechnical

5.1. Regional geology

The regional geology map (3318 Cape Town, 1:250 000 series) (RSA, 1973) indicates that the site is possibly underlain by Greywacke and phyllite with beds and lenses of quartz schist, with occasional limestone lenses, from the Tygerberg Formation, ECCA Group (Nm) as shown in Figure 6 below.

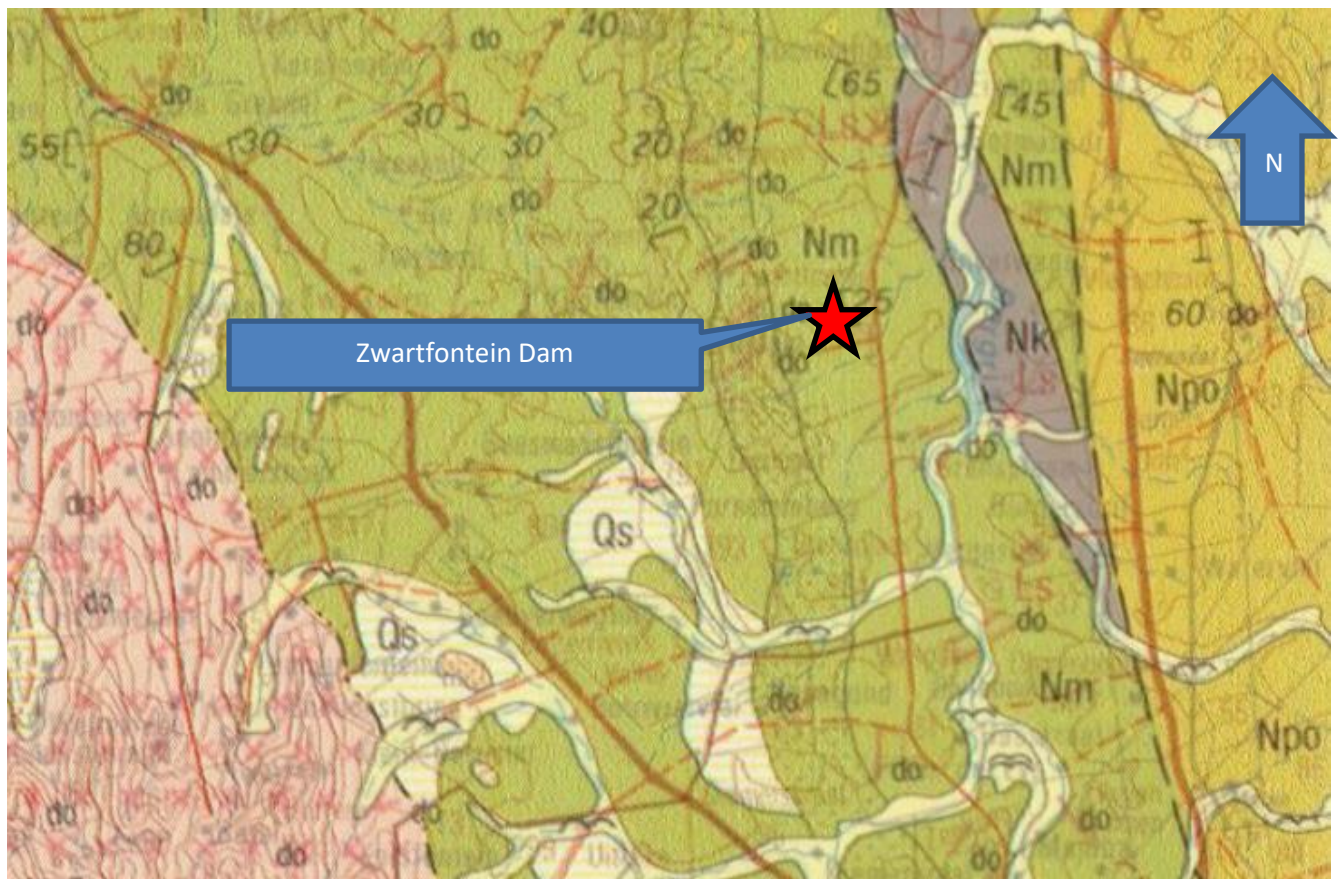


Figure 6: Regional geology at dam site (marked with red asterisk)

The geotechnical investigation was completed in May 2019 where eight (8) test pits were excavated and two (2) samples were taken for laboratory testing in June 2019. The results of the tested samples are included in **Appendix B** for information purposes.

The design (previous raising) drawings indicated that an upstream core trench was planned (and assumed to be constructed) for the now existing embankment (Figure 7). Due to the extent of the raising (raising the

embankment crest with 8.5m) it is proposed that a new core trench be excavated for the total length of the raised embankment.

The enlargement design would further include the construction of a new chimney and blanket drain with a new rock toe drain as well as the placing rip-rap for upstream slope erosion protection.

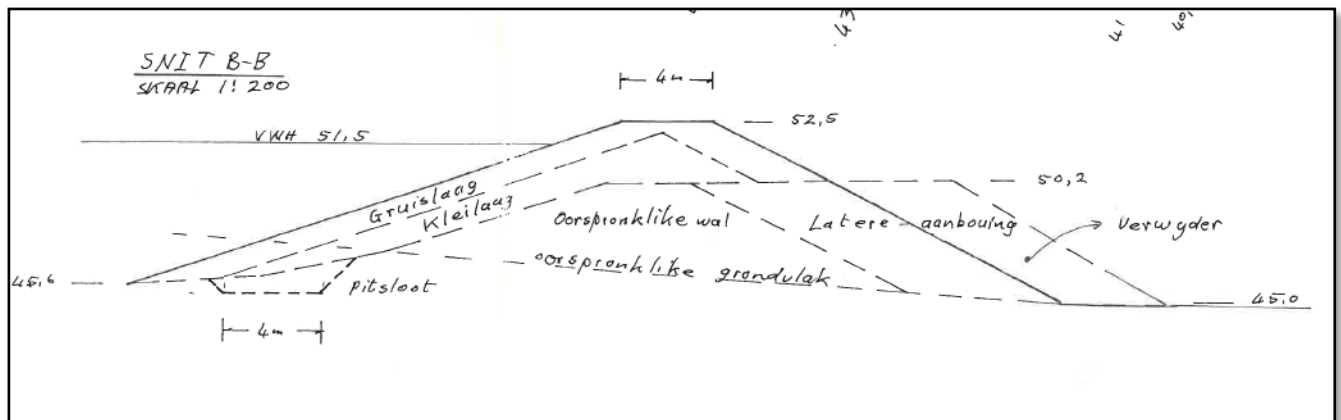


Figure 7: Existing Zwartfontein Dam cross section design

The test pits excavated during the site visit is indicated in Figure 8 below. The samples taken for testing was from TP 5 (dam basin) and TP 7 (existing embankment) for the suitability of core material of the existing embankment and for the proposed raising. The test results are enclosed in **Appendix B**, with the summary included below.

Table 4: Summary of soil test results

Sample Ref No	Atterberg Limits			Dispersivity %	Fines % (< 0,075 mm)	Grain Size Distribution (%)				Classification (in accordance with Unified Soil Classification System)	
	LL	PI	LS			Clay	Silt	Sand	Gravel		
TP5	26	13	6.0	DH: 18.7	36	17	19	45	19	SC	Brownish-yellow clayey sand with gravel
TP7	23	9	4	DH: 14	29	12	17	49	22	SC	Brownish-yellow clayey sand with gravel

The available materials found in these above-mentioned test pits are considered adequate core material based on the following properties:

% Fines: 29 to 36

% Clay: 12 to 17

Plasticity Index: 9 to 13

Classification: SC

The dispersivity of the proposed core material with the SCS Double Hydrometer Test indicates 14 to 18.7 % (non to slightly dispersive) and the crumb test indicates a slight reaction.

The following is recommended during the construction of the dam due t the slightly dispersive soil:

- Compaction of Zone I (clay core): Core to minimum 98% PROCTOR density at a moisture content between Optimum Moisture Content (OMC) and +3% OMC.
- Internal drainage system comprising of a coarse sand chimney and blanket drain connected to a rock toe.

The materials (core and general fill) for the raising of the embankment is proposed to be excavated from the dam basin. Filter material required for chimney and blanket drain (sand), rock toe and rip-rap for upstream slope protection is all proposed to be imported from commercial sources.



Figure 8: Positions (shown by the blue flags) of test pits performed on 29th May 2019



Figure 9: TP 7 Brownish-yellow clayey sand with gravel (existing dam core material)



Figure 10: TP5- Brownish-yellow clayey sand with gravel located in the dam basin (proposed raising core material)

6. Dam options analysis

6.1. Location alternatives

No alternative sites were investigated as this entails an enlargement of an existing Dam.

6.2. Zwartfontein Dam raising optimization

The existing dam was surveyed by Douw Willemse of Boland Opmeting in 2018. Various raising size options were considered, with upstream, downstream and centreline raising options investigated for a detailed cost comparison summarised in **Table 5**. The downstream raisings were preferred by the client for keeping the existing dam in operation while constructing the raised embankment as well as ease of construction to avoid unnecessary sediment removal on the upstream side as well as creating sufficient working space on the downstream side for a complete new central core zone and core trench.


The final preferred dam layout (Option 10) was preferred due to its target storage capacity being in line with the applicant's storage demand, and is shown on Drawing CC169700-L03 included in **Appendix C**.



Figure 11: Aerial view of Option 10

The statistics of the investigated options and proposed option (in yellow) is summarised below and included in **Appendix D**.

Table 5: Statistics of Zwartfontein Dam raising options

	Zwartfontein Dam - Option Analysis										
	Existing	Dam Raising Options 33°30'36.05"S, 18°54'42.68"E									
		Option 1 (upd survey)	Option 2 (upd survey)	Option 3 (upd survey)	Option 4 (upd survey)	Option 5 (upd survey)	Option 6 (upd survey)	Option 7 (upd survey)	Option 8 (upd survey)	Option 9 (upd survey)	Option 10 (upd survey) Preferred Option
	-	270 000 m3 u/s raise	430 000 m3 u/s raise	510 000 m3 u/s raise	595 000 m3 u/s raise	300 000 m3 d/s raise	440 000 m3 d/s raise	550 000 m3 d/s raise	620 000 m3 d/s raise	655 000 m3 d/s raise	915 000 m3 d/s raise
Proposed NOC (masl)	Varies from 52.7m to 52.5 m	55.0	57.5	58.5	59.5	55.5	56.9	58.1	58.7	59.0	61.0
Proposed FSL (masl)	51.7	54.0	56.5	57.5	58.5	54.0	55.9	57.1	57.7	57.8	59.8
Raising (m)	0	2.3	4.8	5.8	6.8	2.8	4.2	5.4	6.0	6.3	8.3
Freeboard (m)	0.3 to 1m	1	1	1	1	1.5	1	1	1	1.2	1.2
Maximum wall height (m)	11.90	14.20	16.70	17.70	18.70	15.00	16.40	18.10	18.70	20.00	22.50
Proposed wall crest width (m)	6	6	6	6	6	6	6	6	6	6	6
Downstream slope (Vertical:Horizontal)	1V:2.2H	1V:2.2H	1V:2.2H	1V:2.2H	1V:2.2H	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H
Upstream slope ((Vertical:Horizontal)	1V:3.6-3.8H	1V:3H	1V:3H	1V:3H	1V:3H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H
Fill volume required for dam wall (m³)	-	30 500	71 180	92 500	116 000	36 800	64 500	91 124	105 600	112 056	175 579
Wall length (m)	280	425	487	515	596	438	475	532	580	575	696
Capacity without cut from basin (m³)	-	238 000	358 600	415 000	470 500	260 000	372 500	458 560	511 550	540 000	739 000
Water surface area at FSL (m²)	36 468	53 631	68 690	75 111	83 428	56 100	70 000	79 550	85 750	89 935	108 530
Water surface area at FSL (Ha)	3.6	5.4	6.9	7.5	8.3	5.6	7.0	8.0	8.6	9.0	10.9
Capacity Increase (m³)	-	119 000	280 000	358 000	437 000	147 000	287 000	400 000	467 000	502 000	765 000
Total Capacity (m³)	150 000	269 000	430 000	508 000	587 000	297 000	437 000	550 000	617 000	652 000	915 000
Estimated average core trench width (m)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Estimated average core trench depth (m)		3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Estimated core trench volume (m³)		11 200	12 800	13 500	15 600	11 500	12 500	14 000	15 200	15 100	18 300
Removal of unsuitable material (m³)		4 000	4 000	4 000	4 000						
Percentage core trench volume of earthworks (%)		25%	15%	12%	12%	24%	16%	13%	13%	12%	9%
Total earthfill (m³)		45 700	87 980	110 000	135 600	48 300	77 000	105 124	120 800	127 156	193 879
Wall Water Ratio (m³)		2.60	3.18	3.25	3.22	3.04	3.73	3.81	3.87	3.95	3.95
Minimum basin level (m)	43.50	43.40	43.00	43.00	43.50	43.00	43.50	43.50	43.50	43.50	43.50
Minimum downstream level (m)	40.80	40.80	40.80	40.80	40.80	40.50	40.50	40.00	40.00	39.00	38.50
Maximum Storage depth (m)	8.2	10.6	13.5	14.5	15.0	11.0	12.4	13.6	14.2	14.3	16.3
Preliminary & General (establish, test, overheads)		R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00
Earthworks excluding diesel		R 1 599 500.00	R 3 079 300.00	R 3 850 000.00	R 4 746 000.00	R 1 690 500.00	R 2 695 000.00	R 3 679 340.00	R 4 228 000.00	R 4 450 460.00	R 6 785 779.81
Dry Tariff (R/m)		R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00
Diesel usage per m³ (liter)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Diesel cost (R/liter)		R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05
Dieselcost		R 642 085.00	R 1 236 119.00	R 1 545 500.00	R 1 905 180.00	R 678 615.00	R 1 081 850.00	R 1 476 992.20	R 1 697 240.00	R 1 786 541.80	R 2 724 005.89
Rebate (R/liter diesel)											
Minus rebate saving											
Outletworks (pipe, concrete, specials and valves), estimated		R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00
Total dam construction cost (excluding VAT)		R 3 116 585.00	R 5 190 419.00	R 6 270 500.00	R 7 526 180.00	R 3 244 115.00	R 4 651 850.00	R 6 031 332.20	R 6 800 240.00	R 7 112 001.80	R 10 384 785.70
Allow for 15% contingencies		R 467 487.75	R 778 562.85	R 940 575.00	R 1 128 927.00	R 486 617.25	R 697 777.50	R 904 699.83	R 1 020 036.00	R 1 066 800.27	R 1 557 717.85
Relocation of Eskom infrastructure		R -	R -	R -	R -	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00
Loss of orchards (Cost/ha)		R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00
Orchard to be removed (ha)		0.20	1.30	2.00	2.90	0.20	1.40	2.00	2.50	3.45	4.50
Loss of orchards (Cost)		R 80 000.00	R 520 000.00	R 800 000.00	R 1 160 000.00	R 80 000.00	R 560 000.00	R 800 000.00	R 1 000 000.00	R 1 380 000.00	R 1 800 000.00
Moving of pumphouse & related infrastructure						R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00
Professionele fees, detail design and construction inputs		R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00
BAR and water use licence applications		R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00
Project cost (excluding VAT)		R 4 194 072.75	R 7 018 981.85	R 8 541 075.00	R 10 345 107.00	R 7 710 732.25	R 9 809 627.50	R 11 636 032.03	R 12 720 276.00	R 13 458 802.07	R 17 642 503.55
R/m³ fill		R 91.77	R 79.78	R 77.65	R 76.29	R 159.64	R 127.40	R 110.69	R 105.30	R 105.84	R 91.00
R/m³ storage		R 15.59	R 16.32	R 16.81	R 17.62	R 25.96	R 22.45	R 21.16	R 20.62	R 20.64	R 19.28

The water/wall ratio represents the volume of water gained per volume of fill required to construct the dam embankment. This is a good indication for selecting the most economical dam design, however, operational benefits come in effect for the downstream raising options.

The main statistics of Option 10 (preferred option) is provided below.

Table 6: Main statistics of the preferred Option 10

Option 10 (Preferred)	
Proposed NOC (masl)	61
Proposed FSL (masl)	59.8
Raising (m) – of full supply level	8.3
Freeboard (m)	1.2
Maximum wall height (m)	22.5
Proposed wall crest width (m)	4
Downstream slope (Vertical: Horizontal)	1V:2H
Upstream slope ((Vertical: Horizontal)	1V:3.6 to 3.8H
Fill volume required for dam wall (m ³)	175 579
Removal of unsuitable material (m ³)	-
Wall length (m)	696
Capacity without cut from basin (m ³)	739 000
Water surface area at FSL (ha)	10.9
Capacity Increase (m ³)	765 000
Total Capacity (m³)	915 000
Estimated core trench volume (m ³)	18 300
Total earthfill (m³)	193 879
Wall Water Ratio (m³)	3.95
Minimum basin level (m)	43.5
Minimum downstream level (m)	38.5
Maximum Storage depth (m)	16.3

7. Legal requirements

7.1. Environmental authorisation

A Basic Assessment Report (BAR) environmental process for this development is required and will be undertaken by Messrs EnviroAfrica cc.

7.2. Water use license

Applications for Section 21 b), c) and i) water uses will be required. Messrs Schoeman en Vennote will embark on this process.

7.3. Dam safety

The dam safety process will commence with the application for re-classification of the proposed dam. A Category II classification is expected due to the increased hazard potential due to the increase in dam size (wall height). The design and application for a license to construct will follow when the other authorisation processes are further advanced.

8. Project cost estimate

A provisional total project cost estimate for the project (excluding escalation to and during construction) can be summarised as follows:

Item no and description	Cost (million R, excl VAT) ¹⁾
1. Construction	
1.1 Proposed dam (Option 10)	12.0
1.2 Relocation of existing Eskom infrastructure	0.12
1.3 Relocation of existing pumphouse and associated infrastructure	3.25
1.4 Los of existing orchards	1.8
Sub-total	17.17
2. Professional costs	
2.1 Engineering of dam	0.3
2.2 Authorisation processes (BAR and WUL)	0.23
Sub-total	0.53
Total	17.7

1) Costs estimated in September 2019

Yours faithfully,



INGEROP SOUTH AFRICA

DJ Hagen Pr.Eng/APP



INGEROP SOUTH AFRICA

Francois van Zyl



INGEROP SOUTH AFRICA

Cherie Starke

References

Bailey A.K., Pitman W.V. (2015): Water Resources of South Africa, 2012 Study (WR2012). Water Research Commission, Pretoria, RSA.

Boland Opmeting, 5 Maart 2018. Beplanning van vergroting van Zwartfontein for Safe Farm Exporters.

Boland Opmeting, 2 Julie 2019. Vergroting van Zwartfontein for Black Orchid Farming (Pty) Ltd.

Appendix A – Provided Information

BERGRIVIER BESPROEIINGSRAAD

Posbus 538
SUIDER-PAARL
7624

Bestuurder: Tel. 083 300 4366
Rekeninge: Tel. 082 578 3050

6 Junie 2019

Wie dit mag aangaan

INGELYTE WATERREGTE

Hiermee bevestig die Bergrivier Besproeiingsraad dat die ondergemelde eiendomme se inlysting op die oomblik as volg is:

<u>Eiendombeskr.</u>	<u>Gedeelte</u>	<u>Eienaar</u>	<u>Hektaar</u>
Zwartfontein Plaas 792	7	Black Orchid Farming (Pty) Ltd	38.0 ha Rondte 1 en 42.0 ha Rondte 2 aangekoopte watergebruiksregte
Zwartfontein Plaas 792	8	Black Orchid Farming (Pty) Ltd	13.5 ha oorspronklike en 30.0 ha Rondte 2 aangekoopte watergebruiksregte
Zwartfontein Plaas 792	Restant	Black Orchid Farming (Pty) Ltd	110.0 ha oorspronklike en 25 ha Rondte 1 aangekoopte watergebruiksregte

Die bogemelde eiendomme is geregtig om 6 000 kubieke meter water per hektaar per jaar te gebruik vir landboubesproeiingsdoeleindes uit die Bergrivier.

Alle gelde en belastinge tot op datum is betaal.

Die uwe



BILLY BOURBON-LEFTLEY
VOORSITTER
BERGRIVIER BESPROEIINGSRAAD



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA


Registration Details of a Dam Registered in terms of Dam Safety Legislation in terms of Chapter 12 of the National Water Act (Act 36 of 1998)


(Please note that registration for dam safety legislation is not an entitlement for water use in terms of Chapter 4 of the National Water Act)


Enter No of dam	g101/db	Column
No of dam	G101/DB	1
WARMS Dam ID	0	2
Name of dam	ZWARTFONTEIN DAM	3
Water management area	9	4
Quaternary Drainage Area	G10D	5
Latitude deg	33	6
Lat min	30	7
Lat sec	36,0	8
Longitude deg	18	9
Long min	54	10
Long sec	42,0	11
Town nearest	MALMESBURY	12
Distance from Town	17	13
Name of farm	RESTANT VAN ZWARTFONTEIN 792	14
District		15
Province	WESTERN CAPE	16
DWS Provincial Office / Region	WESTERN CAPE	17
Completion date	1995	18
Completion date raised		19
River or Watercourse	BERG RIVER TR.	20
Wall type	EARTHFILL	21
Wall height	11,7	22
Crest Length (m)	280	23
Spillway Type	OPEN CHANNEL	24
Capacity (1000 cub m)	160	25
Surface area (ha)	3,8	26
Catchment area (sq km))	0	27
Purpose	IRRIGATION	28
Owner Name	HOOGENFONTEIN BOERDERY EDMS. BPK.	29
Designer	BOLAND OPMETING	30
Contractor	UNKNOWN	31
Registration date	2002-07-03	32
Size	Small	33
Hazard Potential	Low	34
Category	1	35
Classification date	1995-02-23	36
Sector	A	37
Date Last DSE	0	38
Number Last DSE	0	39
Target date next DSE	1900-01-00	40
Manual Status B/E/M	B	41

Appendix B – Geotechnical Results


Zwartfontein dam test pits results: 29 May 2019


Test pit No 1		
General location	In the dam basin	
Coordinates	33°30'39.31"; 18°54'36.43"E	
Elevation	± 139 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.3	Sandy Topsoil	
0.3 to 0.6	Reddish Clayey sand with gravel	
	Hard Rock Foundation	


Test pit No 2		
General location	In the dam basin	
Coordinates	33°30'38.09"S; 18°54'33.12"E	
Elevation	± 140 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.2	Sandy Topsoil	
0.2 to 1.2	Brown Clayey sand and with gravel	
	Hard foundation	


Test pit No 3		
General location	In the dam basin	
Coordinates	33°30'35.49"S; 18°54'34.97"E	
Elevation	± 138 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.4	Sandy Topsoil	
0.4 to 1.0	Reddish Clayey sand with gravel	
	Hard Foundation	

Test pit No 4		
General location	In the dam basin	
Coordinates	33°30'32.34"S; 18°54'36.63"E	
Elevation	± 138 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.4	Sandy Topsoil	
0.4 to 1.1	Reddish Clayey sand with gravel	
	Hard Foundation	



Test pit No 5 (*Sample Taken)		
General location	In the dam basin	
Coordinates	33°30'30.75"S; 18°54'38.65"E	
Elevation	± 138 m	
Sample depth	1.6 m	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.3	Sandy Topsoil	
0.3 to 1.6	Brownish-yellow clayey sand with gravel	
	Hard Foundation	

Test pit No 6		
General location	In the dam basin	
Coordinates	33°30'30.40"S; 18°54'41.25"E	
Elevation	± 136 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 0.3	Topsoil	
0.3 to 1.5	Brownish-yellow clayey sand with gravel	
	Hard Foundation	

Test pit No 7 (*Sample Taken)		
General location	Existing dam crest	
Coordinates	33°30'35.21"S; 18°54'43.31"E	
Elevation	± 131 m	
Sample depth	1.3 m	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 1.3	Brownish-yellow clayey sand with gravel	

Test pit No 8		
General location	Existing dam crest	
Coordinates	33°30'37.74"S; 18°54'41.11"E	
Elevation	± 131 m	
Sample depth	N/A	
Ground water level/ inflow depth	N/A	
Depth (m)	Description	Photos
0 to 1.5	Brownish-yellow clayey sand with gravel	

Results of foundation indicator and dispersivity tests and Soil Classification for Zwartfontein Dam

Sample Ref No	Photo	Atterberg Limits			Dispersivity %	Fines %(< 0,075 mm)	Grain Size Distribution (%)				Classification (in accordance with Unified Soil Classification System)	
		LL	PI	LS			Clay	Silt	Sand	Gravel		
31607 (TP5)		26	13	6	18.7	36	17	19	45	19	SC	Brownish-yellow clayey sand with gravel
31608 (TP7)		23	9	4	14	29	12	17	49	22	SC	Brownish-yellow clayey sand with gravel



CONTROL GEOSCIENCES (PTY) LTD

CIVIL ENGINEERING MATERIAL AND GEOTECHNICAL LABORATORY,
GEOTECHNICAL AND ENVIRONMENTAL SERVICES

CLIENT: UFF Agri Asset Management
Office 201
30 Hudson Street
Cape Town 8001
ATT: Werner Stears

PROJECT: Zwartfontein Dam Raise
DATE: 14-06-2019
REF: L190607

ASTM D422 SIEVE ANALYSIS

DESCRIPTION : yellow olive silty clay
POSITION : TP 5

SAMPLE NO. : 31607
CLIENT SAMPLE NO. :

Sieve Analysis	Percent Passing
SIEVE SIZE (mm)	75,00
	63,00
	53,00
	37,50
	26,50
	19,00
	13,20
	9,50
	6,70
	4,75
	2,36
	2,00
	1,18
	0,600
	0,425
	0,300
	0,150
	0,0750

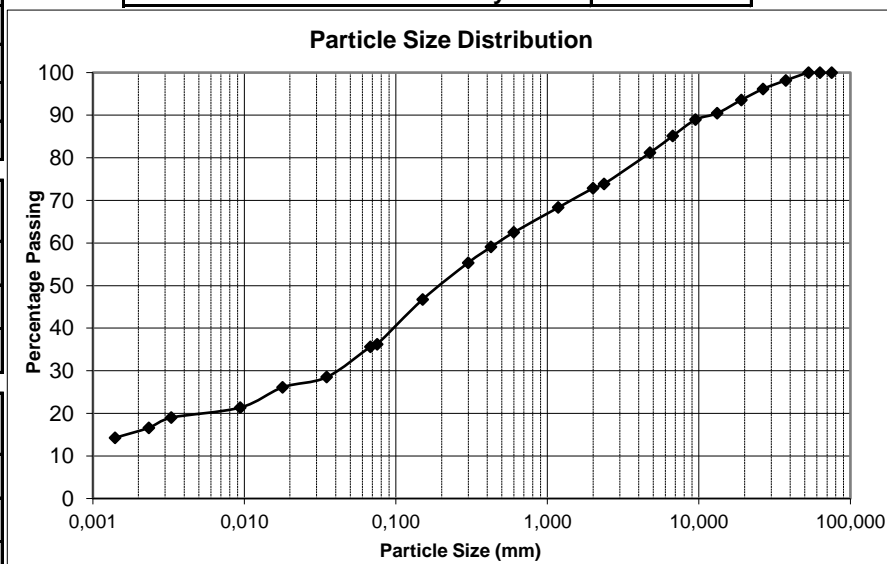
Hydrometer Analysis	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0677	36
0,0349	28
0,0179	26
0,0094	21
0,0033	19
0,0023	17
0,0014	14

SCS Dispersion Test	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0748	12
0,0376	9
0,0192	6
0,0099	5
0,0035	2
0,0025	2
0,0015	2

% SCS Dispersion:	18,7
Initial Moisture Content (%) :	
pH:	
Conductivity mS/m:	

Atterberg Limits :	
Liquid Limit	26
Plastic Index	13
Linear Shrinkage	6,0

MOD AASHTO ; C.B.R. :	
MOD AASHTO (Kg/m ³)	
O.M.C. (%)	
C.B.R. @ 100% Comp.	
C.B.R. @ 98 % Comp.	
C.B.R. @ 95 % Comp.	
C.B.R. @ 93 % Comp.	
C.B.R. @ 90 % Comp.	
Swell (max) %	



Tabulated Summary	Percentage
Gravel : Percentage - 4.75 mm	19
Sand : Percentage - 4.75mm and + 0.075mm	45
Silt : Percentage - 0.075mm and + 0.002mm	19
Clay : Percentage - 0.002mm	17

The above test results are pertinent to the samples received and tested only.

For Geoscience:

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Remarks:

ConSR22



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GEOTECHNICAL AND ENVIRONMENTAL SERVICES

CLIENT: UFF Agri Asset Management (Pty)
Office 201
30 Hudson Street
Cape Town 8001
ATT: Werner Stears

PROJECT: Zwartfontein Dam Raise
DATE: 14-06-2019
REF: L190607

ASTM D422 SIEVE ANALYSIS

DESCRIPTION : yellow olive sandy clay
POSITION : TP 7

SAMPLE NO. : 31608
CLIENT SAMPLE NO. :

Sieve Analysis	Percent Passing
75,00	
63,00	
53,00	
37,50	100
26,50	98
19,00	97
13,20	91
9,50	87
6,70	82
4,75	78
2,36	69
2,00	68
1,18	62
0,600	56
0,425	53
0,300	50
0,150	41
0,0750	29

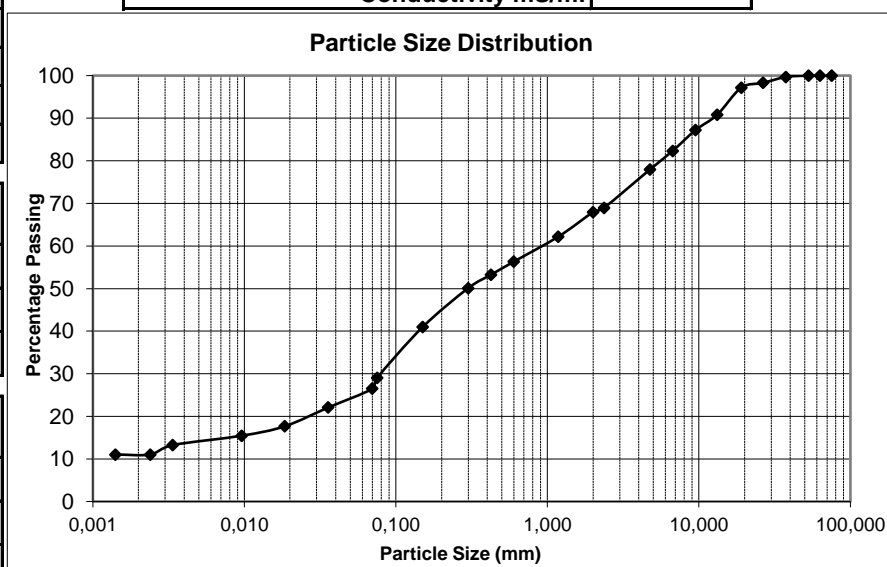
Hydrometer Analysis	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0699	26
0,0357	22
0,0184	18
0,0096	15
0,0034	13
0,0024	11
0,0014	11

SCS Dispersion Test	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0748	11
0,0384	4
0,0193	3
0,0100	2
0,0035	2
0,0025	2
0,0015	2

% SCS Dispersion:	14
Initial Moisture Content (%) :	
pH:	
Conductivity mS/m:	

Atterberg Limits :	
Liquid Limit	23
Plastic Index	9
Linear Shrinkage	4,0

MOD AASHTO ; C.B.R. :	
MOD AASHTO (Kg/m ³)	
O.M.C. (%)	
C.B.R. @ 100% Comp.	
C.B.R. @ 98 % Comp.	
C.B.R. @ 95 % Comp.	
C.B.R. @ 93 % Comp.	
C.B.R. @ 90 % Comp.	
Swell (max) %	



Tabulated Summary	Percentage
Gravel : Percentage - 4.75 mm	22
Sand : Percentage - 4.75mm and + 0.075mm	49
Silt : Percentage - 0.075mm and + 0.002mm	17
Clay : Percentage - 0.002mm	12

The above test results are pertinent to the samples received and tested only.

For Geoscience:

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Remarks:

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GEOTECHNICAL AND ENVIRONMENTAL SERVICES

CLIENT: UFF Agri Asset Management

PROJECT: Zwartfontein Dam Raise

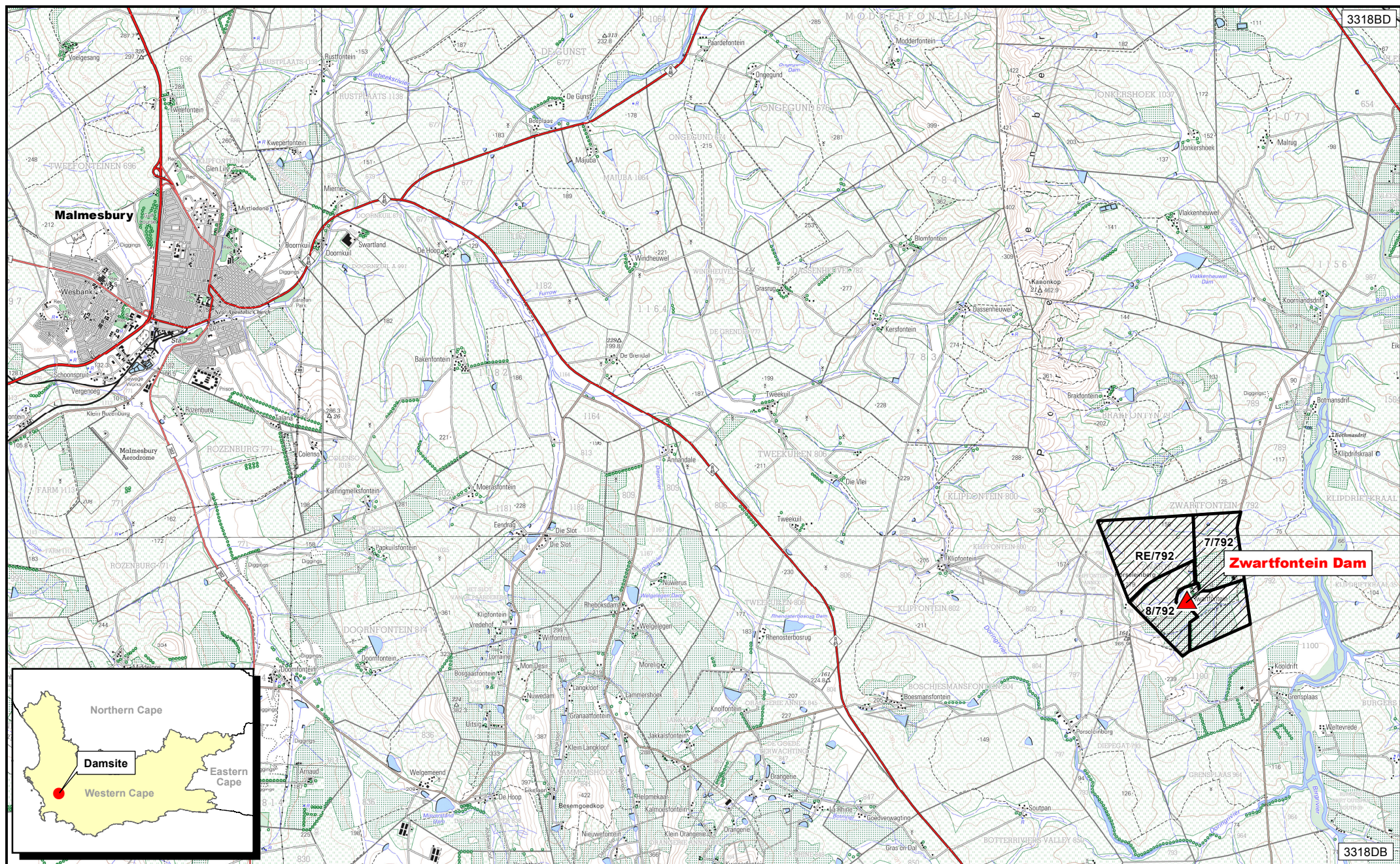
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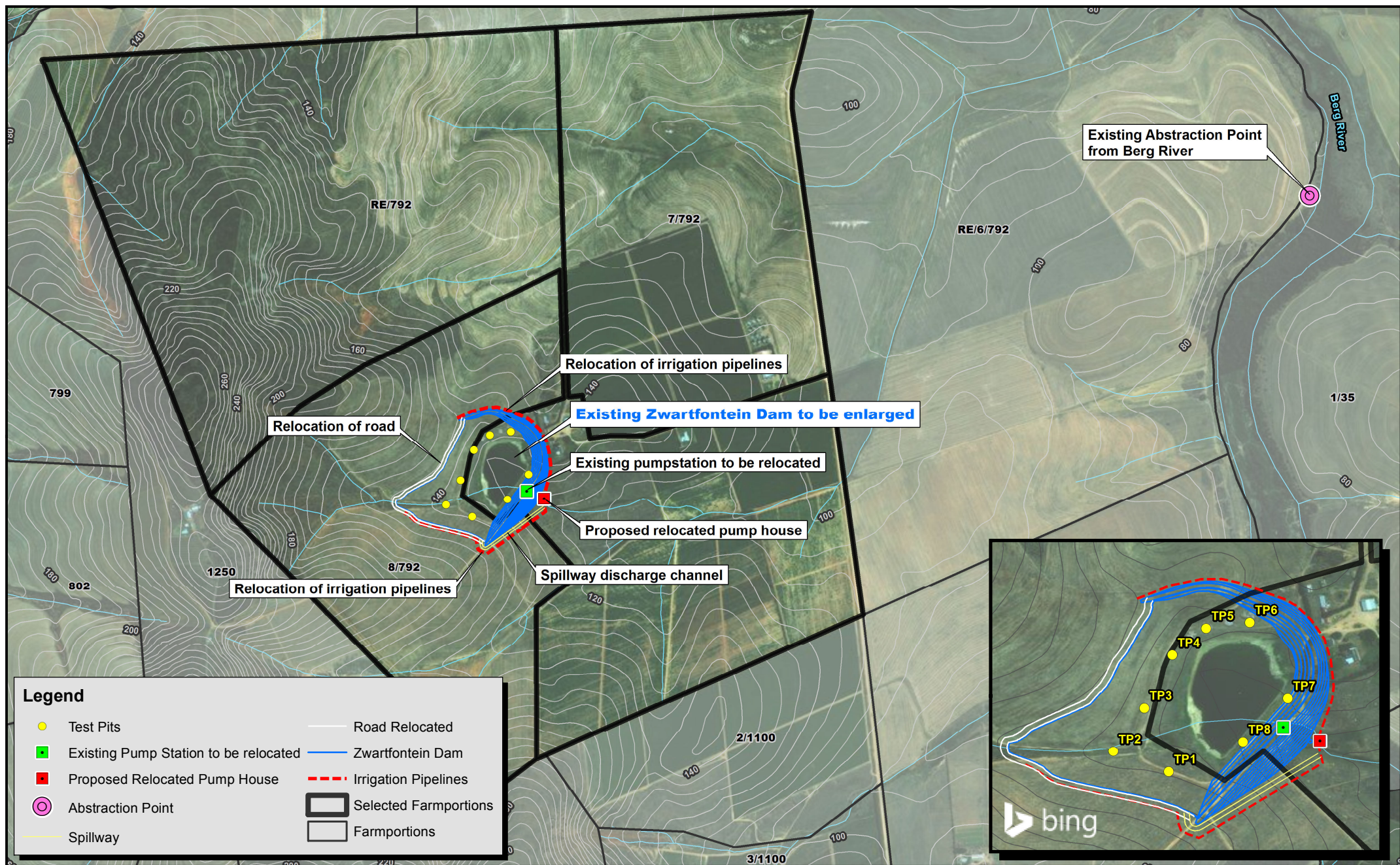
CRUMB TEST (SHERAD ET AL)

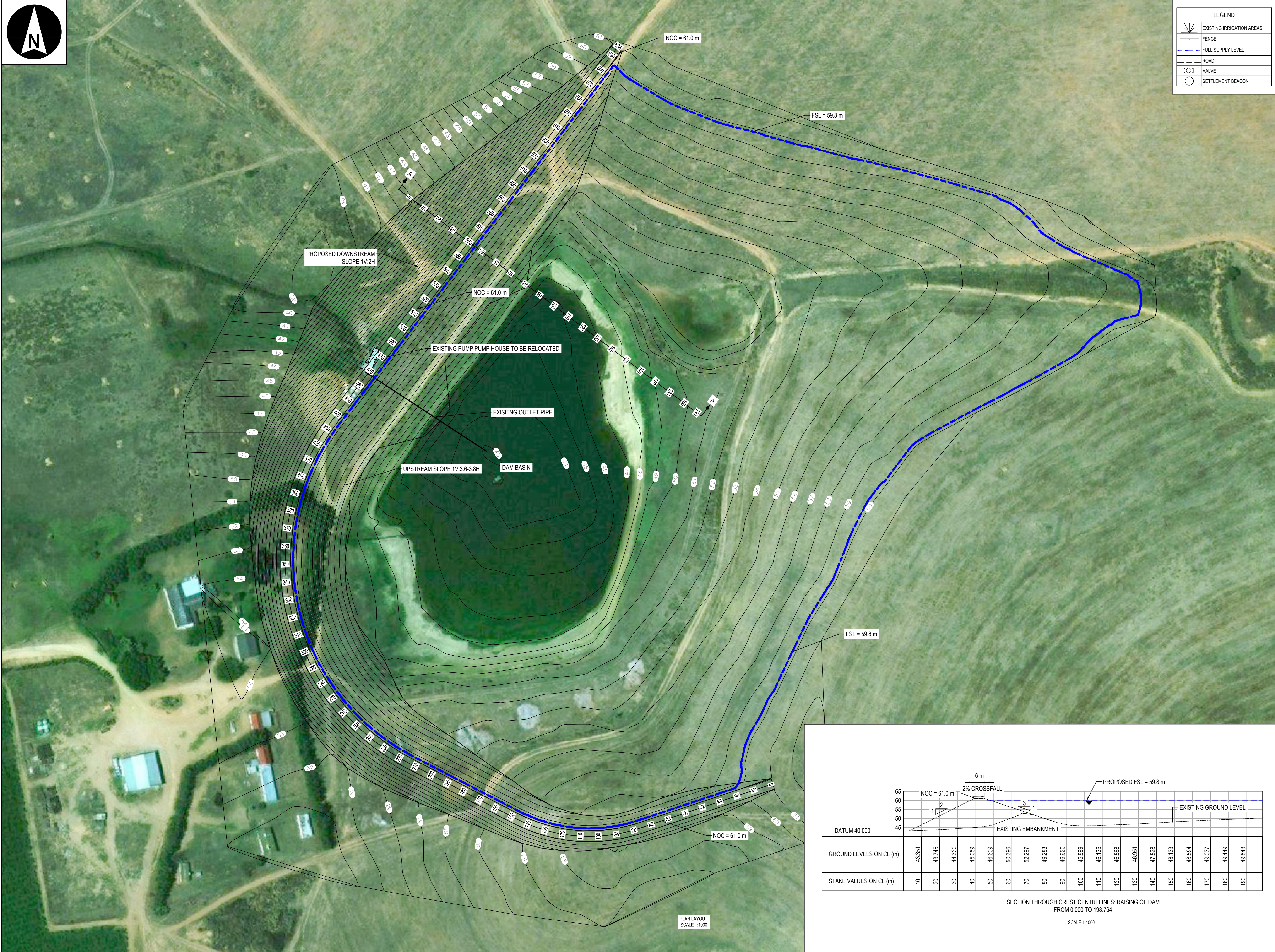
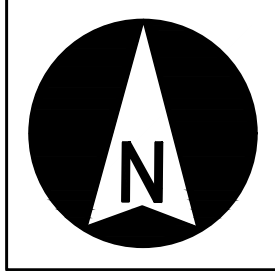
SAMPLE NO:	31607	31608				
POSITION:	TP 5	TP 7				
DESCRIPTION:						

Water (pH 4.5)	slight reaction	slight reaction				
0.001N NaOH (pH 8.5)	slight reaction	slight reaction				
0.006N NaOH (pH 10.7)	slight reaction	slight reaction				

Appendix C – Drawings







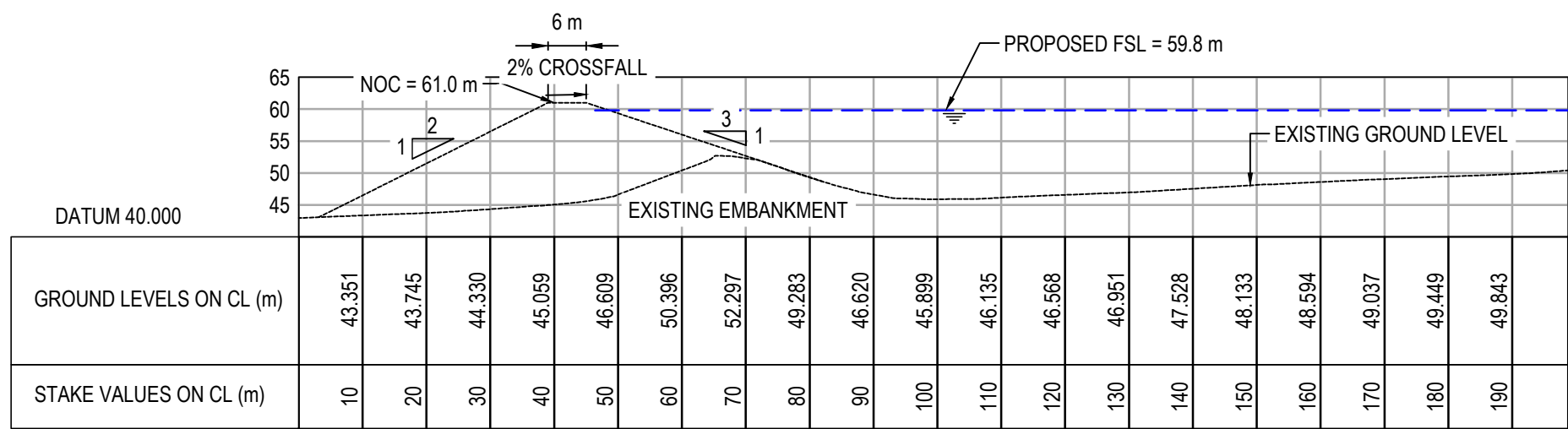
LEGEND	
	EXISTING IRRIGATION AREAS
	FENCE
	FULL SUPPLY LEVEL
	ROAD
	VALVE
	SETTLEMENT BEACON

- NOTES:
- D/S RAISING OF ZWARTFONTEIN DAM
 - NOCL: 61 m *
 - FSL: 59.8 m
 - FREEBOARD: 1.2 m
 - WATER SURFACE AREA AT FSL: 10.9 ha
 - GROSS CAPACITY: 915 000 m³
 - CREST LENGTH: 575 m
 - CREST WIDTH: 6.0 m
 - MAX WALL HEIGHT: 22.5 m
 - UPSTREAM SLOPE: 1V:3H
 - DOWNSTREAM SLOPE: 1V:3.6-3.8H
 - MIN BASIN STORAGE LEVEL: 43.5 m

* BOLAND OPMETING SURVEY (*LOCAL DATUM)

ADDITIONAL NOTES:

- CONTOUR INTERVAL 0.5 m (BASED ON LOCAL SURVEY)
PROJECTION: WGS 84/ Lo 19
- ABBREVIATIONS
 - NOCL= NON-OVERSPILL CREST LEVEL
 - FSL = FULL SUPPLY LEVEL
 - NGL = NATURAL GROUND LEVEL



GROUND LEVELS ON CL (m)	43.351	43.745	44.330	45.059	46.009	50.396	52.297	49.283	46.020	45.899	46.135	46.566	46.951	47.528	48.133	48.594	49.037	49.449	49.843
STAKE VALUES ON CL (m)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190

SECTION THROUGH CREST CENTRELINES: RAISING OF DAM
FROM 0.000 TO 198.764

SCALE 1:1000

THE MASTER HELD AT INGEROP OFFICE
BEARS THE ORIGINAL SIGNATURE OF APPROVAL

No.	DATE	REVISION	NOTES
0	09/19	FOR INFORMATION	DJ HAGEN CONSULT. ENG.

FOR INFORMATION
ORIGINAL SCALE

GENERAL NOTES
NO DIMENSION OR LEVEL TO BE SCALED OFF THIS DRAWING
ALL DIMENSIONS AND LEVELS TO BE CONFIRMED PRIOR TO CONSTRUCTION
THE POSITION OF ALL EXISTING SERVICES ARE TO BE OBTAINED FROM THE MUNICIPAL AUTHORITIES AND IF UNKNOWN THE EXACT POSITION SHALL BE DETERMINED BY CAREFUL HAND EXCAVATION.

CLIENT
UFF AFRICAN AGRICULTURE INVESTMENTS


INGEROP
CONSULTING ENGINEERS AND PROJECT MANAGERS
Office Suite 205, Tiger Lake Building, 2 Wageningen Way, Tyger Falls, Mpumalanga, 2700
Tel: (021) 914-2833, Fax: (021) 914-2816
e-mail: info@ingerop.co.za

RAISING OF ZWARTFONTEIN WELLINGTON
PLAN LAYOUT OF EXISTING EMBANKMENT OPTION 10 - D/S RAISE
SCALE : AS SHOWN

DESIGNED BY	F VAN ZYL	DRAWING CHECKED BY	DJ. HAGEN
PROF. REG. NO.		PROF. REG. NO.	
DRAWN BY	F VAN ZYL	APPROVED BY	DJ. HAGEN
PROF. REG. NO.		PROF. REG. NO.	
PROJECT No.	CC169700-L03	DATE	SEPT 2019
DRG No.	CC169700-L03	REV No.	0

SCALE : AS SHOWN	DRAWING SIZE : A1
------------------	-------------------

Appendix D – Dam Options Summary

<div><div>INGEROP</div><div>Insisting for tomorrow</div></div>	Zwartfontein Dam - Option Analysis										
	Existing	Dam Raising Options 33°30'36.05"S, 18°54'42.68"E									
	-	Option 1 (upd survey)	Option 2 (upd survey)	Option 3 (upd survey)	Option 4 (upd survey)	Option 5 (upd survey)	Option 6 (upd survey)	Option 7 (upd survey)	Option 8 (upd survey)	Option 9 (upd survey)	Option 10 (upd survey) Preferred Option
		270 000 m3 u/s raise	430 000 m3 u/s raise	510 000 m3 u/s raise	595 000 m3 u/s raise	300 000 m3 d/s raise	440 000 m3 d/s raise	550 000 m3 d/s raise	620 000 m3 d/s raise	655 000 m3 d/s raise	915 000 m3 d/s raise
Proposed NOC (masl)	Varies from 52.7m to 52.5 m	55.0	57.5	58.5	59.5	55.5	56.9	58.1	58.7	59.0	61.0
Proposed FSL (masl)	51.7	54.0	56.5	57.5	58.5	54.0	55.9	57.1	57.7	57.8	59.8
Raising (m)	0	2.3	4.8	5.8	6.8	2.8	4.2	5.4	6.0	6.3	8.3
Freeboard (m)	0.3 to 1m	1	1	1	1	1.5	1	1	1	1.2	1.2
Maximum wall height (m)	11.90	14.20	16.70	17.70	18.70	15.00	16.40	18.10	18.70	20.00	22.50
Proposed wall crest width (m)	6	6	6	6	6	6	6	6	6	6	6
Downstream slope (Vertical:Horizontal)	1V:2.2H	1V:2.2H	1V:2.2H	1V:2.2H	1V:2.2H	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H
Upstream slope (Vertical:Horizontal)	1V:3.6-3.8H	1V:3H	1V:3H	1V:3H	1V:3H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H	1V:3.6-3.8H
Fill volume required for dam wall (m³)	-	30 500	71 180	92 500	116 000	36 800	64 500	91 124	105 600	112 056	175 579
Wall length (m)	280	425	487	515	596	438	475	532	580	575	696
Capacity without cut from basin (m³)	-	238 000	358 600	415 000	470 500	260 000	372 500	458 560	511 550	540 000	739 000
Water surface area at FSL (m²)	36 468	53 631	68 690	75 111	83 428	56 100	70 000	79 550	85 750	89 935	108 530
Water surface area at FSL (Ha)	3.6	5.4	6.9	7.5	8.3	5.6	7.0	8.0	8.6	9.0	10.9
Capacity Increase (m³)	-	119 000	280 000	358 000	437 000	147 000	287 000	400 000	467 000	502 000	765 000
Total Capacity (m³)	150 000	269 000	430 000	508 000	587 000	297 000	437 000	550 000	617 000	652 000	915 000
Estimated average core trench width (m)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Estimated average core trench depth (m)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Estimated core trench volume (m³)	11 200	12 800	13 500	15 600	11 500	12 500	14 000	15 200	15 100	18 300	
Removal of unsuitable material (m³)	4 000	4 000	4 000	4 000							
Percentage core trench volume of earthworks (%)	25%	15%	12%	12%	24%	16%	13%	13%	12%	9%	
Total earthfill (m³)	45 700	87 980	110 000	135 600	48 300	77 000	105 124	120 800	127 156	193 879	
Wall Water Ratio (m³)	2.60	3.18	3.25	3.22	3.04	3.73	3.81	3.87	3.95	3.95	
Minimum basin level (m)	43.50	43.40	43.00	43.50	43.00	43.50	43.50	43.50	43.50	43.50	
Minimum downstream level (m)	40.80	40.80	40.80	40.80	40.50	40.50	40.00	40.00	39.00	38.50	
Maximum Storage depth (m)	8.2	10.6	13.5	14.5	15.0	11.0	12.4	13.6	14.2	14.3	
Preliminary & General (establish, test, overheads)		R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00	R 75 000.00
Earthworks excluding diesel		R 1 599 500.00	R 3 079 300.00	R 3 850 000.00	R 4 746 000.00	R 1 690 500.00	R 2 695 000.00	R 3 679 340.00	R 4 228 000.00	R 4 450 460.00	R 6 785 779.81
Dry Tariff (R/m)		R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00	R 35.00
Diesel usage per m³ (liter)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Diesel cost (R/liter)		R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05	R 14.05
Dieseltcost		R 642 085.00	R 1 236 119.00	R 1 545 500.00	R 1 905 180.00	R 678 615.00	R 1 081 850.00	R 1 476 992.20	R 1 697 240.00	R 1 786 541.80	R 2 724 005.89
Rebate (R/liter diesel)											
Minus rebate saving											
Outletworks (pipe, concrete, specials and valves), estimated		R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00	R 800 000.00
Total dam construction cost (excluding VAT)		R 3 116 585.00	R 5 190 419.00	R 6 270 500.00	R 7 526 180.00	R 3 244 115.00	R 4 651 850.00	R 6 031 332.20	R 6 800 240.00	R 7 112 061.80	R 10 384 785.70
Allow for 15% contingencies		R 467 487.75	R 778 562.85	R 940 575.00	R 1 128 927.00	R 486 617.25	R 697 777.50	R 904 699.83	R 1 020 036.00	R 1 066 800.27	R 1 557 717.85
Relocation of Eskom infrastructure		R -	R -	R -	R -	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00	R 120 000.00
Loss of orchards (Cost/ha)		R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00	R 400 000.00
Orchard to be removed (ha)		0.20	1.30	2.90	2.90	0.20	1.40	2.00	2.50	3.45	4.50
Loss of orchards (Cost)		R 80 000.00	R 520 000.00	R 800 000.00	R 1 160 000.00	R 80 000.00	R 560 000.00	R 800 000.00	R 1 000 000.00	R 1 380 000.00	R 1 800 000.00
Moving of pumphouse & related infrastructure						R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00	R 3 250 000.00
Professionele fees, detail design and construction inputs		R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00	R 300 000.00
BAR and water use licence applications		R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00	R 230 000.00
Project cost (excluding VAT)		R 4 194 072.75	R 7 018 981.85	R 8 541 075.00	R 10 345 107.00	R 7 710 732.25	R 9 809 627.50	R 11 636 032.03	R 12 720 276.00	R 13 458 802.07	R 17 642 503.55
R/m³ fill		R 91.77	R 79.78	R 77.65	R 76.29	R 159.64	R 127.40	R 110.69	R 105.30	R 105.84	R 91.00
R/m³ storage		R 15.59	R 16.32	R 16.81	R 17.62	R 25.96	R 22.45	R 21.16	R 20.62	R 20.64	R 19.28