DJ HAGEN
& ASSOCIATES
DAM ENGINEERING SPECIALISTS
PASSION | EXCELLENCE | INNOVATION

Report No: DJH097.2-R01

11 December 2020

Bass* Diii Berries (Pty) Ltd
Postnet Suite 137
Private Bag X3036
Western Cape
Paarl
7620

Attention: Mr Balie Swart

Dear Sir,

PROJECT NO. DJH097.2 – ENLARGED BASS* Diii DAM, WORCESTER

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

1. Introduction and background

Bass* Diii Berries (Pty) Ltd appointed DJ Hagen and Associates to undertake an investigation into feasible dam options to improve the storage capacity on their farm portion 12 of Scherpen Heuvel No 481. This storage would provide balancing storage capacity for their already existing enlistment to irrigate various types of berries and fruit up to 130 ha. The recent drought in the Western Cape, the uncertainties of the impact of climate change and job creation by means of expansion to fully utilise existing water rights are the major drivers for this project.

The proposed dam site is virtually off-channel due to an existing bypass drainage channel above the proposed dam site diverting the runoff water around the dam site with only a portion of the catchment area able to drain into the dam basin.

The proposed scheme consists of the enlargement of the existing Bass* Diii Dam to a gross storage capacity of 300 000 m^3 with a 18.3 m wall height to store a portion of the existing lawful enlistment of 1 125 076 m^3 (130.48 ha) regulated by the Central Breede River Water Users Association (CBWUA). Refer to **Section 2** for a summary of the existing and proposed water uses. A new 315 mm dia HDPE outlet pipe will be constructed in reinforced concrete underneath the dam embankment and a 315 mm dia PVC pipeline (1.4 km long) will be connected to an existing pumpstation to be expanded pumping water from the Breede River. Refer to Drawing DJH097.2-02 included in **Appendix C** for the proposed layout of the scheme and **Section 4** for a detailed description of the works.

The Bass* Diii Dam site is located 22 km south east of Worcester in the Western Cape as shown on Figure 1-1 below and Drawing DJH097.2-01 in **Appendix C**.

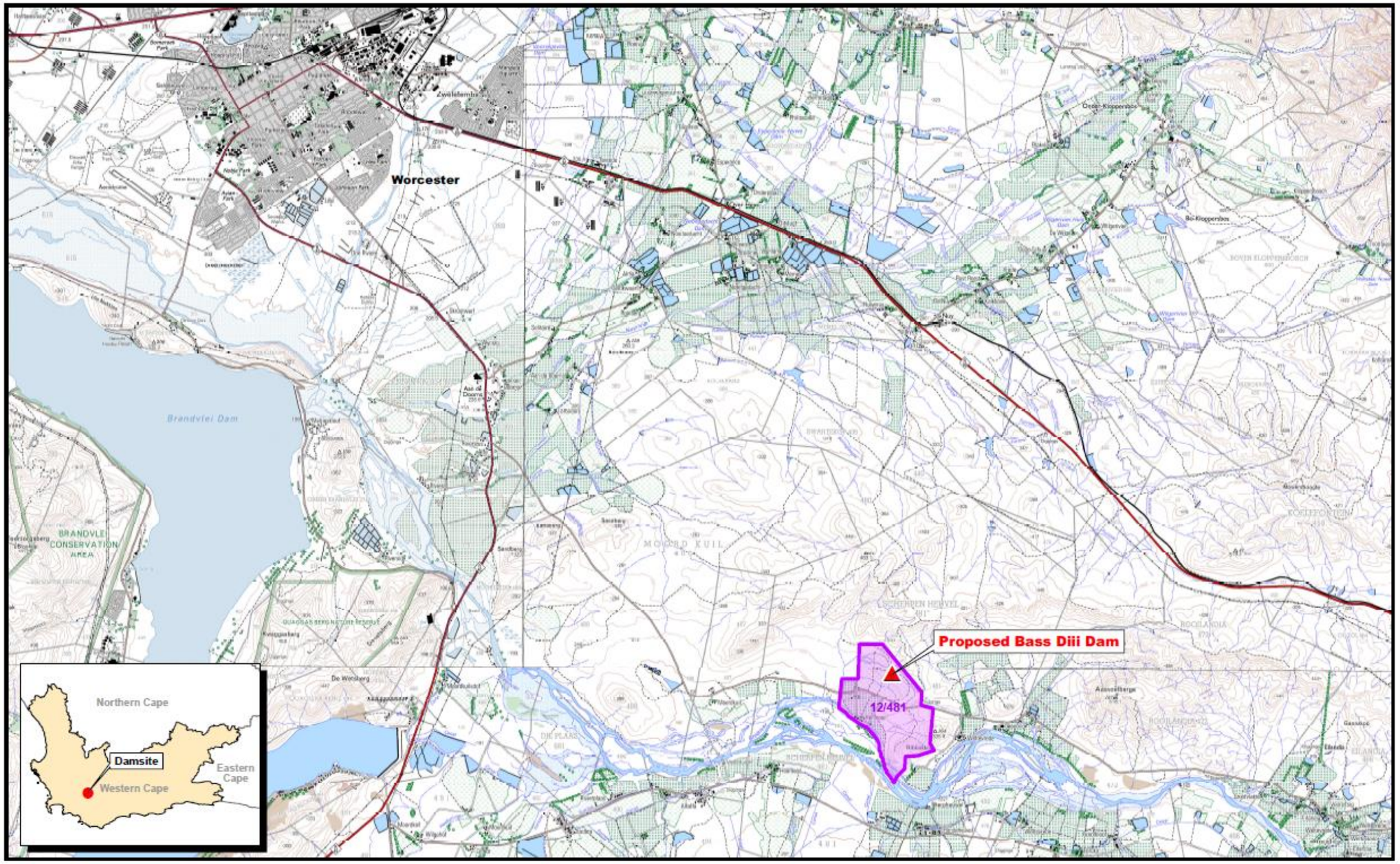


Figure 1-1: Locality map

2. Water rights

The enlarged dam is proposed to be filled with existing water enlistment allocation from the Breede River included in **Appendix A**. The farms existing enlistment (water rights) is summarised in the table below, this table also indicated the proposed storage to be applied for (marked in yellow).

Table 2-1: Summary of existing water enlistment (with application quantities marked in yellow)

Owner	Property	Size (ha)	Voorkeur uit Breerivier @ 10 000 m³/ha/a		Addisioneel uit Breerivier @ 7 450 m³/ha/a		Total taking (m³)	Existing storage (m³)	Proposed storage (m³)	Total storage (m³)
			ha	Volume (m³/a)	ha	Volume (m³/a)				
Bass Diii Berrie (Pty) Ltd	Portion 12 of Fram Scherpen Heuvel No 481	381	60	600 000	70,48	525 076	1 125 076	5 000	295 000	300 000
Total							1 125 076			300 000

It should be noted that the proposed 21 (b) – storage of water equates to only 27% storage of the total ELU 21 (a) – taking of water for the properties.

To summarise, the Water Use Application include the following:

Section 21 (b) – Storing of water to the amount of 300 000 m³/a; and

Section 21 (c) and (i) – Impeding and diverting the bed, banks and flow of a water course for the dam and all associated infrastructure of the proposed scheme summarised in **Section 4**.

3. Available surface water

The very small catchment of the enlarged dam is located in the quaternary catchment H40F, which consists of a catchment area of 340 km^2 and a Mean Annual Precipitation (MAP) of 293 mm. The catchment MAP's from WRC 2012 study (Bailey & Pitman, 2015) and Wide Area Augmentation System (WAAS, 2007) Satellites are shown in Figure 3-1 below.

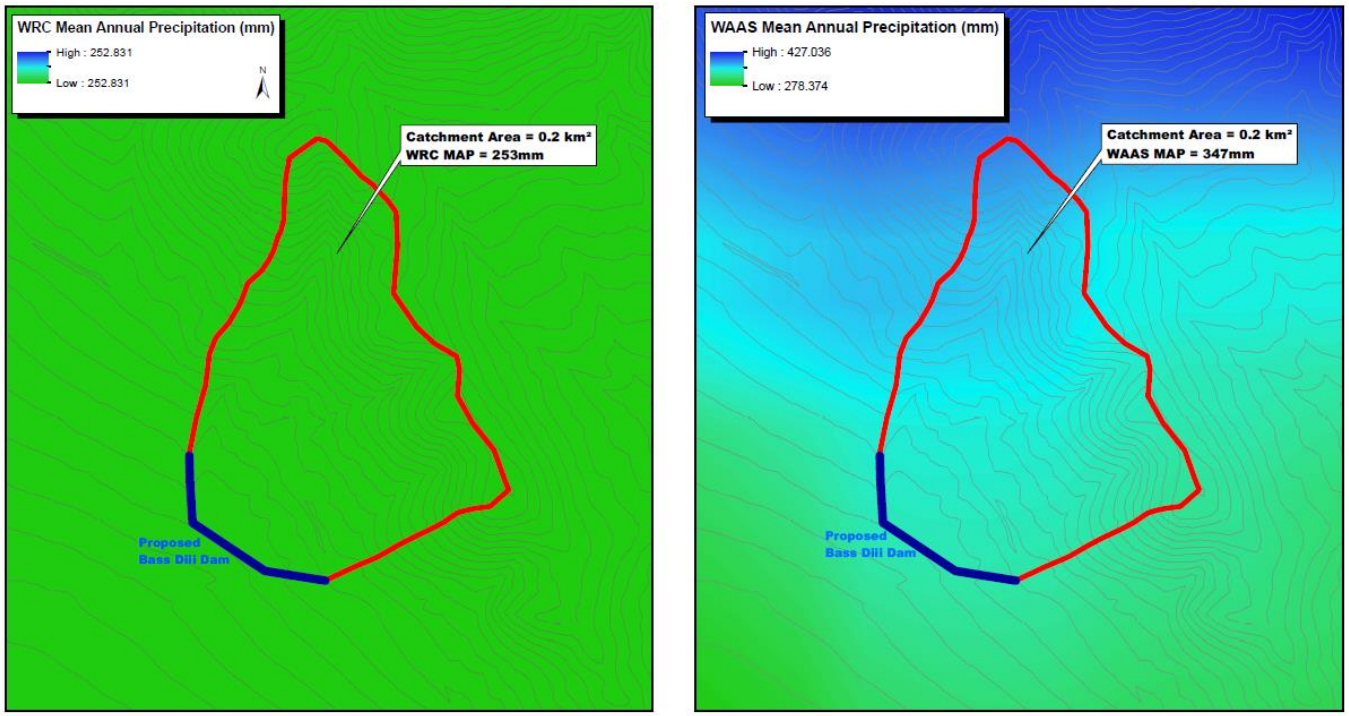


Figure 3-1: Dam catchment area with weighted MAP's (WRC – left, WAAS – right)

The catchment MAP's from WRC 2012 study (Bailey & Pitman, 2015) and Wide Area Augmentation System (WAAS, 2007) Satellites shows MAP's of 253 mm/a and 347 mm/a, respectively. The WAAS MAP is considered more representative for the catchment area, which is predominately mountainous.

The appropriate runoff percentage was assumed based on observed runoff in other parts of the Western Cape for the quaternary catchment H40F (Ninham Shand, 2009). The runoff percentage of the entire H40F quaternary catchment is <10%, which is considered to be lower than the runoff percentage for the hilly catchment area. The estimated runoff percentage for the site-specific catchment characteristics is 15%.

Due to the existing drainage channel on the left abutment (to be reconstructed upstream of the enlarged dam basin), of the catchment area, it is clear that only 50 % of the catchment runoff will reach the dam basin. Therefore, for the proposed Bass* Diii Dam, with a catchment size of 0.2 km^2 and a MAP of 347 mm, the estimated MAR (Mean Annual Runoff) was calculated as 10 000 m^3/a, thus only 5 000 m^3/a will flow into the dam basin which is < 2 % of the total proposed dam capacity and negligible. It is therefore logical that no additional EWR releases from the dam basin be made, this is supported by the freshwater specialist.

The existing and proposed relocated drainage channel is indicated in the figures below.

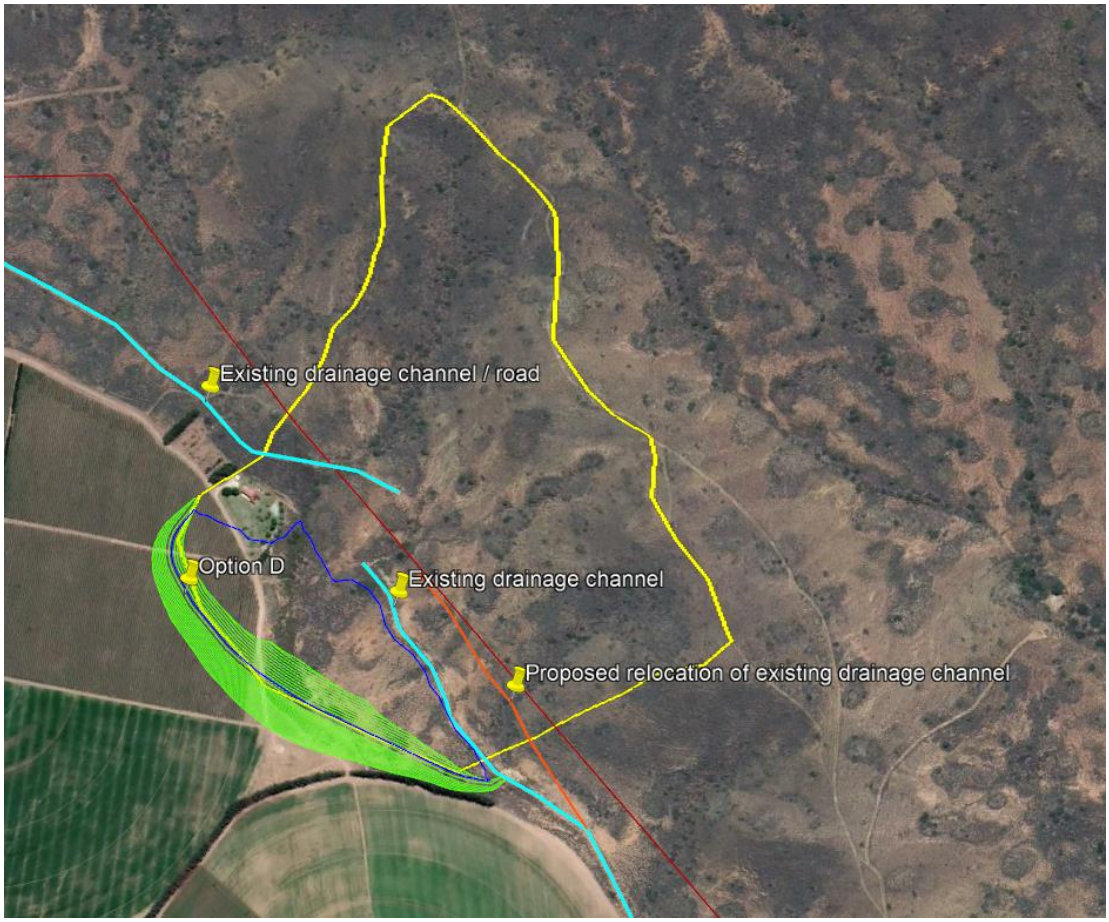


Figure 3-2: Enlarged Dam layout (green), catchment area (yellow), existing drainage channels (cyan), proposed relocation of existing drainage channel (orange) and property fence (red)

Figure 3-3: View of the existing drainage channels above the dam site

4. Proposed scheme

The project is proposed to include the following developments listed below which are shown on Figure 4-1 and Drawing DJH097.2-02 included in **Appendix C**. A summary of the project drawings is listed in Table 4-1.

4.1. Dam

- Enlargement of existing Bass* Diii Dam to a gross storage capacity of 300 000 m^3 with an earthfill embankment with a wall height of 18.3 m and a 315 mm dia HDPE Class PE100 PN8 outlet pipe connected to the new irrigation network.
- The existing bypass channel upstream of the dam to be relocated to above the proposed borrow area.
- Virgin land borrow areas for the enlargement of the existing dam (6ha in and upstream of the dam basin and 0.5 ha of waaisand to be flattended for use of filters in the embankment).

4.2. Pipelines and pump stations

- Expansion of the existing pumpstation at the Breede river with 5 m x 5 m.
- A new 315 mm dia PVC Class 8 irrigation pipeline connecting the new irrigation network and the enlarged dam with one road crossing where the irrigation pipeline crosses the Eilandia road.

4.3. Irrigation areas

- The expansion of irrigation areas up to between 120 to 130 ha, refer to Irrigation areas drawing in Figure 4-7 also included in **Appendix C**.

Table 4-1: Drawing reference summary

Drawing Description	Drawing Number (Appendix C)	Report Figure
Locality Map	DJH097.2-01	Figure 1-1
Proposed Scheme Layout	DJH097.2-02	Figure 4-1
Test pits	DJH097.2-03	Figure 5-2
Option D layout	DJH097.2-04	Figure 4-5
Irrigation areas	353	Figure 4-8

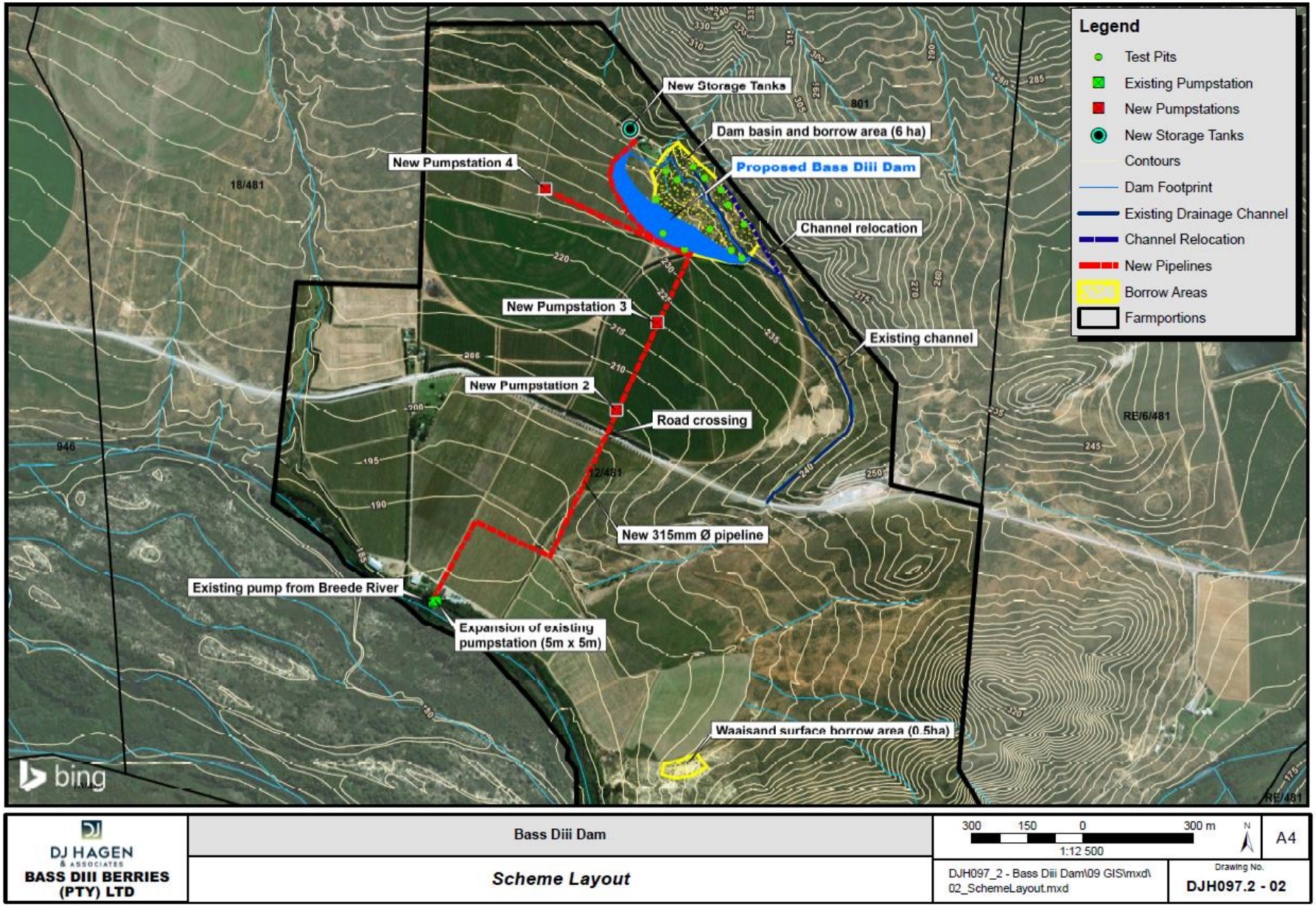


Figure 4-1: Proposed scheme layout of Enlarged Bass* Diii Dam

The existing embankment and drainage channel upstream of the dam (to be partly relocated) is indicated below along with 1997 and 2003 imagery indicating the existing dam. The layout drawing for the enlargement Option D is shown in Figure 4-5 and included in **Appendix C**.

Figure 4-2: Existing embankment and dam basin in foreground

Figure 4-3: Existing bypass channel upstream of the embankment to be partly relocated

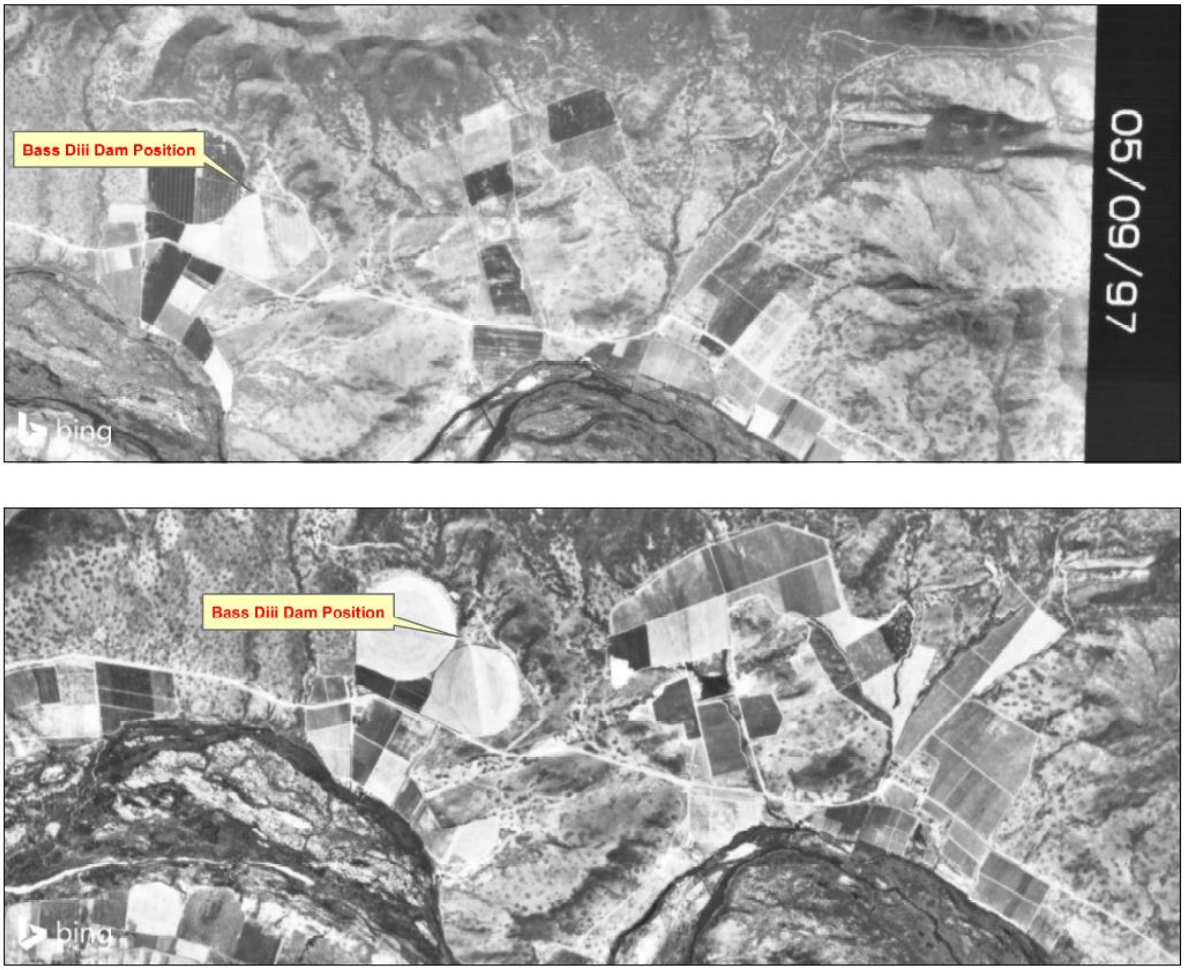
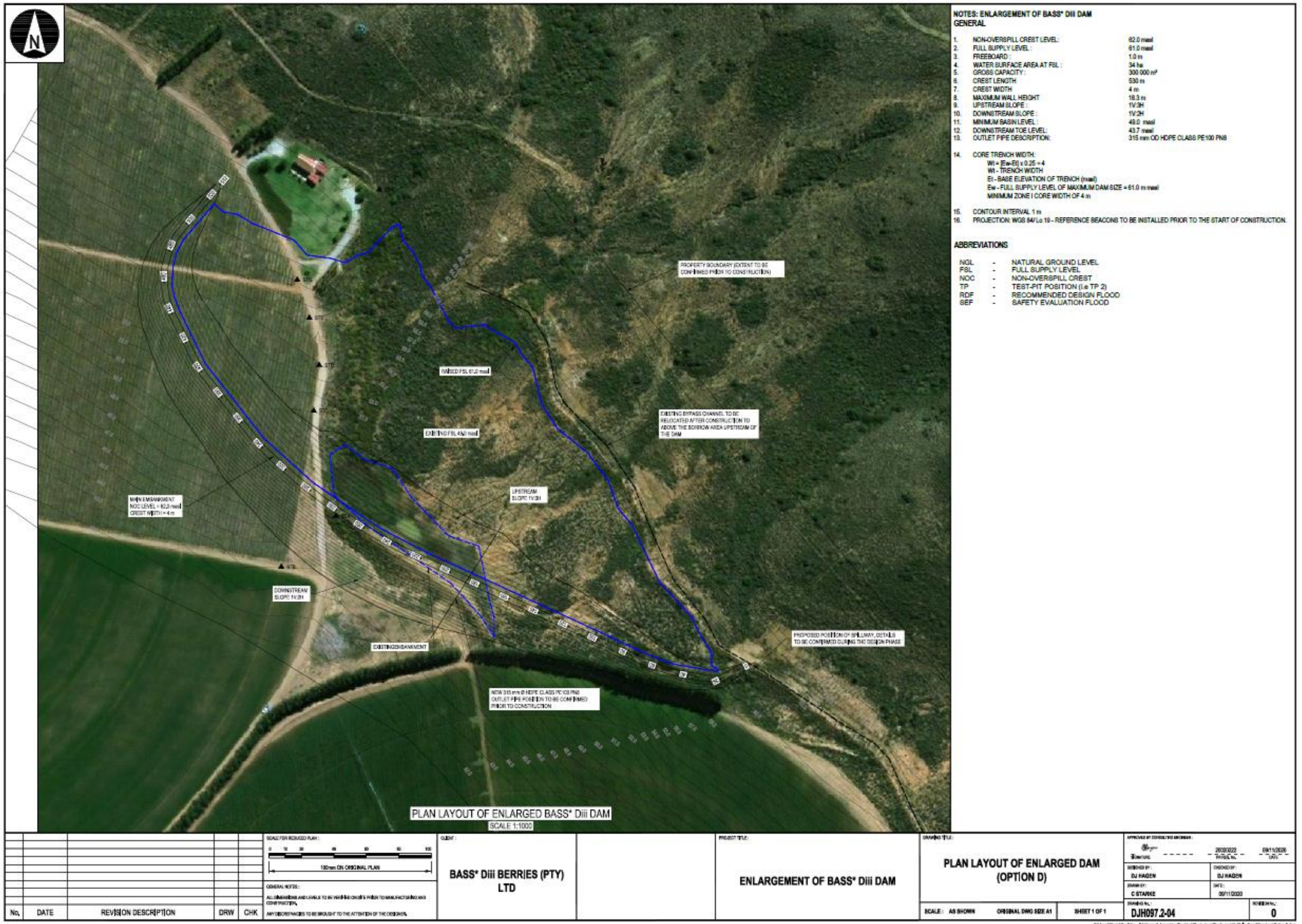


Figure 4-4: 1997 and 2003 imagery indicating the existing Bass* Diii Dam



PLAN LAYOUT OF ENLARGED BASS* Diii DAM
SCALE 1:1000

NOTES: ENLARGEMENT OF BASS* DIII DAM
GENERAL

1.	NON-OVERSPILL CREST LEVEL:	62.0 masl
2.	FULL SUPPLY LEVEL :	61.0 masl
3.	FREEBOARD :	1.0 m
4.	WATER SURFACE AREA AT FSL :	34 ha
5.	GROSS CAPACITY :	300 000 m³
6.	CREST LENGTH	530 m
7.	CREST WIDTH	4 m
8.	MAXIMUM WALL HEIGHT	18.3 m
9.	UPSTREAM SLOPE :	1V:3H
10.	DOWNSTREAM SLOPE :	1V:2H
11.	MINIMUM BASIN LEVEL :	49.0 masl
12.	DOWNSTREAM TOE LEVEL:	43.7 masl
13.	OUTLET PIPE DESCRIPTION:	315 mm OD HDPE CLASS PE100 PN8

14. CORE TRENCH WIDTH:
    Wt = [Ew-Et] x 0.25 + 4
    Wt - TRENCH WIDTH
    Et - BASE ELEVATION OF TRENCH (masl)
    Ew - FULL SUPPLY LEVEL OF MAXIMUM DAM SIZE = 61.0 m masl
    MINIMUM ZONE I CORE WIDTH OF 4 m
15. CONTOUR INTERVAL 1 m
16. PROJECTION: WGS 84/ Lo 19 - REFERENCE BEACONS TO BE INSTALLED PRIOR TO THE START OF CONSTRUCTION.

ABBREVIATIONS

NGL	-	NATURAL GROUND LEVEL
FSL	-	FULL SUPPLY LEVEL
NOC	-	NON-OVERSPILL CREST
TP	-	TEST-PIT POSITION (i.e TP 2)
RDF	-	RECOMMENDED DESIGN FLOOD
SEF	-	SAFETY EVALUATION FLOOD

No.	DATE	REVISION DESCRIPTION	DRW	CHK

SCALE FOR REDUCED PLAN : 0 10 20 40 60 80 100
100mm ON ORIGINAL PLAN
GENERAL NOTES:
ALL DIMENSIONS AND LEVELS TO BE VERIFIED ON SITE PRIOR TO MANUFACTURING AND CONSTRUCTION.
ANY DISCREPANCIES TO BE BROUGHT TO THE ATTENTION OF THE DESIGNER.

CLIENT : BASS* Diii BERRIES (PTY) LTD

PROJECT TITLE: ENLARGEMENT OF BASS* Diii DAM

DRAWING TITLE: PLAN LAYOUT OF ENLARGED DAM (OPTION D)

SCALE : AS SHOWN | ORIGINAL DWG SIZE A1 | SHEET 1 OF 1

APPROVED BY CONSULTING ENGINEER : 28/03/2022
DESIGNED BY : DJ HAGEN
CHECKED BY : DJ HAGEN
DRAWN BY : C STARKE
DATE : 09/11/2020
DRAWING No. : DJH097.2-04
REVISION No. : 0

Figure 4-5: Plan layout of the enlargement Option D

The proposed waaisand borrow area and the existing Breede river pumpstation/configuration is also indicated below.

Figure 4-6: Waaisand proposed filter sand borrow area

Figure 4-7: Existing pump configuration from the Breede River

The proposed irrigation areas **are indicated in the figure below and the Drawing included in Appendix C.**

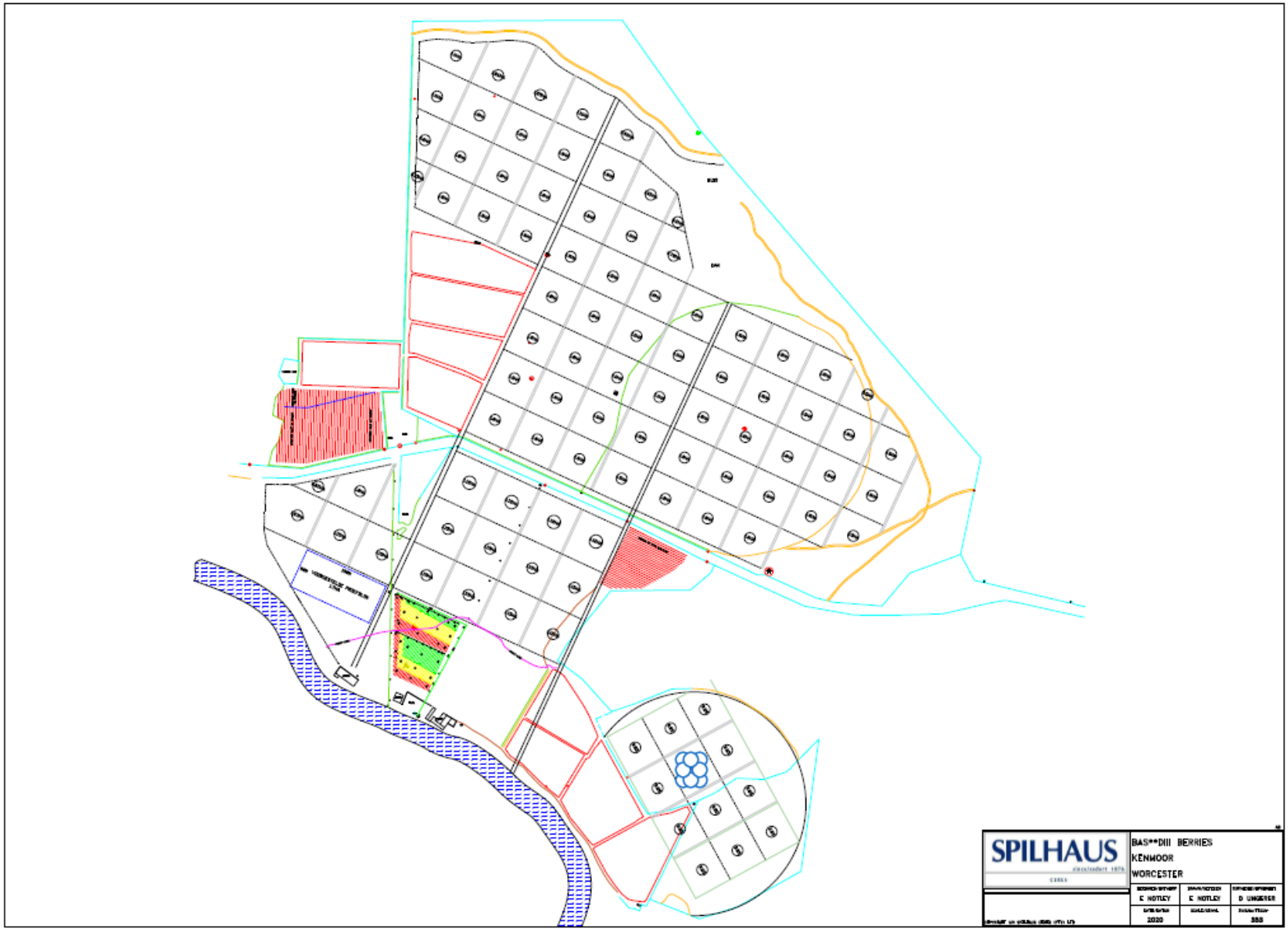


Figure 4-8: Proposed irrigation areas

5. Geotechnical

5.1. Regional geology

The regional geology map (3319 Worcester, 1:250 000 series) (RSA, 1973) indicates that the dam site is possibly underlain by dark-grey to grey-black shale, mudstone and siltstone (Pt) from the Ecca group as shown in the figure below. A syncline is indicated to cross the proposed enlarged embankment. It is expected that the rock joints may be open in the syncline area, therefore the recommended deep core trench excavation (refer to Section 5.2). It is also noted that the road quarry located south of the dam site is located in a different geological formation.

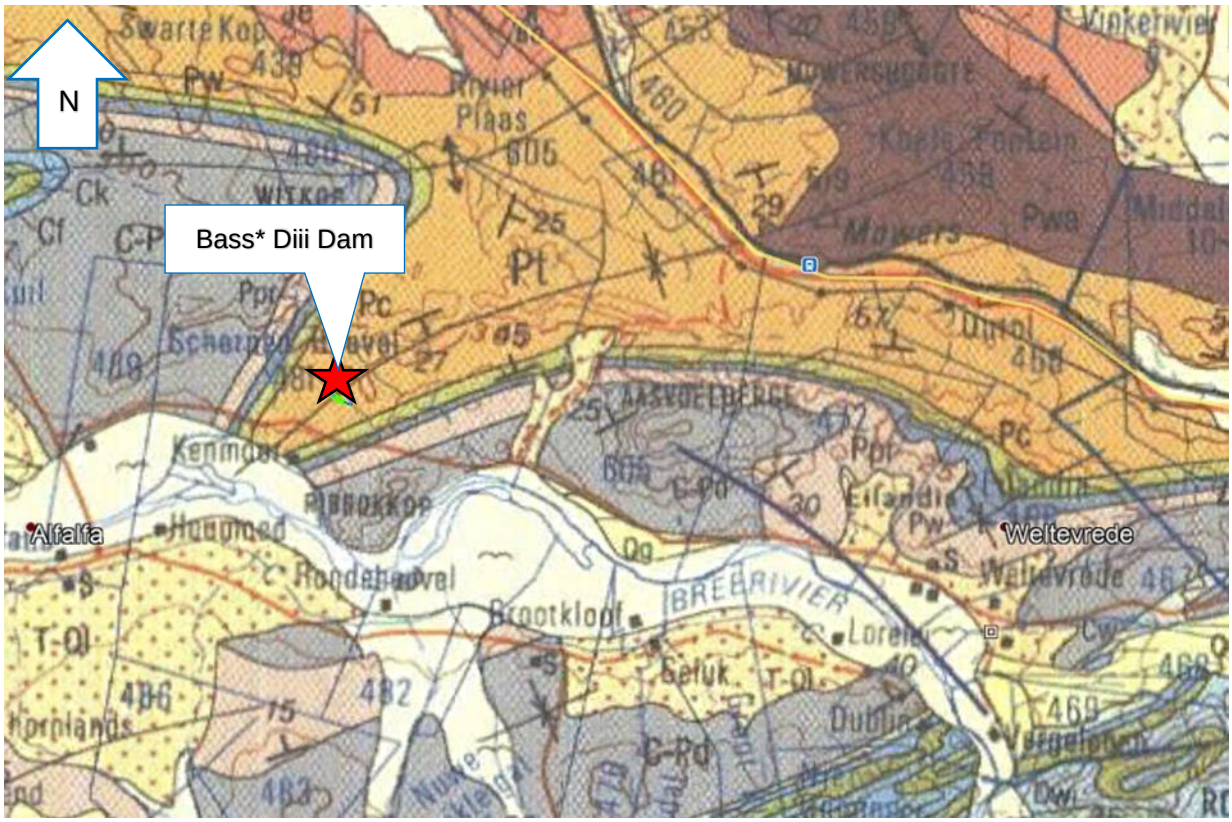


Figure 5-1: Regional geology at dam sites (marked with red asterisks)

5.2. Foundation and construction materials

Geotechnical test pits were excavated along the centreline of the proposed enlarged embankment and in the dam basin and proposed borrow area upstream of the dam on 03 November 2020, to determine the depth of the core trench and availability of the construction materials in the dam basin. A total of 13 test pits were excavated as shown in **Figure 5-2**. Refer **to Figure 5-3** to **Figure 5-6** for photographs of some of the test pits.

Three basin samples (TP 6, 10 and 13) were taken to the laboratory for further testing. Testing methods that were requested on the samples include foundation indicators, SCS double hydrometer (dispersivity), permeability and crump test (dispersivity). A sand sample was also taken from the "waaisand" borrow area for a grading analysis.

The foundation conditions appear to be acceptable for the proposed enlarged Bass* Diii Dam provided that the core trench is excavated to a sufficient depth. The estimated average founding depth of the embankment is expected to be approx. 6m into slightly weathered to hard shale rock. Where fractured

bedrock is encountered the excavations may be deeper. In a test pit previously excavated near the central section of the embankment in the dam basin standing water was noted on the in-situ rock, which is a good sign in terms of impermeability. Bedrock was not yet reached in Test Pit No 3, but in 2, 4 & 5. TP 1 showed groundwater inflow originating either from the stream or irrigation of the of the property above it.

From the test results it can be summarised that the dam site contains sufficient clay and general fill material to be placed in the core trench, core, general fill and gravel capping zones. Sand for the filters is proposed to be borrowed from the identified "waaisand" area approx. 2.5 km (one-way) from the dam site. Rock for rip-rap upstream slope protection and rock toe is expected to be ripped from the dam basin and is available from existing stockpiles on the farm.

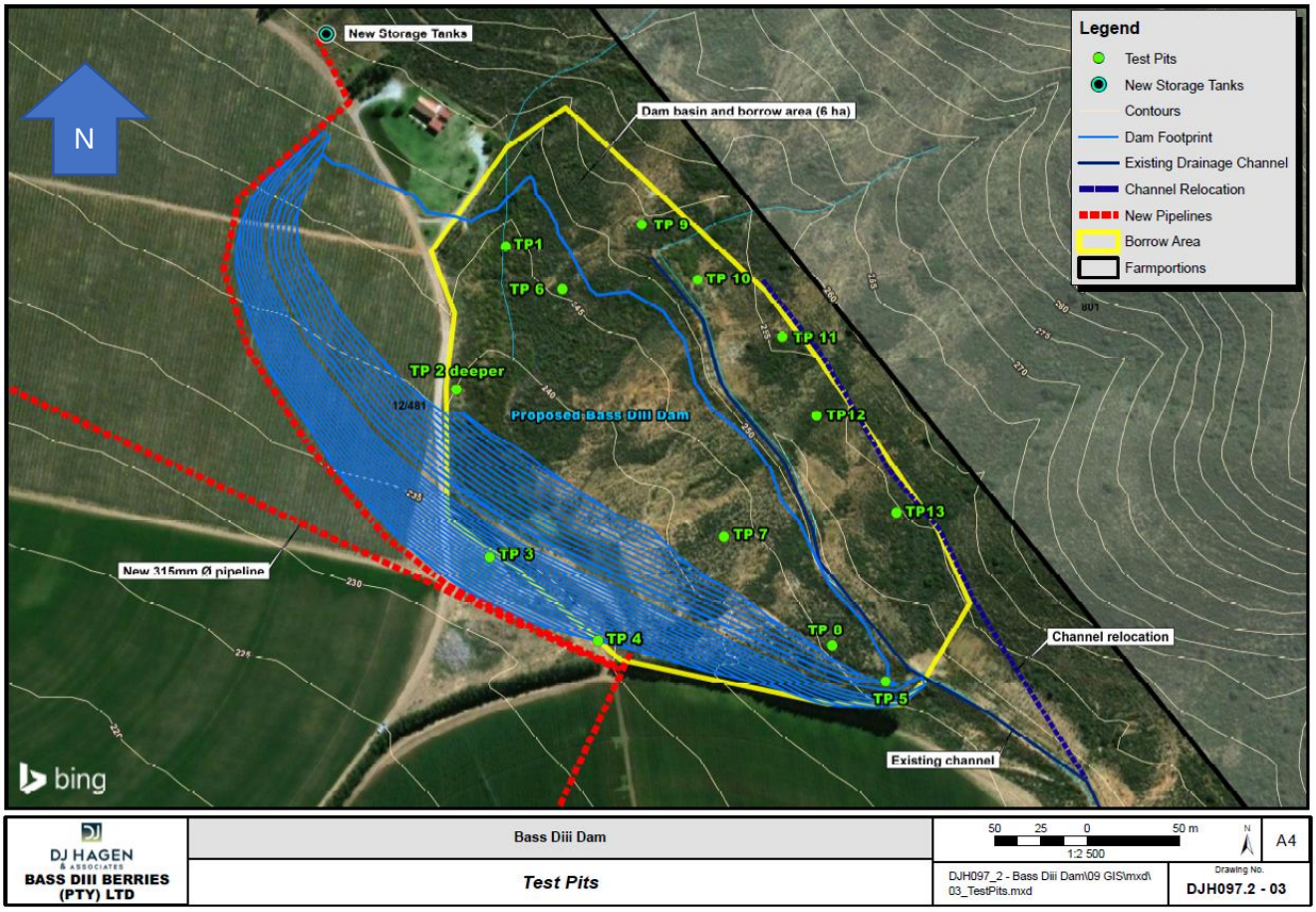


Figure 5-2: Positions of test pits overlaid on the proposed enlarged Bass*Diii Dam footprint (Option D)

The summary and results of the abovementioned geotechnical investigation are included in **Appendix B**.

According to the Unified Soil Classification System (USCS), the sand is classified as SP (waaisand) and SW-SM (TP13) and the core material classification varies between SC and SC-SM. Although the clay content of 13 to 19 % is acceptable according to the Druyts (1988) or van Schalkwyk (1991), the soil (for core material) should have a clay content between 10 % and 30 %, the silt content (12 to 13 %) is good which makes the tested material acceptable for an impermeable core together with the permeability of 7.53 x 10^{-7} cm/s.

The clay samples (TP 6 and TP 10) were classified and is considered acceptable based on the following properties:

% Fines: 25 to 32
% Clay: 13 to 19
Plasticity index: 6 to 11
Classification SC (Clayey sand with gravel) to SC-SM (Clayey silty sand).

As the dispersivity of the core material samples (TP6 and TP10) with the SCS Double Hydrometer test indicated 13.5 to 14.2 % (non-dispersive) and the crumb test indicated no reaction, the TP13 sample (sand/general fill) indicated 407.5 % (highly dispersive) and the crumb test indicated a strong reaction, therefore, the following design allowances will be made to combat the dispersive soil properties:

- Compaction of the clay core: Core to minimum 98% PROCTOR Density at a moisture content between Optimum Moisture content (OMC) and + 3% OMC; and
- Internal drainage system comprising of a downstream sand filter chimney and blanket drain (expected finger drains) connected to a rock toe drain with a gravel filter.

Further material testing (PROCTOR Density, permeability, etc.) will be conducted prior to the design phase with frequent density testing to be undertaken during construction to ensure sufficient compaction of the various zones.

Figure 5-3: TP 4 located below the embankment footprint, note weathered shale rock encountered at the bottom of the test pit

Figure 5-4: TP 6 located in the dam basin (clayey material sample taken for testing), note visible rock veins

Figure 5-5: TP 10 located in the borrow area above the dam basin (clayey material sample taken for testing)

Figure 5-6: TP 13 located in the borrow area above the dam basin (material sample taken for testing)

6. Dam options analysis

6.1. Location alternatives

Raising of the existing embankment and a site upstream of the existing embankment was considered for the enlarged Bass Diii Dam. Due to the natural state (virgin land) and therefore expected more environmental impact, the steep topography, the more expensive construction estimate and the fact that the applicant does not own the alternative site property, the alternative upstream site was not further investigated. The raising of the existing embankment option makes sense due its location above the targeted irrigation areas and existing impact of the existing dam and drainage channel.

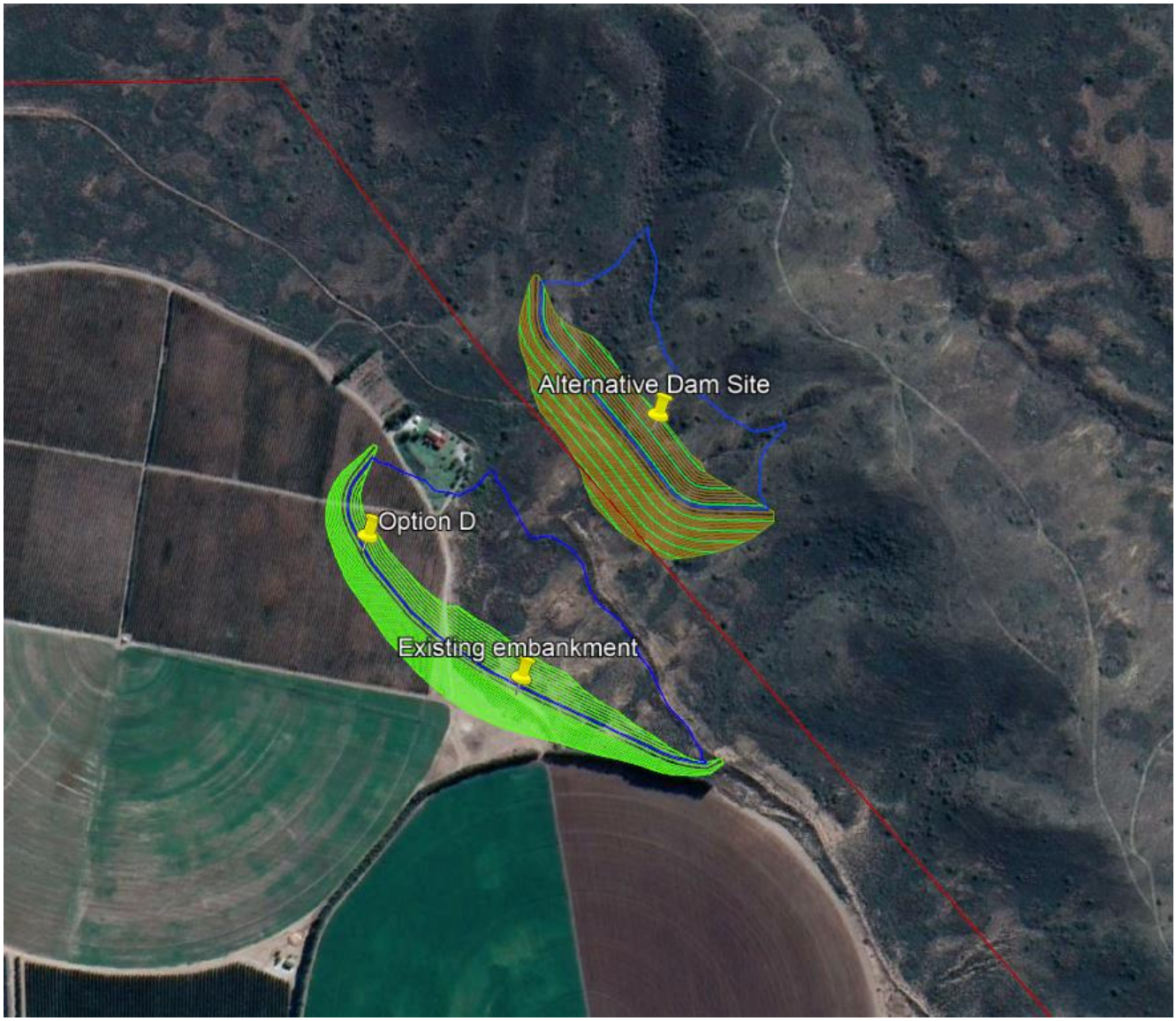


Figure 6-1: Aerial layout of the various site options investigated

6.2. Enlargement of existing embankment options analysis

A total of 4 dam options were modelled for the enlargement of the existing embankment. A gross storage capacity of 300 000 m^3 were aimed for and therefore Option B and D is considered applicable. Refer to Figure 6-2 below for an aerial layout and summary of the options analysis included in **Appendix D**.

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 centreline. Option

D indicates a much more economical dam centreline with a water/wall ratio of 1.62 vs 0.93 and a unit cost of R35.30 vs R60.08 compared to Option B. The significant variation is the material availability in the dam basin as the material available for borrowing in and above the dam basin of Option D (90% material obtained from the dam basin below FSL) is much more than the material available in and around Option B (20% material obtained from the dam basin below FSL) not passing the applicants existing property boundary. Option D was therefore further listed as the preferred option. This option will result in the loss of 2 ha of existing irrigation land, but less natural vegetation above the dam basin.

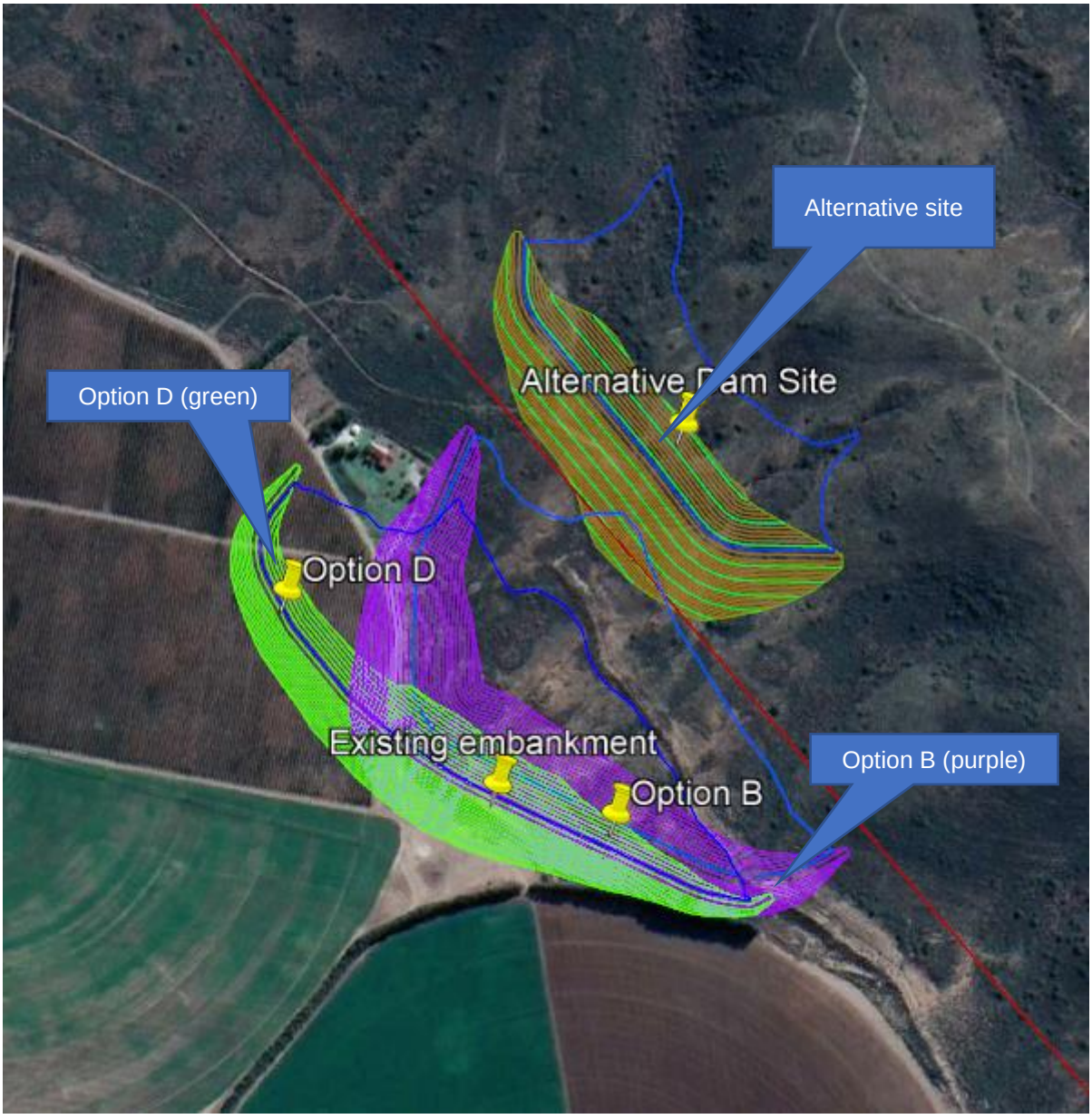


Figure 6-2: Aerial layout of dam options B, D and alternative dam site

Table 6-1: Summary of dam option comparison Option B and D including the statistics of the existing dam

DJ HAGEN & ASSOCIATES DAM ENGINEERING SPECIALISTS PASSION | EXCELLENCE | INNOVATION	Bass* Diii Dam		
	Existing Dam	DJ Hagen and Associates	
	Based on Survey	Based on Survey	
		Option B	Option D
	5 000 m³	330 000 m³	300 000 m³
Proposed NOC (m)	50	70	62
Proposed FSL (m)	49	69	61
Rasing of NOC (m)		20	12
Raising of FSL (m)	0	20	12
Freeboard	1	1	1
Maximum wall height (m)	4,80	26,30	18,30
Proposed Wall crest width (m)	4	4	4
DS Dam wall Slope	1V:2H	1V:2H	1V:2H
US Dam wall Slope	1V:3H	1V:3H	1V:3H
New Wall Fill above NGL (m^3)		306 200	146 000
Wall length (m)	0	545	530
Capacity without cut from basin (m^3)		263 800	169 000
Water surface area at FSL (m^2)	3 500	43 400	39 600
Water surface area at FSL (Ha)	0,35	4,3	4,0
Available borrow area (m^2)		18 000,0	40 000,0
Average excavation depth (m)	**0,0**	**3,4**	**3,3**
Total Capacity (m^3)	**5 000**	**325 040**	**300 000**
% Earthfill available from the dam basin		**20%**	**90%**
Additional Capacity	**0**	**320 040**	**295 000**
Estimated average core trench width (m)		5,8	5,3
Estimated average core trench depth (m)		6,0	6,0
Estimated core trench volume (m^3)		38 500	35 800
Percentage core trench volume of earthworks (%)		11%	20%
Total earthfill (m^3)	**0**	**344 700**	**181 800**
Wall Water Ratio (m^3)		**0,93**	**1,62**
Minimum basin level (m)	47,00	52,70	49,00
Minimum downstream level (m)	45,20	43,70	43,70
Maximum Storage depth (m)	2,0	16,3	12,0
Site establishment and geotechnical testing		**R 50 000,00**	**R 50 000,00**
Earthworks without diesel		**R 12 064 500,00**	**R 6 363 000,00**
Dry rate (R/m)		R 35,00	R 35,00
Diesel consumption per m^3 (liter)		1,0	1,0
Diesel price (R/liter)		R 11,80	R 11,80
Diesel cost		**R 4 067 460,00**	**R 2 145 240,00**
Rebate (R/liter diesel)			
Minus rebate saving			
Outlet pipe (pipe, concrete, specials and valves), estimated		**R 800 000,00**	**R 650 000,00**
Totale construction cost (VAT excluded)		**R 16 981 960,00**	**R 9 208 240,00**
Allowed for 15% contingencies		R 2 547 294,00	R 1 381 236,00
Professional fees, investigation phase			
Professional fees, detail design and construction inputs			
EA and water licence applications			
Proejct cost (VAT excluded)		**R 19 529 254,00**	**R 10 589 476,00**
R/m^3 fill		R 56,66	R 58,25
R/m^3 storage		R 60,08	R 35,30

6. Legal requirements

6.1. Environmental authorisation

A Basic Assessment Report (BAR) process for the environmental authorisation is required and will be undertaken by Messrs EnviroAfrica Environmental Consultant Services for the construction of the dam and its associated infrastructure.

6.2. Water use license

Applications for Section 21 b), c) and i) water uses will be required. Messrs HDL Consulting will embark on the process.

6.3. Dam safety

The dam safety process will commence with the application for classification of the proposed enlarged Bass* Diii Dam. A Category II classification is expected for the dam due to the capacity, wall height and expected hazard potential. The design and application for the licenses to construct will follow when the other authorisation processes are further advanced.

7. Project cost estimate

A provisional total project cost estimate for the project (excluding escalation to and during construction) can be summarised as follows. The construction cost estimate for the dam is at feasibility level and further development costs should still be confirmed.

Item no and description	Cost (million R, excl. VAT)[1)]
1. Construction	
1.1 Bass* Diii Dam (Option D)	10.6
1.2 Development costs (Including pumpstations, pipelines etc.)	To be confirmed
Sub-total	**10.6**
2. Professional costs	
2.1 Engineering of dams	0.4
2.2 Authorisation processes	0.3
Sub-total	**0.7**
Total	**11.3**

1) Estimated in October 2020

Yours faithfully,

DJ Hagen and Associates

DJ Hagen Pr.Eng/APP

DJ Hagen and Associates

C Starke Engineer

References

A.K., Dec. 1984. The Revised ASTM Standard on the Unified Soil Classification System. Geotechnical Testing Journal, 7 (4): 216-222

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

RSA. (1973). Geological Survey Maps. Republic of South Africa, 1973.

RSA, “National Water Act (No 36 of 1998): Dam Safety Regulations (R139 of 2012),” Republic of South Africa, Pretoria, 2012.

Appendix A – Provided Information

SENTRAAL-BREëRIVIER WATERGEBRUIKERSVERENIGING
CENTRAL BREEDE RIVER WATER USERS ASSOCIATION
Tel (023) 626 2451
Faks/Fax (023) 626 5259
E-pos/E-mail breewater@lando.co.za
Paul Krugerstraat 45 Paul Kruger Street
Posbus 232 P O Box
6705 ROBERTSON

10 Desember 2020

SERTIFIKAAT VAN WATERGERUIKSREG

Hiermee word gesertifiseer dat die eiendom hieronder genoem vir 130.48 ha ingelys is vir water uit die Groter-Brandvleidamwaterwerke geleë binne die Breërivier Staatswaterbeheergebied:

Eienaar	**Eiendom**	**Voorkeur uit Breërivier @ 10 000 m³/ha/jaar**	**Addisioneel uit Breërivier @ 7 450 m³/ha/jaar**
BASS DIII BERRIES (PTY) LTD	Restant Gedeelte 12 van die Plaas Scherpen Heuvel 481, Afdeling Worcester, Groot 381.2485 ha	60.00 ha	70.48 ha

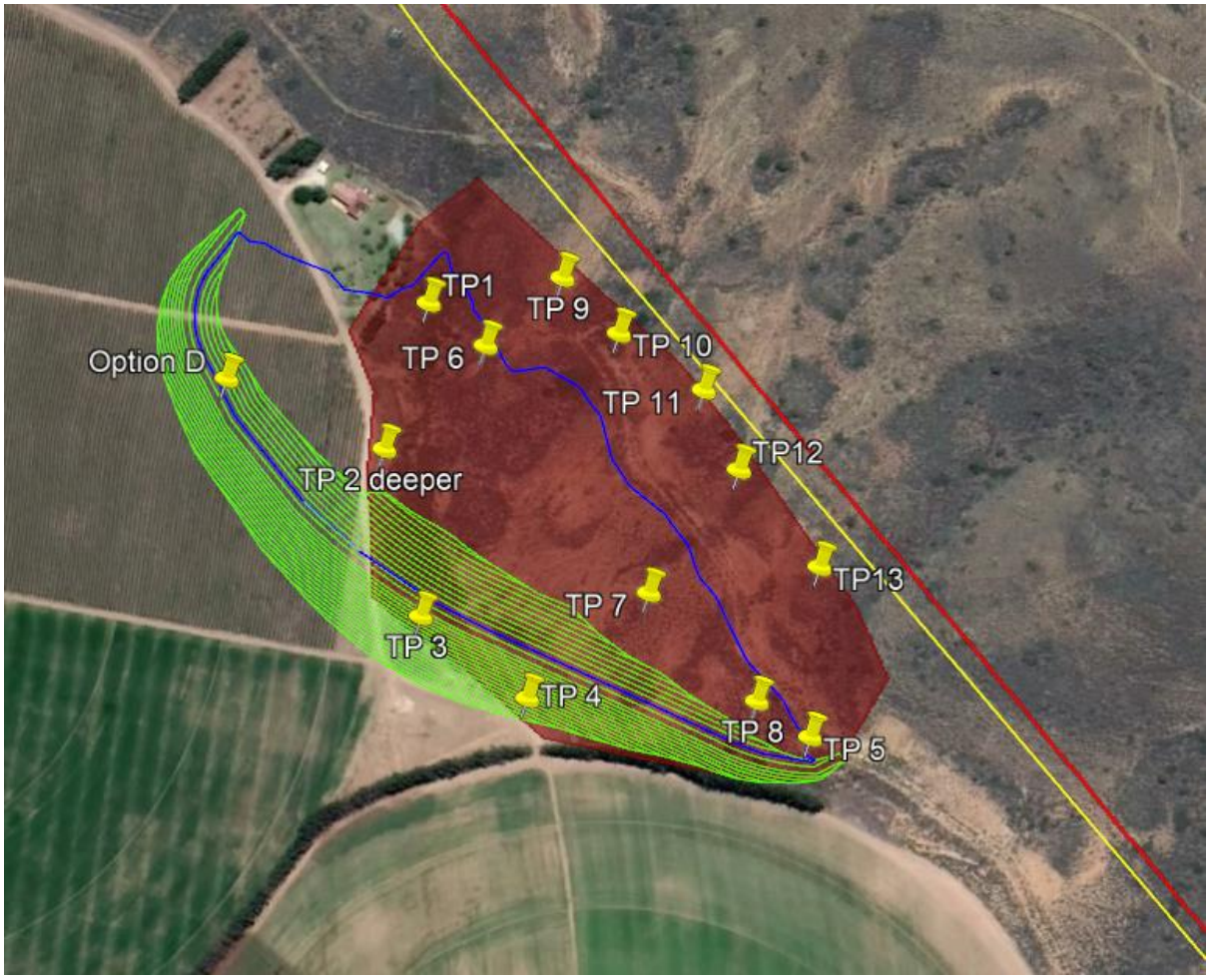
Gesertifiseer te Robertson op 10 Desember 2020

.....
HOOF-UITVOERENDE BEAMPTE

Sentraal-Breërivier
Watergebruikersvereniging
Posbus 232 Robertson 6705
Tel. 023-626 2451

Appendix B – Geotechnical Results

Bass Diii Dam Geotechnical investigation completed 3 November 2020



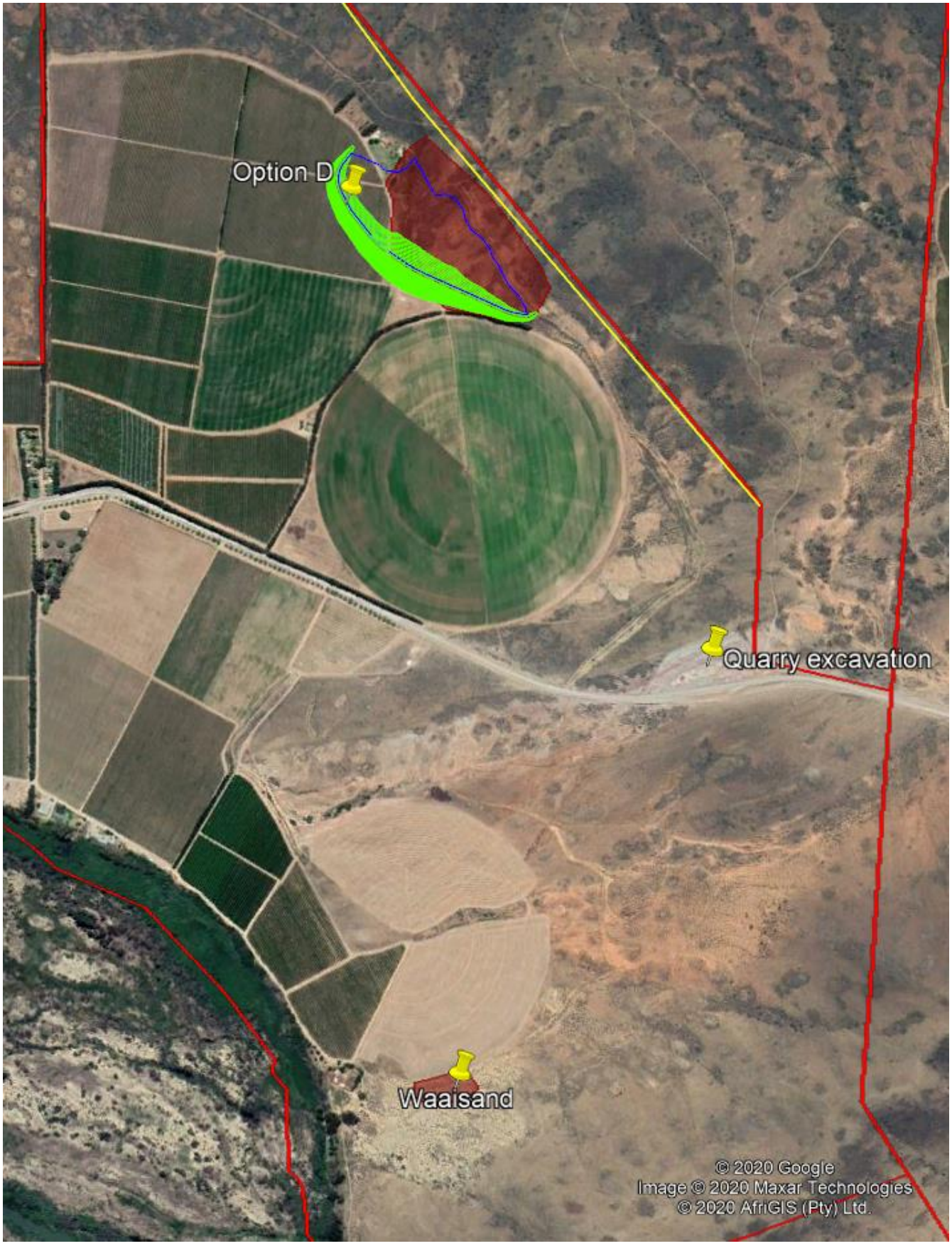


Figure 1: Aerial layout of Bass Diii Dam and position of test pits completed during the geotechnical investigation

Test pit No TP1		
General location	In the dam basin – inflow channel (General fill borrow area)	
Ground water level/ inflow depth	Water present in the test pit (unknown level)	
Depth (m)	**Description**	**Photos**
0 to 0.3	Overburden	
0.3 to 2.6	Sandy general fill material	
	Water seeping in	

Test pit No TP2		
General location	In the dam basin (upstream of the toe)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 1.5	Overburden (dispersive nature expected, note holes)	
1.5 to 4.6m	Red to yellow clayey sand	
	Weathered shale encountered	

Test pit No TP3		
General location	Below embankment (central)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 2.6	Sandy, clayey? Material	
	No hard rock noted, but 20T excavator max excavation depth	

Test pit No TP4		
General location	Below embankment (central)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 3.5	Sandy clayey material	
	Excavation into weathered shale rock	

Test pit No TP5		
General location	Below embankment (left flank)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.4	Overburden / topsoil	
0.4 to 3.3	Sandy clayey material with visible rock veins	
	Hard excavation	

Test pit No TP6 (Clay sample taken)		
General location	In dam basin	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.3	Overburden	
0.3 to 1.6	Sandy clay expected with visible rock veins	
	Hard excavation	

Test pit No TP7		
General location	In dam basin	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 2.2	Clayey? sand	
	Not yet refusal	

Test pit No TP8		
General location	In dam basin	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 1.5	Sandy material	
1.5 to 4.0	Clayey sand expected	
	Hard excavation	

Test pit No TP9		
General location	In dam basin (borrow area)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.3	Overburden	
0.3 to 2.3	Clayey sand/ sandy clay with visible rock veins	
	No yet refusal	

Test pit No TP10 (Clay sample taken)		
General location	In dam basin (borrow area)	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.3	Overburden	
0.3 to 3.2	Clayey sand/sandy clay expected with visible rock veins	
	Hard excavation	

Test pit No TP11		
General location	In dam basin	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.6	Clayey sand? with gravel	
	Refusal	

Test pit No TP12		
General location	In dam basin	
Ground water level/ inflow depth	N/A	
Depth (m)	**Description**	**Photos**
0 to 0.6	Hard less weathered shale rock	
	Refusal	

<table>
<tr><th colspan="3">Test pit No TP13 (Clay sample taken)</th></tr>
<tr><td>General location</td><td colspan="2">In dam basin (borrow area)</td></tr>
<tr><td>Ground water level/ inflow depth</td><td colspan="2">N/A</td></tr>
<tr><th>Depth (m)</th><th>Description</th><th>Photos</th></tr>
<tr><td>0 to 0.5</td><td>Overburden</td><td rowspan="3">  </td></tr>
<tr><td>0.5 to 1.9</td><td>Clayey sand?</td></tr>
<tr><td></td><td>Hard excavation</td></tr>
</table>

Figure 2: Existing quarry

Figure 3: "Waaisand" sand borrow area, note sand heaps to be flattened, no excavation activity to take place

Sample Ref No	Photo	Atterberg Limits			Dispersivity %	Permeability (cm/s) (mixed)	Fines %(< 0,075 mm)	Grain Size Distribution (%)				Classification (in accordance with Unified Soil Classification System)	
		LL	PI	LS				Clay	Silt	Sand	Gravel		
TP 6 (33128) Clayey material		16	6	2.0	13.5	SCS Dispersivity: 7.53 x 10^{-7} at 98% PROCTOR Density Crumb: TP6 and TP10 no reaction, TP13 strong reaction	32	19	13	63	5	SC-SM	Clayey, silty sand
TP 10 (33129) Clayey material		29	11	6.0	14.2		25	13	12	56	19	SC	Clayey sand with gravel

Sample Ref No	Photo	Atterberg Limits			Dispersivity %	Permeability (cm/s) (mixed)	Fines %(< 0,075 mm)	Grain Size Distribution (%)				Classification (in accordance with Unified Soil Classification System)	
		LL	PI	LS				Clay	Silt	Sand	Gravel		
TP 13 (33130) Clayey material		S-P			407.5		10	3	7	85	5	SW-SM	Well graded sand with silt
“Waaisand” (33131) Sand							2.6	2.6		97.4	-	SP	Poorly graded sand

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CIVIL ENGINEERING MATERIAL AND GEOTECHNICAL LABORATORY,
GEOTECHNICAL AND ENVIRONMENTAL SERVICES

A division of ControLab South Africa (Pty) Ltd – Accreditation Number: T0308

1986/091003/07

LABORATORY: 7 Milan Street, Airport Industria, Cape Town, Tel: (021) 934 1114, email: geosci@mweb.co.za
CONTROLAB HEAD OFFICE: 1 Alfred Road, Vincent, East London, Tel: (043) 726 7859, Fax: (043) 726 7426, email: info@controlab.co.za
OTHER CONTROLAB BRANCH OFFICES: East London, Johannesburg, Mthatha, Kokstad, Queenstown, Lusaka - Zambia

CLIENT: DJ Hagen & Associates
PO Box 3972
Tygervalley
7536

ATT: Cherie Starke

PROJECT: Bass Diii Dam

DATE: 17-11-2020

REF: L201102

ASTM D422 SIEVE ANALYSIS

DESCRIPTION : red orange silty clayey sand
POSITION : TP 6

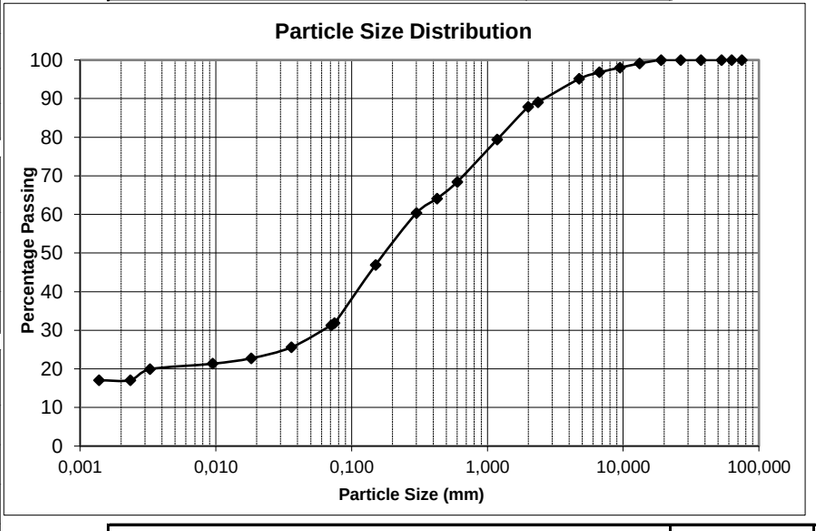
SAMPLE NO. : 33128
CLIENT SAMPLE NO. :

Sieve Analysis		Percent Passing
SIEVE SIZE (mm)	75,00	
	63,00	
	53,00	
	37,50	
	26,50	
	19,00	100
	13,20	99
	9,50	98
	6,70	97
	4,75	95
	2,36	89
	2,00	88
	1,18	79
	0,600	68
	0,425	64
	0,300	60
	0,150	47
	0,0750	32

Hydrometer Analysis	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0707	31
0,0360	26
0,0182	23
0,0095	21
0,0033	20
0,0023	17
0,0014	17

SCS Dispersion Test	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0767	6
0,0386	3
0,0193	3
0,0100	3
0,0035	3
0,0024	3
0,0014	3

% SCS Dispersion:	13,5
Initial Moisture Content (%) :	
pH:	
Conductivity mS/m:	



Atterberg Limits (SANS3001-GR10)	
Liquid Limit	16
Plastic Index	6
Linear Shrinkage	2,0

MOD (SANS3001- GR30) & CBR (SANS3001-GR40)	
MOD AASHTO (Kg/m³)	
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	5
Sand : Percentage - 4.75mm and + 0.075mm	63
Silt : Percentage - 0.075mm and + 0.005mm	13
Clay : Percentage - 0.005mm	19

Technical Signatory: M Hofman

Remarks:

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CLIENT: DJ Hagen & Associates
PO Box 3972
Tygervalley
7536

ATT: Cherie Starke

PROJECT: Bass Diii Dam

DATE: 17-11-2020

REF: L201102

ASTM D422 SIEVE ANALYSIS

DESCRIPTION : yellow olive silty clayey sand
POSITION : TP 10

SAMPLE NO. : 33129
CLIENT SAMPLE NO. :

Sieve Analysis		Percent Passing
SIEVE SIZE (mm)	75,00	
	63,00	
	53,00	
	37,50	100
	26,50	96
	19,00	93
	13,20	93
	9,50	89
	6,70	85
	4,75	81
	2,36	67
	2,00	65
	1,18	54
	0,600	42
	0,425	37
	0,300	34
	0,150	29
	0,0750	25

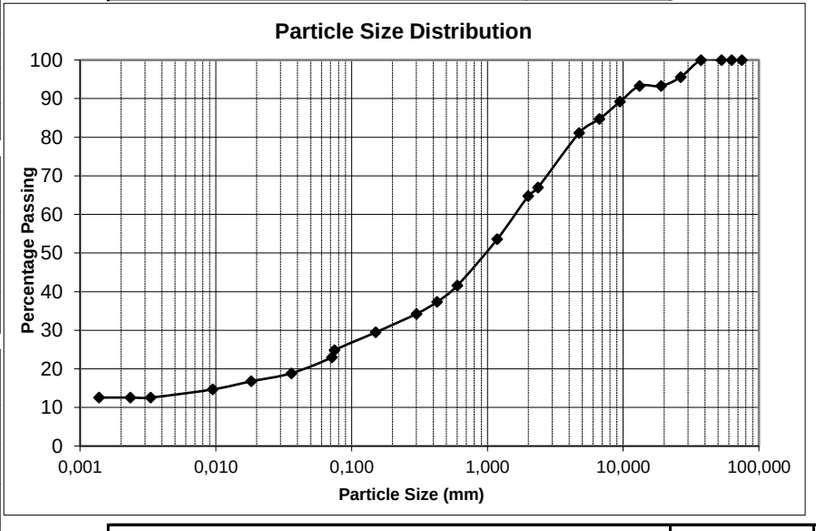
Hydrometer Analysis	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0715	23
0,0360	19
0,0182	17
0,0095	15
0,0033	13
0,0023	13
0,0014	13

SCS Dispersion Test	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0760	6
0,0384	4
0,0193	2
0,0100	2
0,0035	2
0,0024	2
0,0014	2

% SCS Dispersion:	14,2
Initial Moisture Content (%) :	
pH:	
Conductivity mS/m:	

Atterberg Limits (SANS3001-GR10)	
Liquid Limit	29
Plastic Index	11
Linear Shrinkage	6,0

MOD (SANS3001- GR30) & CBR (SANS3001-GR40)	
MOD AASHTO (Kg/m³)	
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	56
Silt : Percentage - 0.075mm and + 0.005mm	12
Clay : Percentage - 0.005mm	13

Technical Signatory: M Hofman

Remarks:

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CLIENT: DJ Hagen & Associates
PO Box 3972
Tygervalley
7536

ATT: Cherie Starke

PROJECT: Bass Diii Dam

DATE: 17-11-2020

REF: L201102

ASTM D422 SIEVE ANALYSIS

DESCRIPTION : yellow orange silty sand
POSITION : TP 13

SAMPLE NO. : 33130
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	100
	6,70	97
	4,75	95
	2,36	81
	2,00	79
	1,18	67
	0,600	56
	0,425	50
	0,300	43
	0,150	24
	0,0750	10

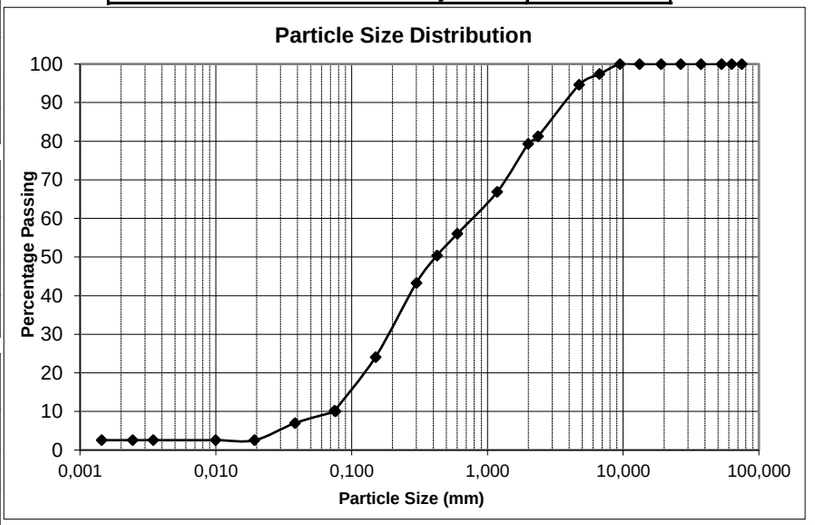
Hydrometer Analysis	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0760	10
0,0384	7
0,0193	3
0,0100	3
0,0035	3
0,0024	3
0,0014	3

SCS Dispersion Test	
Diameter of particle (mm)	Percentage of soil suspension (%)
0,0740	15
0,0374	13
0,0188	10
0,0097	10
0,0034	10
0,0024	10
0,0014	8

% SCS Dispersion:	407,5
Initial Moisture Content (%) :	
pH:	
Conductivity mS/m:	

Atterberg Limits (SANS3001-GR10)	
Liquid Limit	
Plastic Index	S-P
Linear Shrinkage	

MOD (SANS3001- GR30) & CBR (SANS3001-GR40)	
MOD AASHTO (Kg/m³)	
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	5
Sand : Percentage - 4.75mm and + 0.075mm	85
Silt : Percentage - 0.075mm and + 0.005mm	7
Clay : Percentage - 0.005mm	3

Technical Signatory: M Hofman

Remarks:

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PERMEABILITY TEST RESULTS

CLIENT : DJ Hagen & Associates
PROJECT NAME : Bass Diii Dam

admin only
JOB NO : L201102
SAMPLE NO : 33131A

COMPACTION MOULD PERMEAMETER

POSITION : Mixed Sample of TP 6, TP 10 & TP 13
SOIL DESCRIPTION :
PERMEANT USED : TAP WATER

SAMPLE DATA		
MDD	kg/m^3	1991
OMC	%	11,30
Percent of MDD specified	%	98,00
Dry density of soil required	kg/m^3	1951,18
Moisture content of sample	%	11,30
Length of sample	mm	125,00
Diameter of sample	mm	150,00
Area of sample	mm^2	17671,46
Volume of sample	mm^3	2208932,33
Mass of dry soil required	g	4310,02
Mass of wet soil required	g	4797,06

ACTUAL DATA		
Mould Number		P6
Mass of Mould	g	4665
Mass of Mould and wet soil	g	9462,06
Mass of wet soil	g	4797,06
moisture content	%	11,30
Bulk Density	kg/m^3	2171,66
Dry Density	kg/m^3	1951,18
Percentage MDD	%	98,00

Standpipe dia	mm	3,75
Standpipe area	mm^2	11,04

TEST READINGS								
	Start Test				End Test			Comments
Test	Height	Time			Height	Time		
	mm	min	sec		mm	min	sec	
1	1600				1550	4	50	
2	1600				1550	5	13	
3	1600				1550	5	51	
4	1600				1550	6	15	

Number of tests = 4

CALCULATIONS FOR FALLING HEAD		
Log H1/H2	Elapsed Time	COEFFICIENT OF PERMEABILITY
mm	sec	m/s
0,0138	290,00	8,54E-09
0,0138	313,00	7,92E-09
0,0138	351,00	7,06E-09
0,0138	375,00	6,61E-09

AVERAGE =	7,53E-09	m/s
AVERAGE =	7,53E-07	cm/s

Notes :

Technical Signatory: M Hofman

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OTHER CONTROLAB BRANCH OFFICES: East London, Johannesburg, Mthatha, Kokstad, Queenstown, Lusaka - Zambia

CLIENT:	DJ Hagen & Associates PO Box 3972 Tygervalley 7536	**PROJECT:**	Bass Diii Dam
ATT:	Cherie Starke	**REF. NO:**	L201102

SAND GRADING RESULT SUMMARY

33131	CLIENT SAMPLE NO.	SAMPLE DESCRIPTION
		yellow olive sand

SAMPLE POSITION

Sand

GRADING MODULUS

1,36

SIEVE ANALYSIS

Sieve mm	Percentage Passing	Sieve mm	Percentage Passing
75		2,36	
63		2,00	100
53		1,18	99
37,5		0,850	98
26,5		0,600	87
19		0,425	61
13,2		0,300	37
9,50		0,250	29
6,70		0,150	14
4,750		0,075	2,6

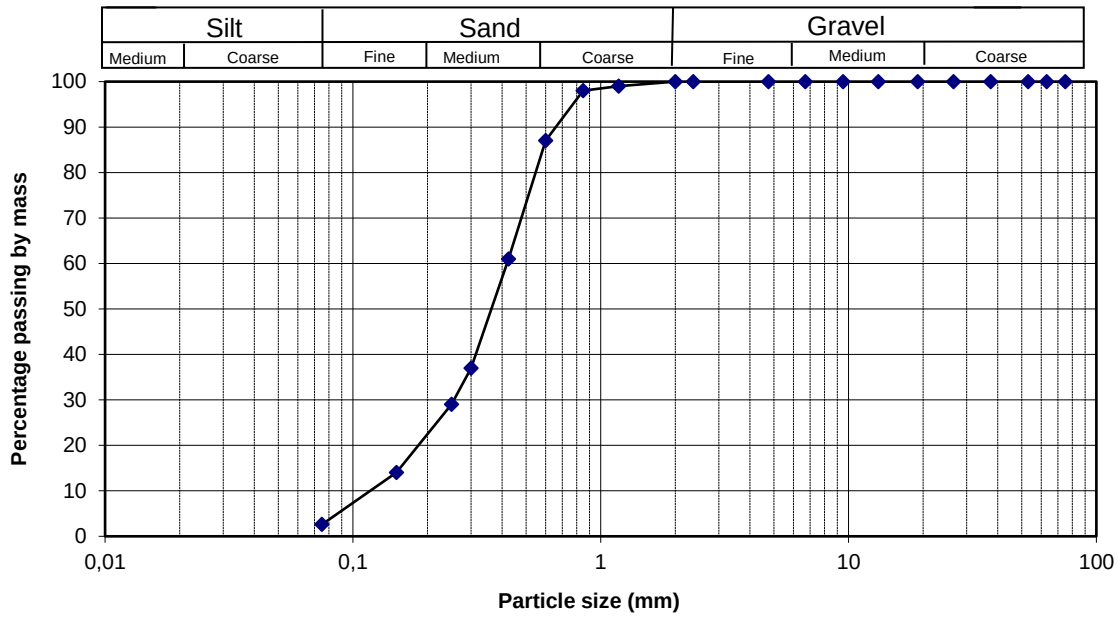
ATTERBERG LIMITS

Liquid Limit	
Plastic Index	
Linear Shrinkage %	

MOD / CBR

MOD	
O.M.C.	
100%	
98%	
95%	
93%	
90%	
Max Swell	

Particle Size Distribition



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CLIENT: DJ Hagen & Associates **PROJECT:** Bass Diii Dam

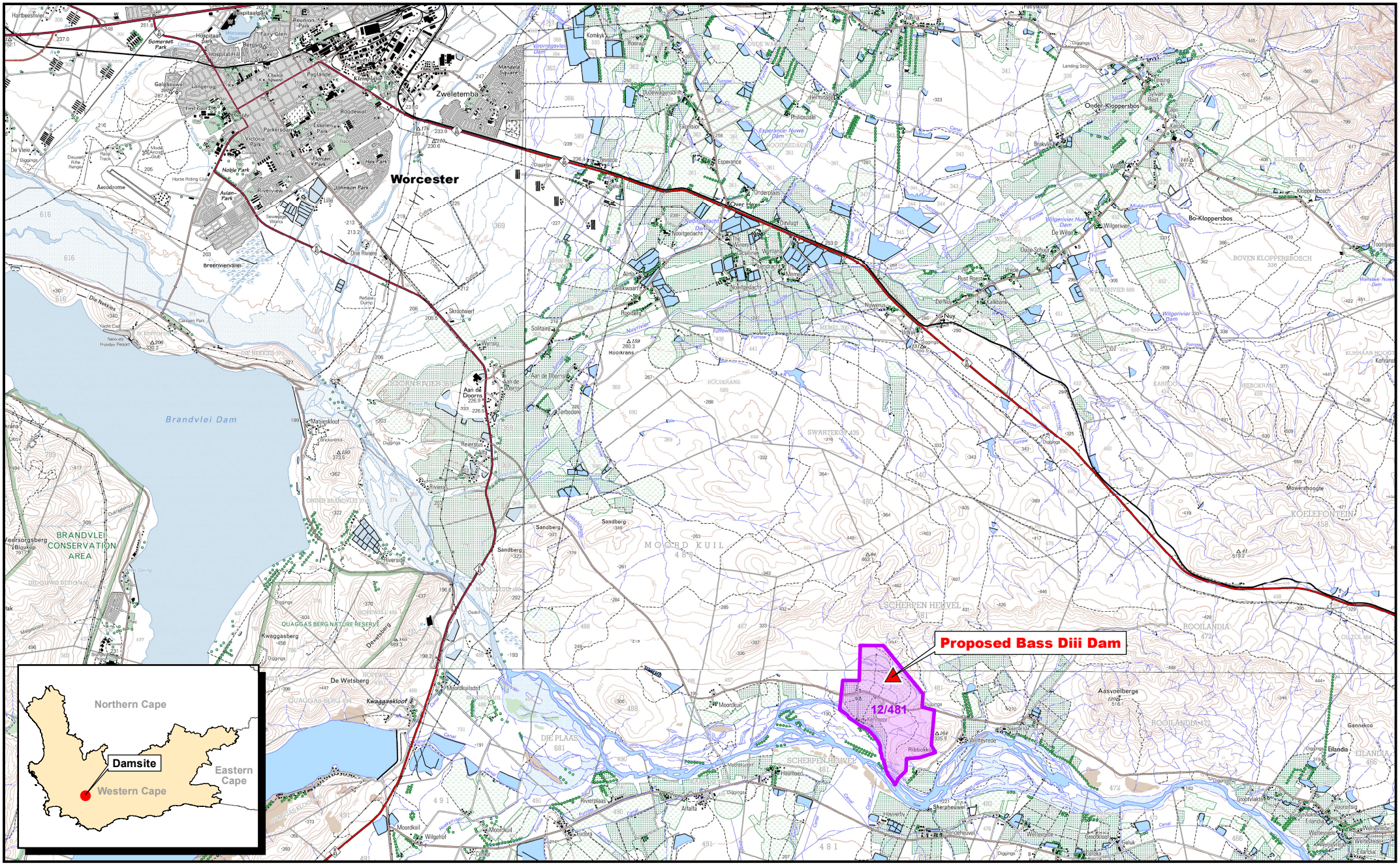
REF: L201102

CRUMB TEST (SHERAD ET AL)

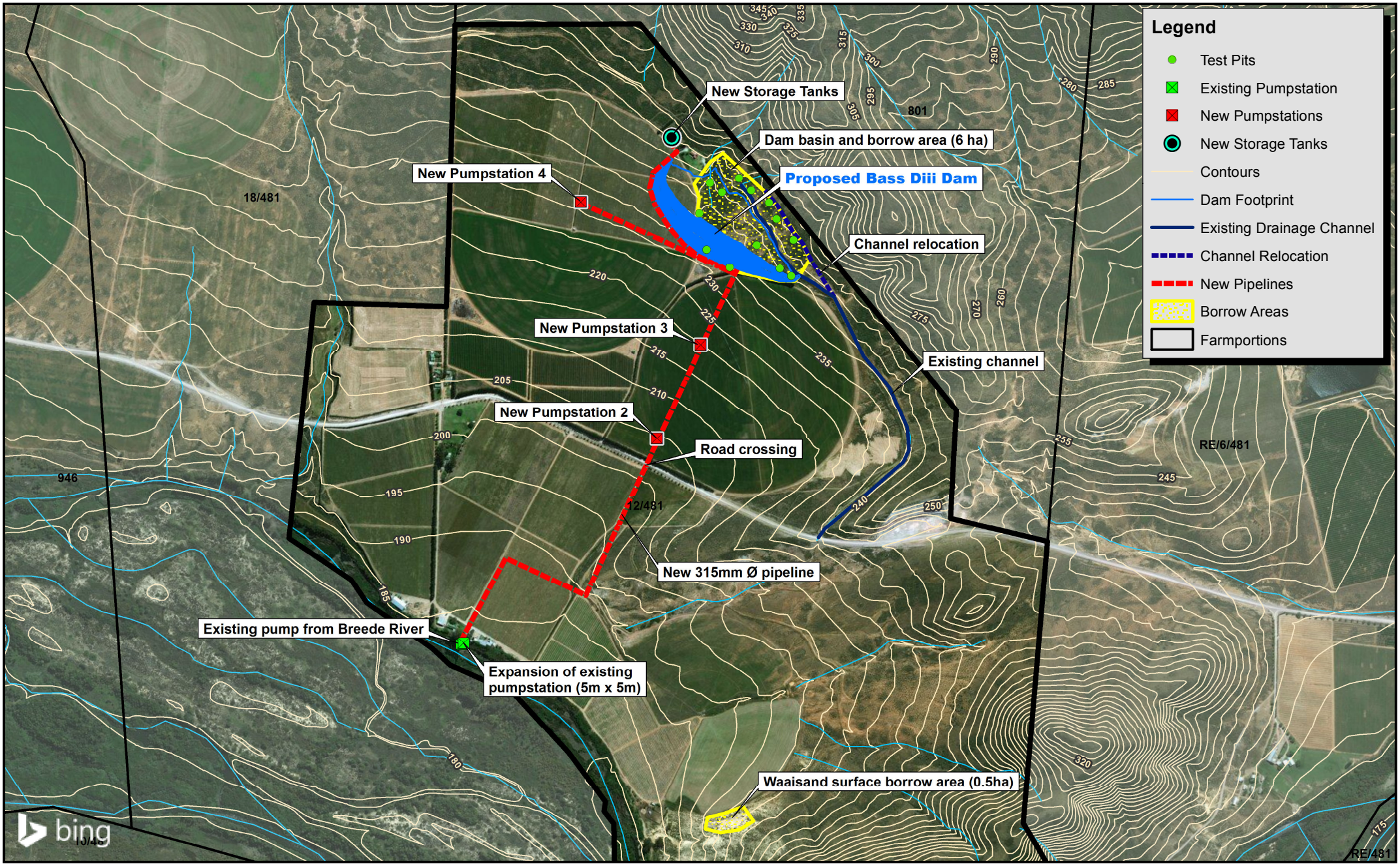
SAMPLE NO:	33128	33129	33130			
POSITION:	TP 6	TP 10	TP 13			
DESCRIPTION:						

Water (pH 4.5)	no reaction	no reaction	strong reaction			
0.001N NaOH (pH 8.5)	no reaction	no reaction	strong reaction			
0.006N NaOH (pH 10.7)	no reaction	no reaction	strong reaction			

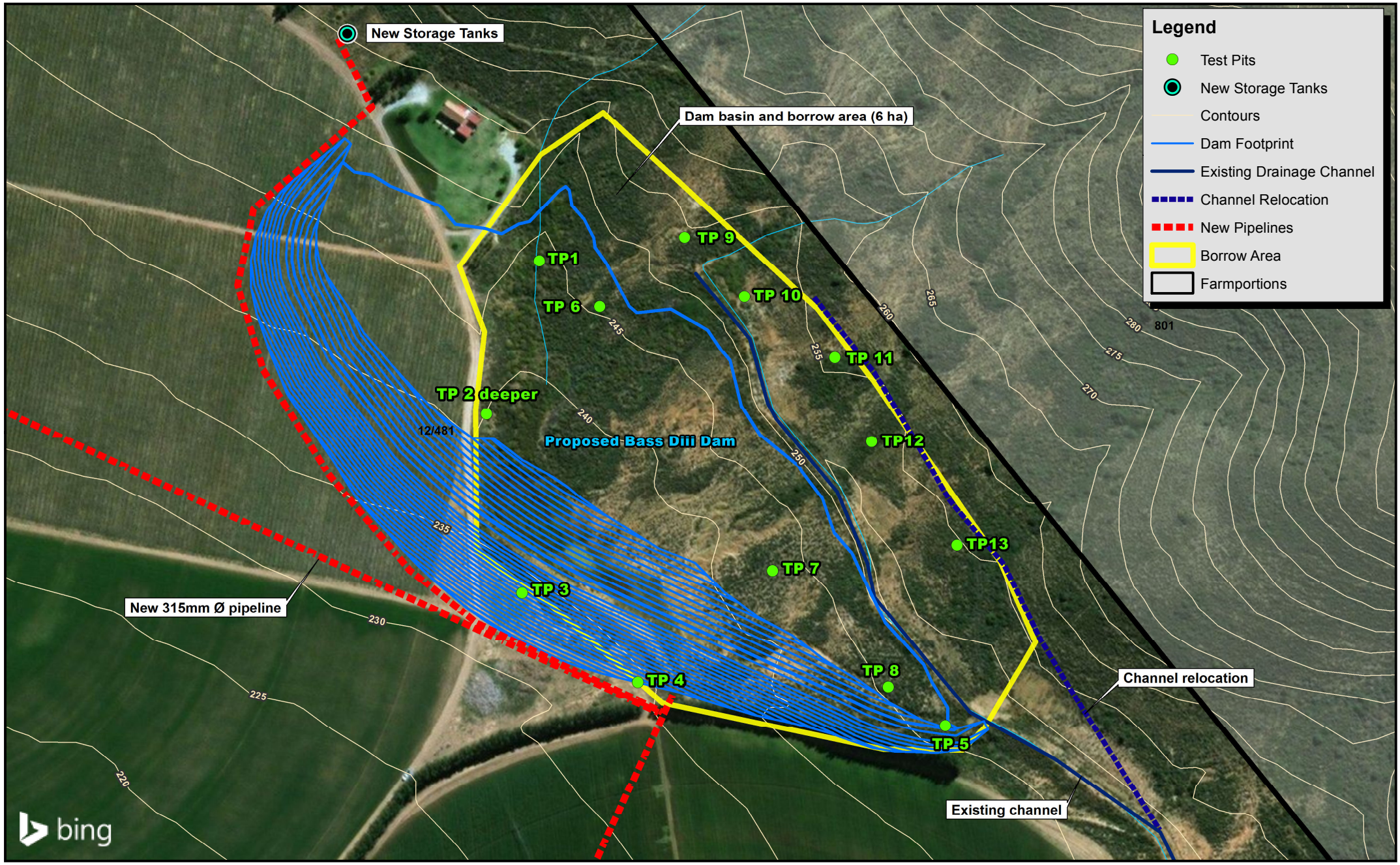
Appendix C – Drawings



DJ HAGEN & ASSOCIATES **BASS DIII BERRIES (PTY) LTD**	**Bass Diii Dam**	2 1 0 2 Km 1:100 000 N	A4
	Locality map	DJH097_2 - Bass Diii Dam\09 GIS\mxd\ 01_LocalityMap.mxd	Drawing No. **DJH097.2 - 01**



DJ HAGEN & ASSOCIATES **BASS DIII BERRIES (PTY) LTD**	**Bass Diii Dam**	300 150 0 300 m N 1:12 500	A4
	Scheme Layout	DJH097_2 - Bass Diii Dam\09 GIS\mxd\ 02_SchemeLayout.mxd	Drawing No. **DJH097.2 - 02**



DJ HAGEN & ASSOCIATES

BASS DIII BERRIES (PTY) LTD

Bass Diii Dam

Test Pits

50 25 0 50 m

1:2 500

N

A4

DJH097_2 - Bass Diii Dam\09 GIS\mxd\ 03_TestPits.mxd

Drawing No.

DJH097.2 - 03

PLAN LAYOUT OF ENLARGED BASS* Diii DAM

SCALE 1:1000

NOTES: ENLARGEMENT OF BASS* Diii DAM

GENERAL

1.	NON-OVERSPILL CREST LEVEL:	62.0 masl
2.	FULL SUPPLY LEVEL :	61.0 masl
3.	FREEBOARD :	1.0 m
4.	WATER SURFACE AREA AT FSL :	34 ha
5.	GROSS CAPACITY :	300 000 m³
6.	CREST LENGTH	530 m
7.	CREST WIDTH	4 m
8.	MAXIMUM WALL HEIGHT	18.3 m
9.	UPSTREAM SLOPE :	1V:3H
10.	DOWNSTREAM SLOPE :	1V:2H
11.	MINIMUM BASIN LEVEL :	49.0 masl
12.	DOWNSTREAM TOE LEVEL:	43.7 masl
13.	OUTLET PIPE DESCRIPTION:	315 mm OD HDPE CLASS PE100 PN8

14. CORE TRENCH WIDTH:
    - Wt = [Ew-Et] x 0.25 + 4
    - Wt - TRENCH WIDTH
    - Et - BASE ELEVATION OF TRENCH (masl)
    - Ew - FULL SUPPLY LEVEL OF MAXIMUM DAM SIZE = 61.0 m masl
    - MINIMUM ZONE I CORE WIDTH OF 4 m

15. CONTOUR INTERVAL 1 m
16. PROJECTION: WGS 84/ Lo 19 - REFERENCE BEACONS TO BE INSTALLED PRIOR TO THE START OF CONSTRUCTION.

ABBREVIATIONS

NGL	-	NATURAL GROUND LEVEL
FSL	-	FULL SUPPLY LEVEL
NOC	-	NON-OVERSPILL CREST
TP	-	TEST-PIT POSITION (i.e TP 2)
RDF	-	RECOMMENDED DESIGN FLOOD
SEF	-	SAFETY EVALUATION FLOOD

No.	DATE	REVISION DESCRIPTION	DRW	CHK

SCALE FOR REDUCED PLAN :

0 10 20 40 60 80 100

100mm ON ORIGINAL PLAN

GENERAL NOTES :

ALL DIMENSIONS AND LEVELS TO BE VERIFIED ON SITE PRIOR TO MANUFACTURING AND CONSTRUCTION.

ANY DISCREPANCIES TO BE BROUGHT TO THE ATTENTION OF THE DESIGNER.

CLIENT :

BASS* Diii BERRIES (PTY) LTD

PROJECT TITLE :

ENLARGEMENT OF BASS* Diii DAM

DRAWING TITLE :

PLAN LAYOUT OF ENLARGED DAM (OPTION D)

SCALE : AS SHOWN | ORIGINAL DWG SIZE A1 | SHEET 1 OF 1

APPROVED BY CONSULTING ENGINEER :

SIGNATURE | 20020222 PR REG. No. | 09/11/2020 DATE

DESIGNED BY : DJ HAGEN	CHECKED BY : DJ HAGEN
DRAWN BY : C STARKE	DATE : 09/11/2020
DRAWING No. : DJH097.2-04	REVISION No. : 0

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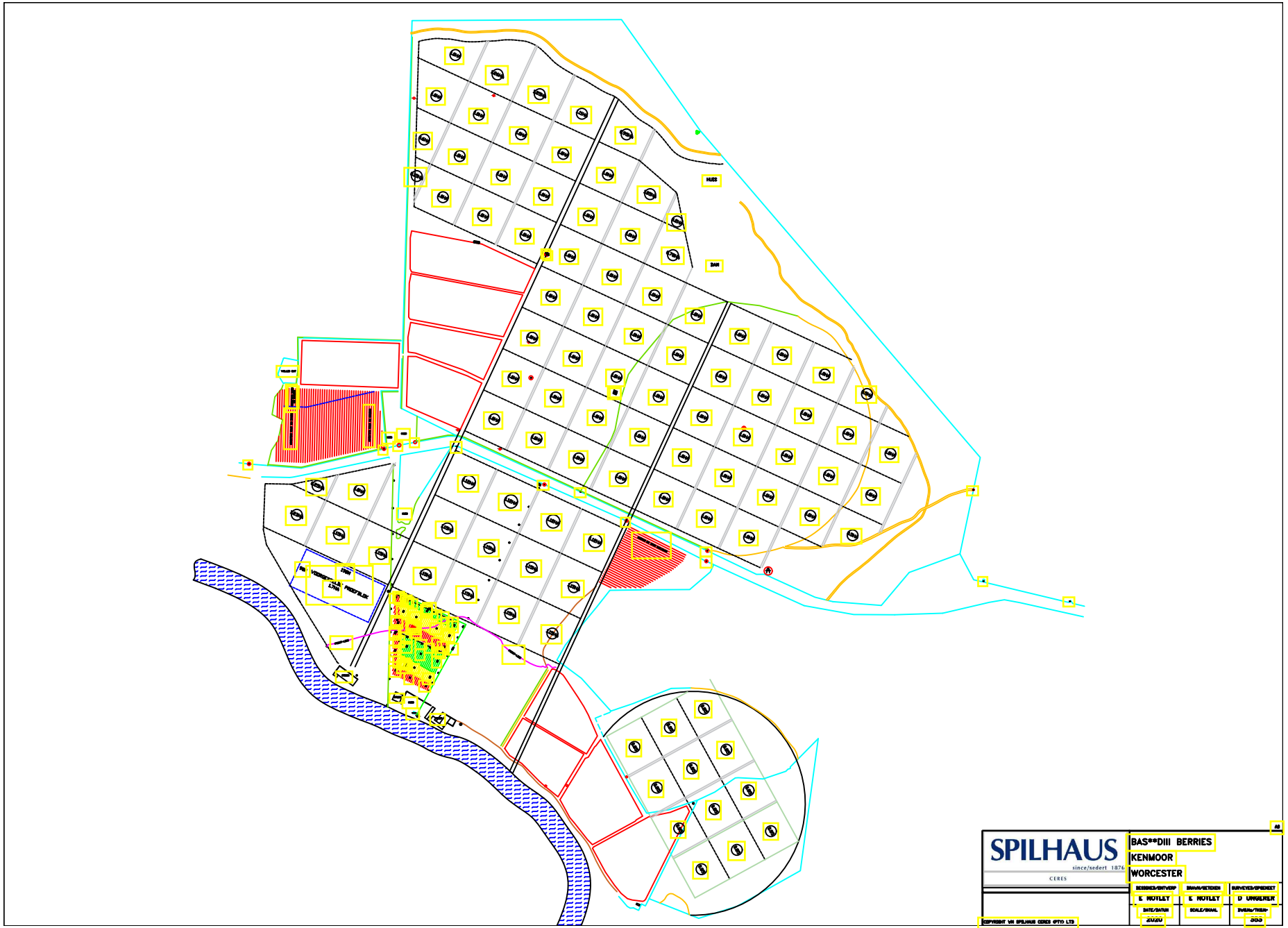
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Appendix D – Dam Options Analysis Summary

DJ HAGEN & ASSOCIATES
DAM ENGINEERING SPECIALISTS
PASSION | EXCELLENCE | INNOVATION

Bass* Diii Dam

	Existing Dam	DJ Hagen and Associates				
	Based on Survey	Based on Survey				Based on 5m contours
		Model B Check (Option A)	Option B	Option C	Option D	Alternative Dam Site 1
	5 000 m³	330 000 m³	330 000 m³	265 000 m³	300 000 m³	300 000 m³
Proposed NOC (m)	50	65	70	61	62	282
Proposed FSL (m)	49	64	69	60	61	281
Rasing of NOC (m)		15	20	11	12	
Raising of FSL (m)	0	15	20	11	12	
Freeboard	1	1	1	1	1	1
Maximum wall height (m)	4,80	21,30	26,30	17,30	18,30	29,00
Proposed Wall crest width (m)	4	4	4	4	4	4
DS Dam wall Slope	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H	1V:2H
US Dam wall Slope	1V:3H	1V:3H	1V:3H	1V:3H	1V:3H	1V:3H
New Wall Fill above NGL (m³)		177 500	306 200	122 500	146 000	200 000
Wall length (m)	0	475	545	510	530	350
Capacity without cut from basin (m³)		172 500	263 800	142 500	169 000	120 000
Water surface area at FSL (m²)	3 500	34 300	43 400	35 500	39 600	22 500
Water surface area at FSL (Ha)	0,35	3,4	4,3	3,6	4,0	2,3
Available borrow area (m²)		22 000,0	18 000,0	40 000,0	40 000,0	50 000,0
Average excavation depth (m)	**0,0**	**3,6**	**3,4**	**3,1**	**3,3**	**3,6**
Total Capacity (m³)	**5 000**	**252 375**	**325 040**	**265 000**	**300 000**	**300 000**
% Earthfill available from the dam basin		**45%**	**20%**	**100%**	**90%**	**90%**
Additional Capacity	**0**	**247 375**	**320 040**	**260 000**	**295 000**	**295 000**
Estimated average core trench width (m)		5,4	5,8	5,1	5,3	5,1
Estimated average core trench depth (m)		6,0	6,0	6,0	6,0	6,0
Estimated core trench volume (m³)		32 400	38 500	34 000	35 800	23 400
Percentage core trench volume of earthworks (%)		15%	11%	22%	20%	10%
Total earthfill (m³)	**0**	**209 900**	**344 700**	**156 500**	**181 800**	**223 400**
Wall Water Ratio (m³)		**1,18**	**0,93**	**1,66**	**1,62**	**1,32**
Minimum basin level (m)	47,00	51,00	52,70	49,00	49,00	270,00
Minimum downstream level (m)	45,20	43,70	43,70	43,70	43,70	253,00
Maximum Storage depth (m)	2,0	13,0	16,3	11,0	12,0	11,0
Site establishment and geotechnical testing		**R 50 000,00**	**R 50 000,00**	**R 50 000,00**	**R 50 000,00**	**R 50 000,00**
Earthworks without diesel		**R 7 346 500,00**	**R 12 064 500,00**	**R 5 477 500,00**	**R 6 363 000,00**	**R 7 819 000,00**
Dry rate (R/m)		R 35,00	R 35,00	R 35,00	R 35,00	R 35,00
Diesel consumption per m³ (liter)		1,0	1,0	1,0	1,0	1,0
Diesel price (R/liter)		R 11,80	R 11,80	R 11,80	R 11,80	R 11,80
Diesel cost		**R 2 476 820,00**	**R 4 067 460,00**	**R 1 846 700,00**	**R 2 145 240,00**	**R 2 636 120,00**
Rebate (R/liter diesel)						
Minus rebate saving						
Outlet pipe (pipe, concrete, specials and valves), estimated		**R 700 000,00**	**R 800 000,00**	**R 650 000,00**	**R 650 000,00**	**R 650 000,00**
Totale construction cost (VAT excluded)		**R 10 573 320,00**	**R 16 981 960,00**	**R 8 024 200,00**	**R 9 208 240,00**	**R 11 155 120,00**
Allowed for 15% contingencies		R 1 585 998,00	R 2 547 294,00	R 1 203 630,00	R 1 381 236,00	R 1 673 268,00
Professional fees, investigation phase						
Professional fees, detail design and construction inputs						
EA and water licence applications						
Proejct cost (VAT excluded)		**R 12 159 318,00**	**R 19 529 254,00**	**R 9 227 830,00**	**R 10 589 476,00**	**R 12 828 388,00**
R/m³ fill		R 57,93	R 56,66	R 58,96	R 58,25	R 57,42
R/m³ storage		R 48,18	R 60,08	R 34,82	R 35,30	R 42,76