Our ref: CC136700/2017/04/03/DJH
Your ref: Elohim Dam

3 April 2017

Arbeidsgenot
Arbeidsgenot Farm
Moorreesburg
7310

For attention: Mr Marius Hanekom

Dear Sir,

PROPOSED ELOHIM DAM, MOORREESBURG

1. Background

Arbeidsgenot would like to construct a new dam to utilize their existing winter enlistment under the Benede-Bergrivier Irrigation Board of 45.6 ha at 7 000 m^3/ha (320 000 m^3). The proposed dam is located on an unnamed tributary of the Berg River. The proposed Elohim Dam will be filled solely by pumping from the Berg River under the existing irrigation scheme.

The Arbeidsgenot Farm is located near Moorreesburg in the Western Cape Province. Refer to the locality map below (Figure 1).

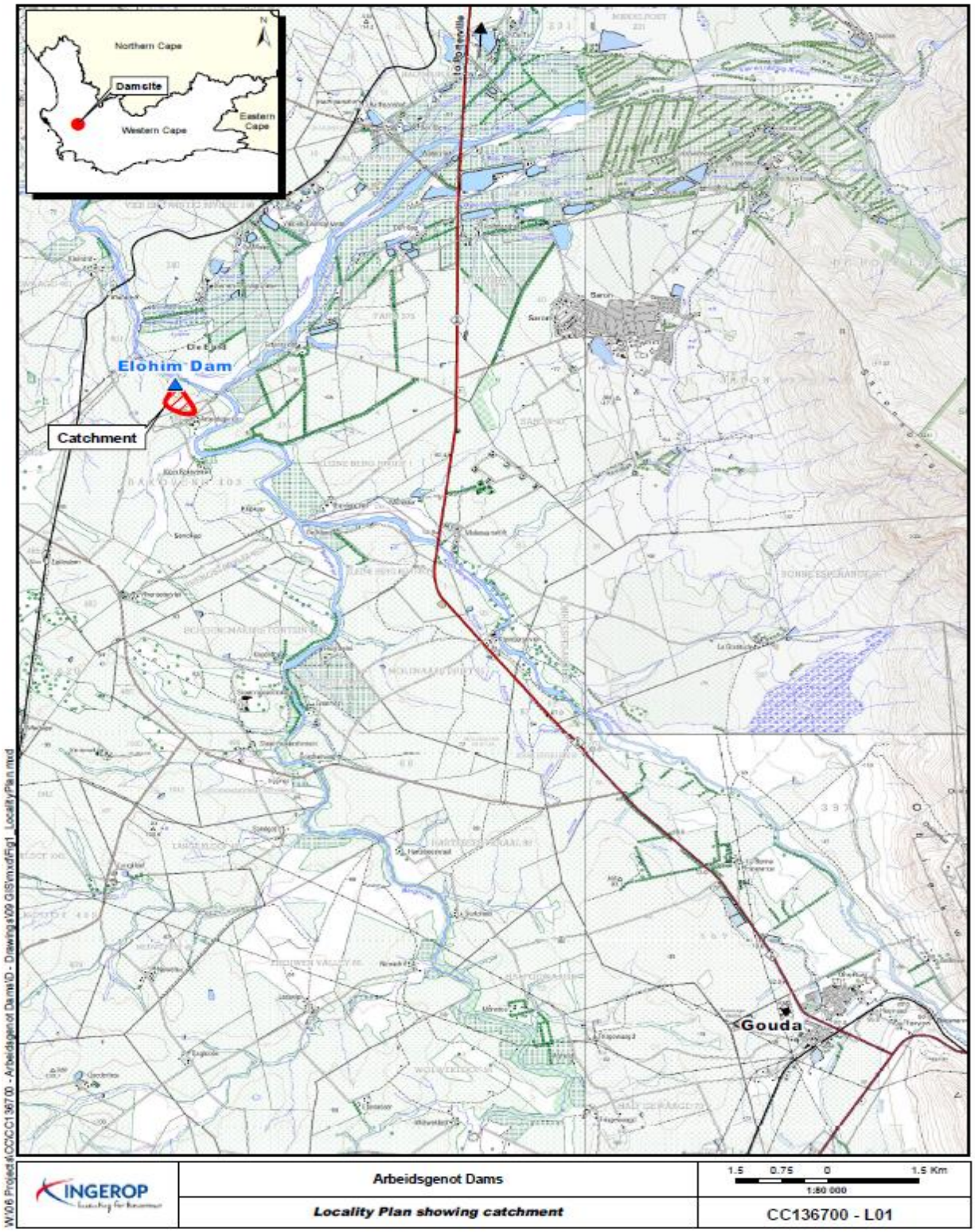

Figure 1: Locality map

2. Existing water sources and water entitlement

Arbeidsgenot Farm only water source is the enlistment below. There are no boreholes (groundwater use) or other private surface water use.

The Benede-Bergrivier Irrigation Board confirmed the enlistment of Arbeidsgenot Landgoed to be 17 ha summer and 45.6 ha winter with an allocation of 7 000 m^3/ha/a each amounting to 438 200 m^3/a. Refer to **Appendix A**.

Correspondence with Aurecon, which are doing the Validation & Verification (V&V) study in this area for the Department of Water and Sanitation at present, indicated that only the above enlistment will be allocated to the farm. There are therefore no other water sources. The V&V forms provided by Aurecon are also contained in **Appendix A**.

3. Geotechnical

The site, as shown below in Figure 2, is on the Porterville Formation of the Malmesbury Group. It appears to be underlain by phyllite shale, schist and greywacke with dark-grey limestone, sporadic quartzitic sandstone beds and conglomerate beds (Npo (dark yellow) on the map).

Figure 2: Regional geology (site marked with red asterisk)

Several test pits were excavated near the proposed dam site in January 2017. Test pit 3, 5 and 7 contained clayey sand and sandy lean clay under the topsoil overburden, with test pit 4 containing sand. Test pit 2 and 3 is located on the right abutment, to give an indication of the possible depth of the core trench depth. A good impermeable foundation in weathered shale at about 1.5 m depth is present. Alluvial sandy material is present in the river section (test pit 1 & 4) and the depth to an acceptable shale foundation is not considered to be more than 6 m. Refer to the photos in Figure 3 below.

Based on previous experience in shale foundations care must be taken to excavate the core trench foundation to below permeable features for example quartz vines.

Figure 3: Geology test pit locations

Right abutment at bend in embankment

Right flank (TP3)

In River section (TP1)

In Dam basin (TP5)

In Dam basin (TP7)

Figure 4: Founding conditions on dam site

Four samples from the test pit were taken for laboratory testing per the above pictures. The test results are enclosed in **Appendix B**. The available materials found in the test pits (TP3, TP5 & TP7), are considered adequate core material based on the following properties:

% Fines: 30 to 52

% Clay: 20 to 35

Plasticity Index: 8 to 14

Classification: SC & CL

The dispersivity of the proposed core material also appear to not be a problem with the SCS Double Hydrometer Test indicating 30 to 31 % (non-dispersive to moderate) and the Crumb test indicating no reaction.

Although the dispersivity of the specific samples are moderate, to accommodate other core material which may show higher dispersive potential the following is recommended:

- 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 sub-soil toe drain.

Rip-rap upstream slope protection and rock toe material can be sourced in various positions at excavations in the dam basin area and spillway excavation. The materials required for the sand filters can also be acquired from the area surrounding the natural tributary within the dam basin (test pit 4).

There therefore appears to be sufficient core, sand filter and general fill on site within the proposed dam basin to construct the dam.

No other geotechnical testing will be required prior to construction.

4. Catchment and hydrology

The dam's catchment of 0.2 km^2 is located in the quaternary catchment G10J. The catchment is shown in Figure 4 below.

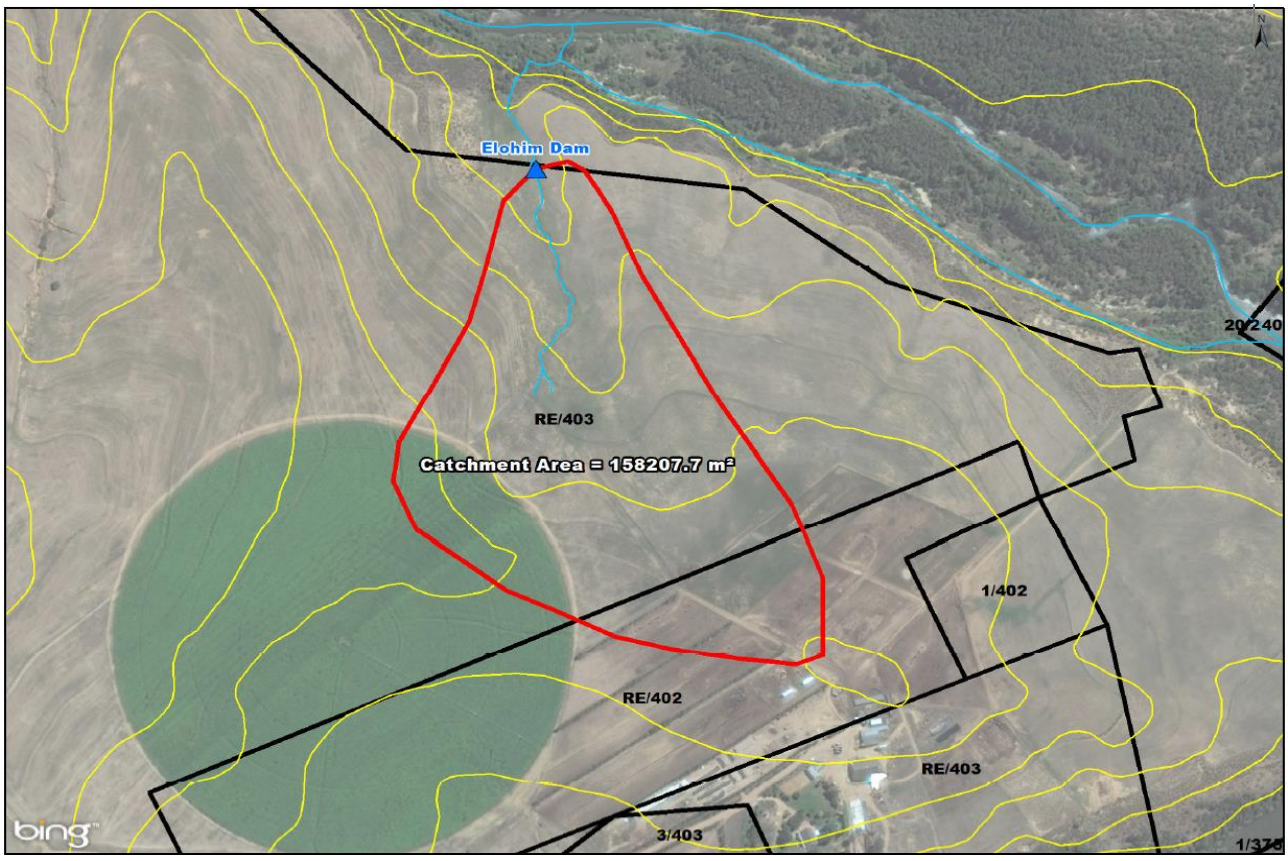

Figure 5: Catchment area

The catchment MAP's from WRC2012 study (Bailey & Pitman, 2015) and Wide Area Augmentation System (WAAS, 2007) Satellites are shown in Figure 5 below. The WRC MAP of 471 mm is considered more representative.

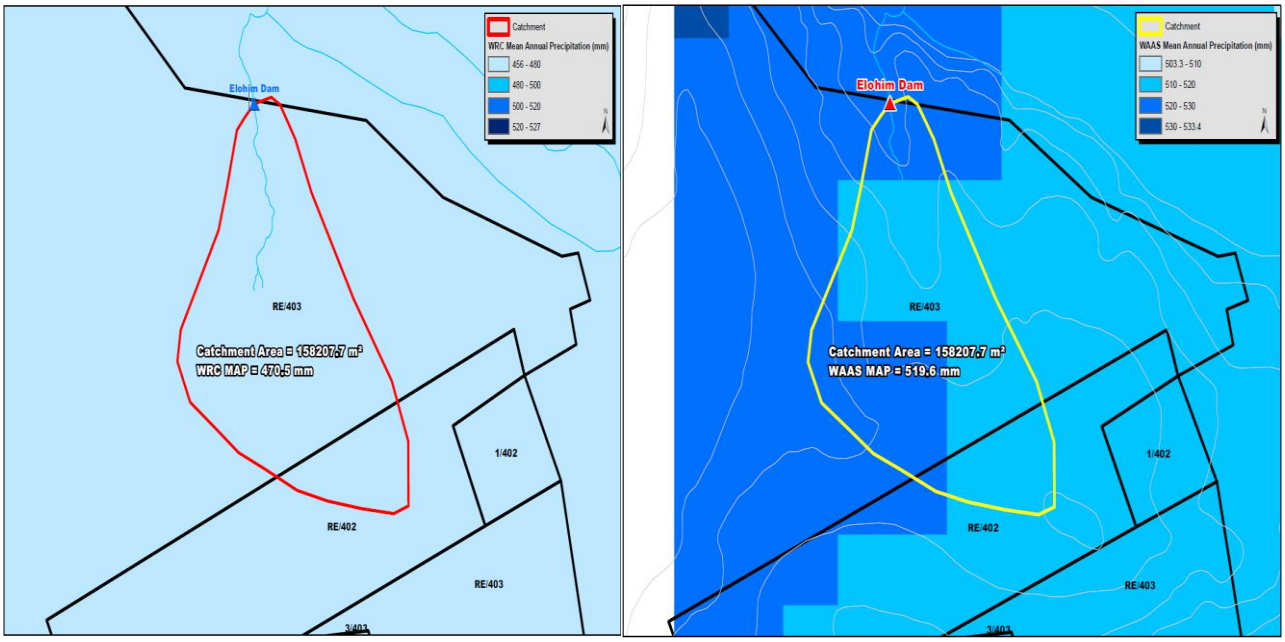

Figure 6: Catchment area and weighted MAP's

The Mean Annual Runoff (MAR) from the catchment is estimated at less than 10 000 m^3 (little runoff from sandy overburden soils) and therefore neglible.

5. Dam options

5.1 Location alternatives

An on-channel dam option on the Berg River was discarded due to environmental concerns and the high cost of a spillway.

Three alternatives sites location were considered during the planning stage (site 1, site 2-upstream and site 2-downstream) as shown in the figure below.

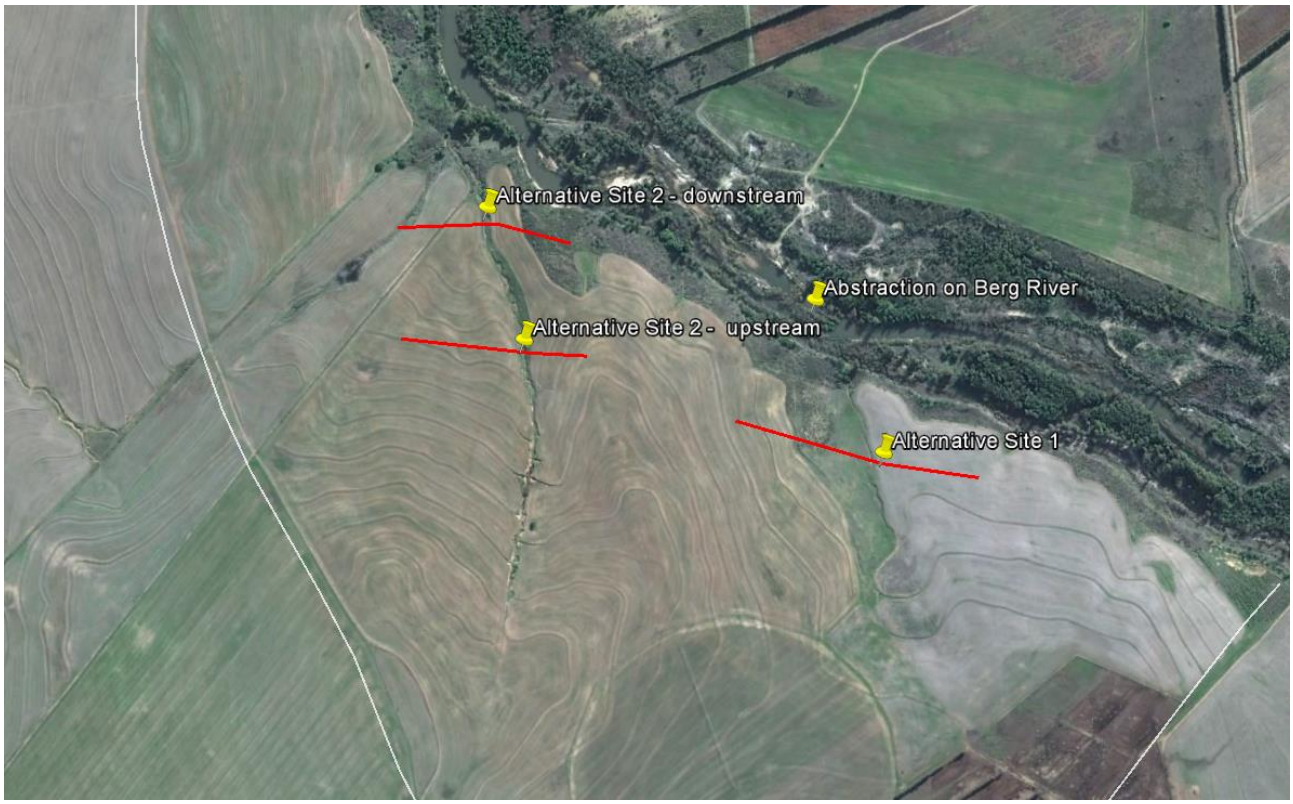

Figure 6: Indication of alternatives sites location

Various dam options were compared based on 5 m contour survey information for target storage capacities of 300 000 m^3 and 700 000 m^3 and dam site 1 was found to be the most economical dam site with a water/wall ratio of 2.8 for the 300 000 m^3 dam size. The water/wall ratio of site 2 -upstream was 2.3 and site 2 – downstream 2.2 for the same dam size. The dam options are shown in Figure 7 below. Full details of the options are provided in **Appendix C**.

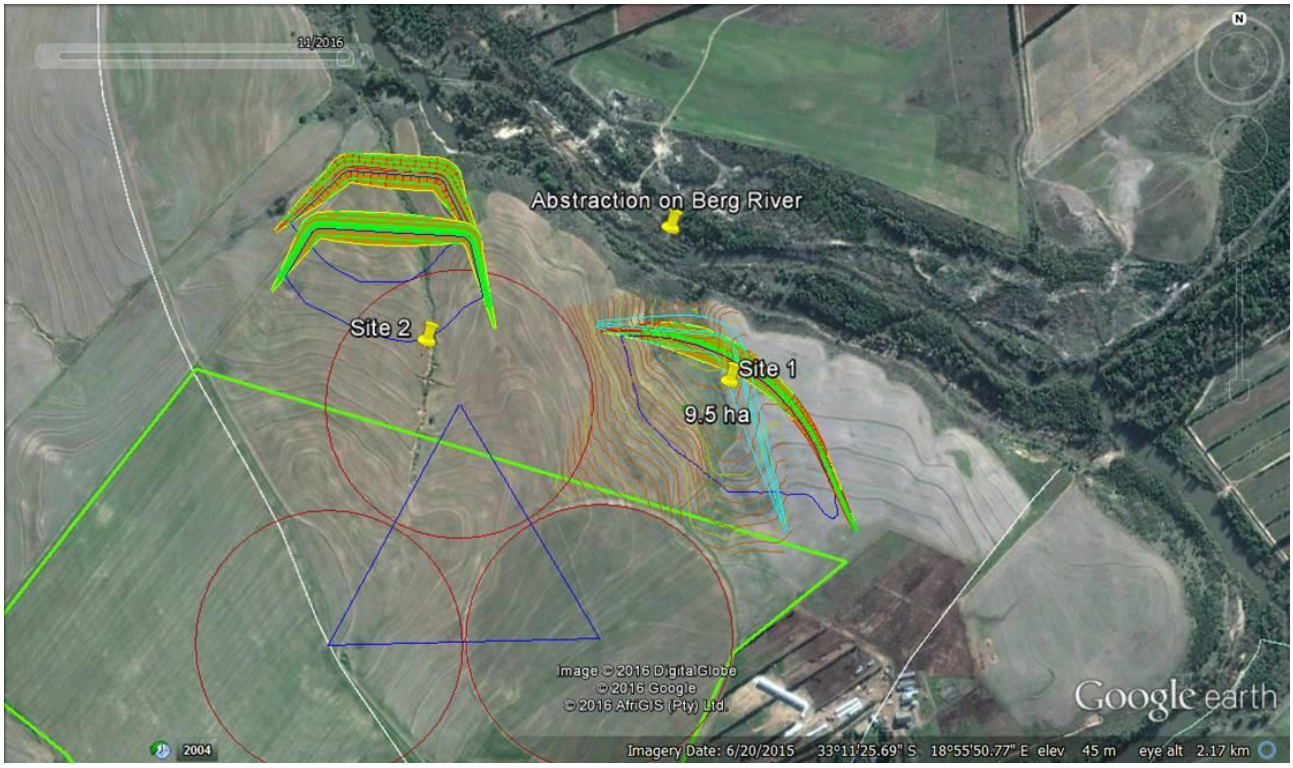

Figure 7: Dam options for 300 000 m³ dam size

5.2 Dam optimization

The selected site 1 was surveyed by Billy West. For the proposed zoned earthfill dam, all the options were analysed, with the target storage capacity required of 320 000 m³ and compared on the basis of the water/wall ratio (the amount of earthworks required for a certain storage). Refer to the full results in **Appendix D.** The statistics of the options are summarised in the table below.

Table 1: Statistics of Design Alternatives

	Storage Capacity (m³)	Full supply Level (m)	Wall height (m)	Surface area at FSL (ha)	New Wall Volume (m³)	Water/wall ratio
Option 1	324 000	57.5	13.5	6.2	95 000	2.81
Option 4	319 000	56.8	13.8	6.2	94 000	2.79
Option 6	322 000	57.4	13.4	6.1	94 000	2.80

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 alternative.

The six options analyses did not differ much in results. Option 6 was selected with straight flanks and far enough upstream of the Berg River. Refer to the layout drawing under **Appendix C** and Figure 7 below. The total footprint of the dam wall and basin is 8.8 ha.

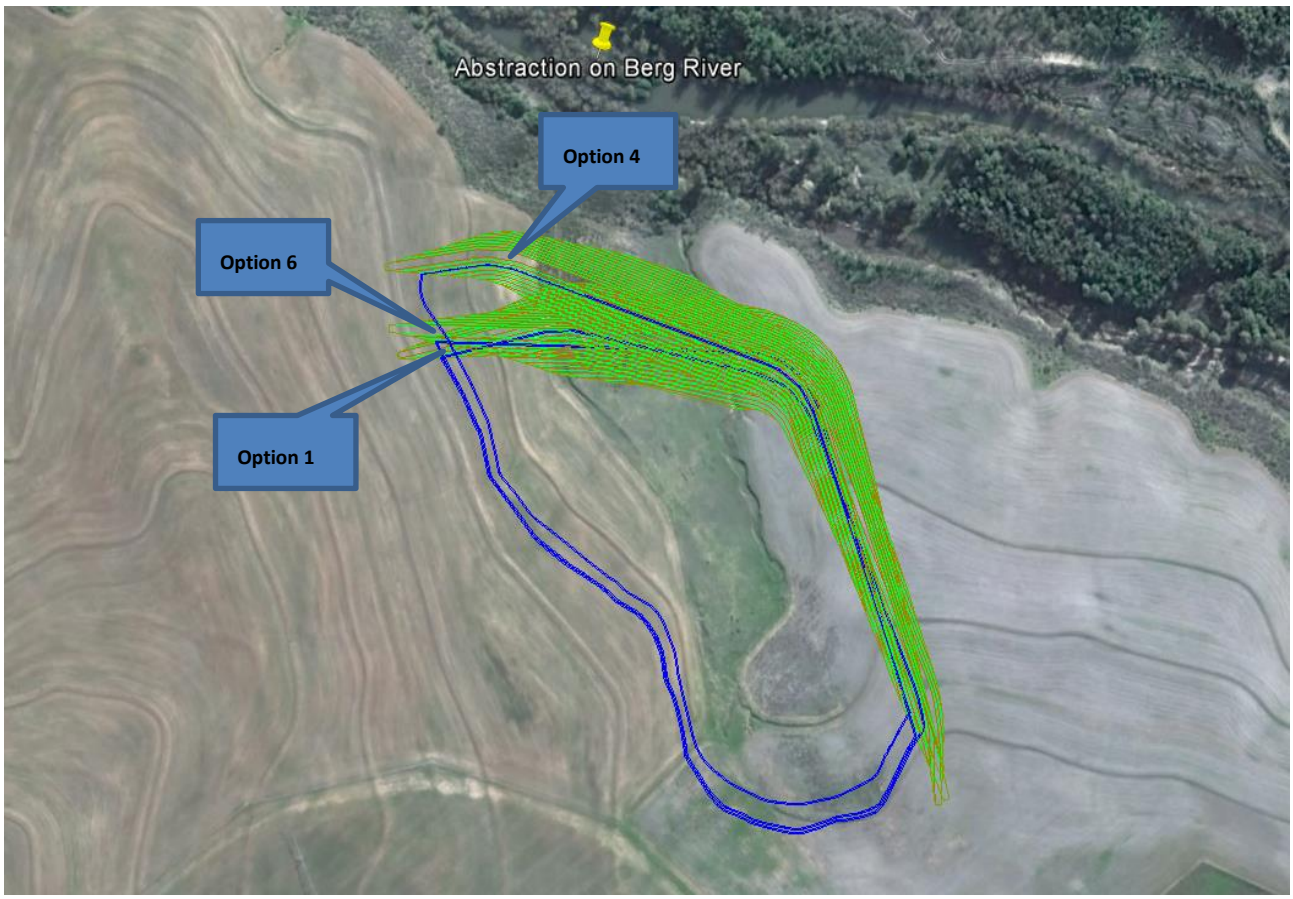

Figure 8: Layout of dam options

6. Associated infrastructure

The farm has two existing abstraction points on the Berg River south of the farm house and north-east. The existing pipelines (125 & 165 mm dia) from these abstraction points will be upgraded to 250 mm dia each to fill the proposed dam. An additional abstraction point with 250 mm dia pipeline (130 m long) is proposed just below (to the north) of the proposed dam, which will be the shortest route to fill the dam. A new power line will be required from the north-eastern abstraction point to the new point.

All areas to be irrigated from the new dam will be located within the green outline on existing cultivated land. A raft abstraction pump from the dam basin will be used for bulk conveyance to the areas. The bulk conveyance pipelines will be all less than 200 mm dia and must still be designed.

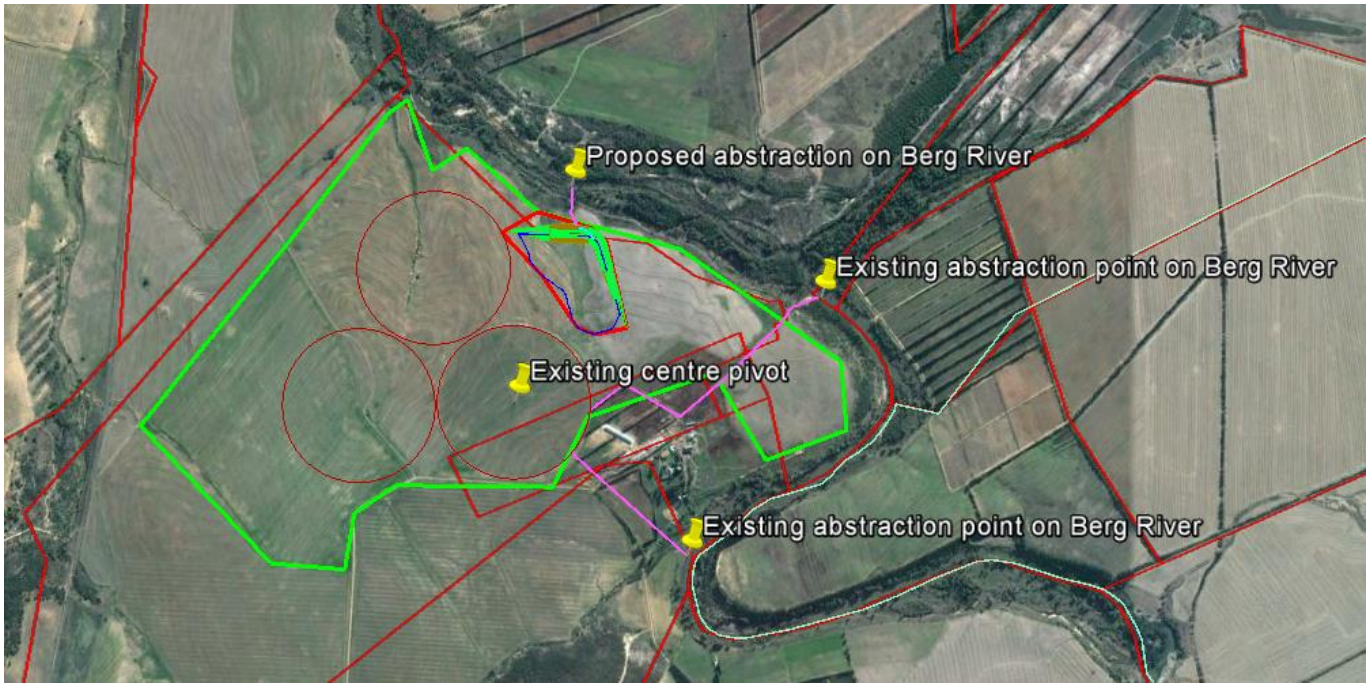

Figure 9: Layout of dam options

7. Cost estimates

A provisional total project cost estimate for the project can be summarised as follows:

Table 3: Cost estimate of the proposed dam

Item No and description	Cost (million R, excl VAT)
1. Construction	
1.1 Proposed Dam	4.7
1.2 Pipelines and pump stations	1.3
Sub-total	**6.0**
2 Professional costs	
2.1 Engineering of dam	0.4
2.2 Authorisation processes	0.3
Sub-total	**0.7**
Total	**6.7**

8. Legal requirements

8.1 Environmental authorization

The EIA environmental authorisation process will be undertaken by Messrs Eco Impact Legal Consulting.

8.2 Water use license

Application for Section 21 b), c), and i) water uses will be required. Messrs Eco Impact Legal Consulting (Pty) Ltd will also arrange this process.

8.3 Dam safety

The Dam Safety process will commence with the application for registration and classification of the new dam. The design and application for a Licence to construct will follow when the other authorisation processes are further advanced.

Yours Faithfully

Joseph Mbenga
Technician

DJ Hagen
Pr Eng

References

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

Ninham Shand (Pty) Ltd (now Aurecon) in Association with Umvoto Africa (Pty) Ltd, (2007). The Assessment of Water Availability in the Berg Catchment (WMA 19) by means of Water Resources Related Models. Report No 2: Rainfall Data Preparation and MAP Surface.

Appendix A: Provided information

Appendix B: Geotechnical Results

Appendix C: Drawings

Appendix D: Dam Quantities Summary