Geophysical survey for a subsurface foundation assessment for the expansion of an existing dam on Zwartfontein, southwest of Hermon, Western Cape

REPORT: GEOSS Report No: 2020/03-29 ***PREPARED FOR:*** Werner Stears Werner.stears@uff.co.za ***and*** Cherie Starke Ingerop 021 914 2833 / 074 158 0499 cstarke@ingerop.co.za	***PREPARED BY:*** Daniél Mulder GEOSS South Africa (Pty) Ltd Unit 12, Technostell Building, 9 Quantum Street, TechnoPark Stellenbosch 7600 Tel: 021 880 1079 Email: info@geoss.co.za (www.geoss.co.za)

13 March 2020

EXECUTIVE SUMMARY

Werner Stears of UFF – African Agri Investments appointed GEOSS South Africa (Pty) Ltd to complete a geophysical survey for a new proposed dam at the Zwartfontein Farm, southeast of Hermon, Western Cape.

The objective of the study is to assess the subsurface at the proposed dam wall sites. This is to delineate areas that may potentially be associated with leakage/fractured zones below the proposed new dam wall site. This is to be done by means of a geophysical survey defined by a geohydrologist. The locations of proposed geophysical traverses were provided by Mrs. Cherie Starke from Ingerop South Africa (Pty) Ltd and might vary depending on access and physical conditions on site. The proposed project terms of reference are as follows:

1. Field geophysics
2. Data processing and analysis
3. Report.

From the ERT survey conducted and field observations, potential leakage is expected through fractured zones in the shallow bedrock. Leakage is expected to decrease over time with silt and clay build up. For the structural integrity of the dam wall it is recommended that excavations are made to a depth where competent bedrock is intersected.

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TABLE OF CONTENTS

LIST OF FIGURES AND MAPS

LIST OF TABLES

ABBREVIATIONS

CGS	Council for Geoscience
DD	Decimal degrees
ERT	Electrical Resistivity Tomography
m	metres
mamsl	meters above mean sea level
mbgl	meters below ground level

GLOSSARY OF TERMS

Pseudo-section: data is plotted along a traverse and at a depth specified by an intersection angle of 45 ° to produce a cross-section of the measured parameter (resistivity in this case).

Resistivity: is an intrinsic property of earth materials that defines how strongly a given material opposes the flow of electric current. Low resistivity is indicative of a material that allows easy flow of electric current.

Tomography: imaging of sections through the use of a penetrating wave for e.g. electrical flow.

Suggested reference for this report:

GEOSS (2020). Geophysical survey for a subsurface foundation assessment for the expansion of an existing dam on Zwartfontein, southwest of Hermon, Western Cape. Report Number: 2020/03-12. GEOSS South Africa (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

View of dam and existing borehole

GEOSS project number:

2019_01-3808

Reviewed by:

Dale Barrow (13 March 2020).

1. INTRODUCTION

Werner Stears of UFF – African Agri Investments appointed GEOSS South Africa (Pty) Ltd to complete a geophysical survey for a new proposed dam at the Zwartfontein Farm, southeast of Hermon, Western Cape **(Figure 1)**. The site is located within a valley area draining towards the east.

2. TERMS OF REFERENCE

The objective of the study is to assess the subsurface at the proposed dam wall sites. This is to delineate areas that may potentially be associated with leakage/fractured zones below the existing and proposed new dam wall site. This is to be done by means of a geophysical survey defined by a hydrogeologist. The locations of proposed geophysical traverses were provided by Mrs. Cherie Starke from Ingerop South Africa (Pty) Ltd and might vary depending on access and physical conditions on site. The proposed project terms of reference are as follows:

1. Field geophysics
2. Data processing and analysis
3. Report.

3. REGIONAL SETTING

The existing dam site on Zwartfontein is located approximately 8 km south of Hermon The Council for Geoscience (CGS) has mapped the area at 1:250 000 scale (3318 – Cape Town). The geological setting is shown in **Figure 2** and the main geology of the area is listed in **Table 1.**

Table 1: Geological formations within the study area

Code	Formation	Group	Description
~	N/A – Quaternary Age deposits		Alluvium
do	Dolorite		Dolorite dyke intrusion
Npo	Porterville	Malmesbury	Phyllitic shale, schist and greywacke with feldspathic grit
Nm	Moorreesburg		Greywacke and phyllite with beds of quartz schist, limestone and grit
Nk	Klipplaat		Quartz schist with phyllite beds ad minor limestone and chlorite-schist lenses

The regional geological setting comprises of Quaternary age deposits, rocks of the Malmesbury Group and Cambrian age dolerite intrusions. The lower lying areas towards the Berg River and valley areas are underlain by alluvium of Quaternary age. Phyllitic shales of the Porterville Formation are well represented towards the east of the study area, where the study area is directly underlain by greywacke with phyllite beds of the Moorreesburg Formation. Quartz schist of the Klipplaat Formation is well represented towards the east. There are several dolerite dyke intrusions mapped within the stud area. Intrusive events are often associated with fractured and baked zones within the parent bedrock (Mooreesburg Formation).

There is a mapped faulted contact between the Moorreesburg and Klipplaat Formation towards the far east of the property. These fault structures are mapped as dipping towards the east. Fault structures are often associated with large discontinuities in the rock, hence fractured bedrock.

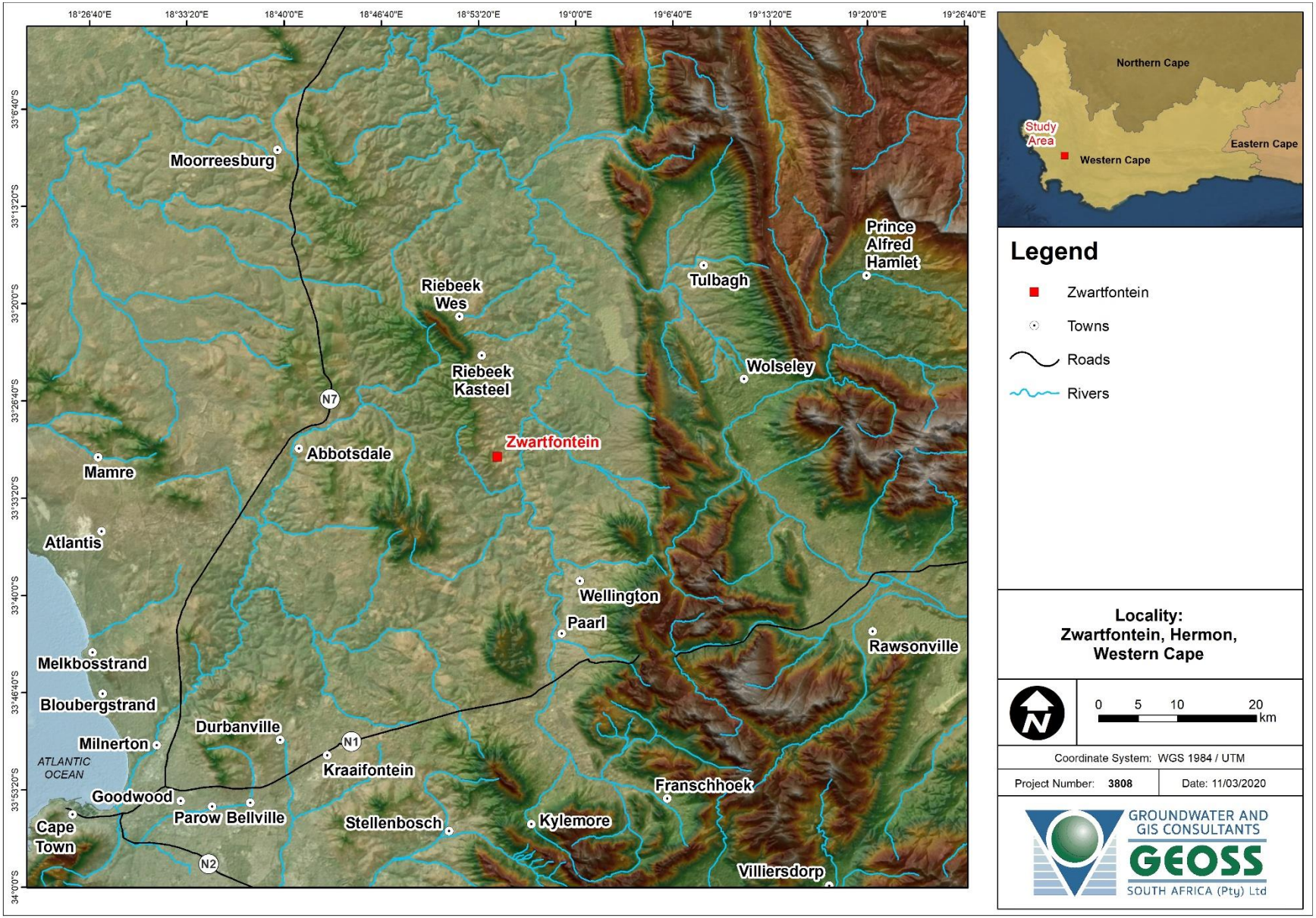

Figure 1: Locality of the proposed expansion of an existing dam at Zwartfontein, near Hermon, Western Cape.

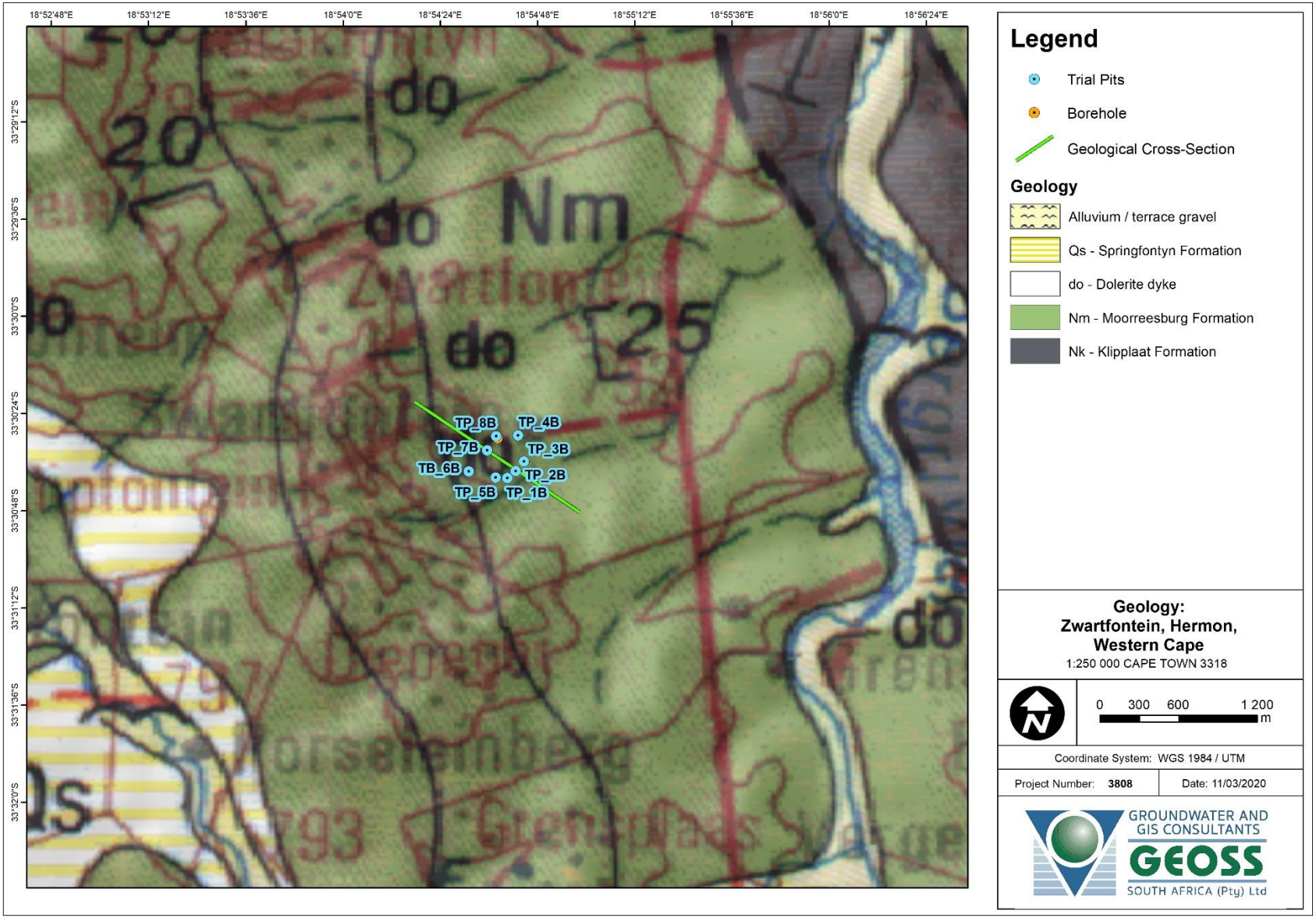

Figure 2: Geological setting (CGS, 1997) of the proposed new proposed dam on Zwartfontein, Hermon, Western Cape, showing geological cross-section in green.

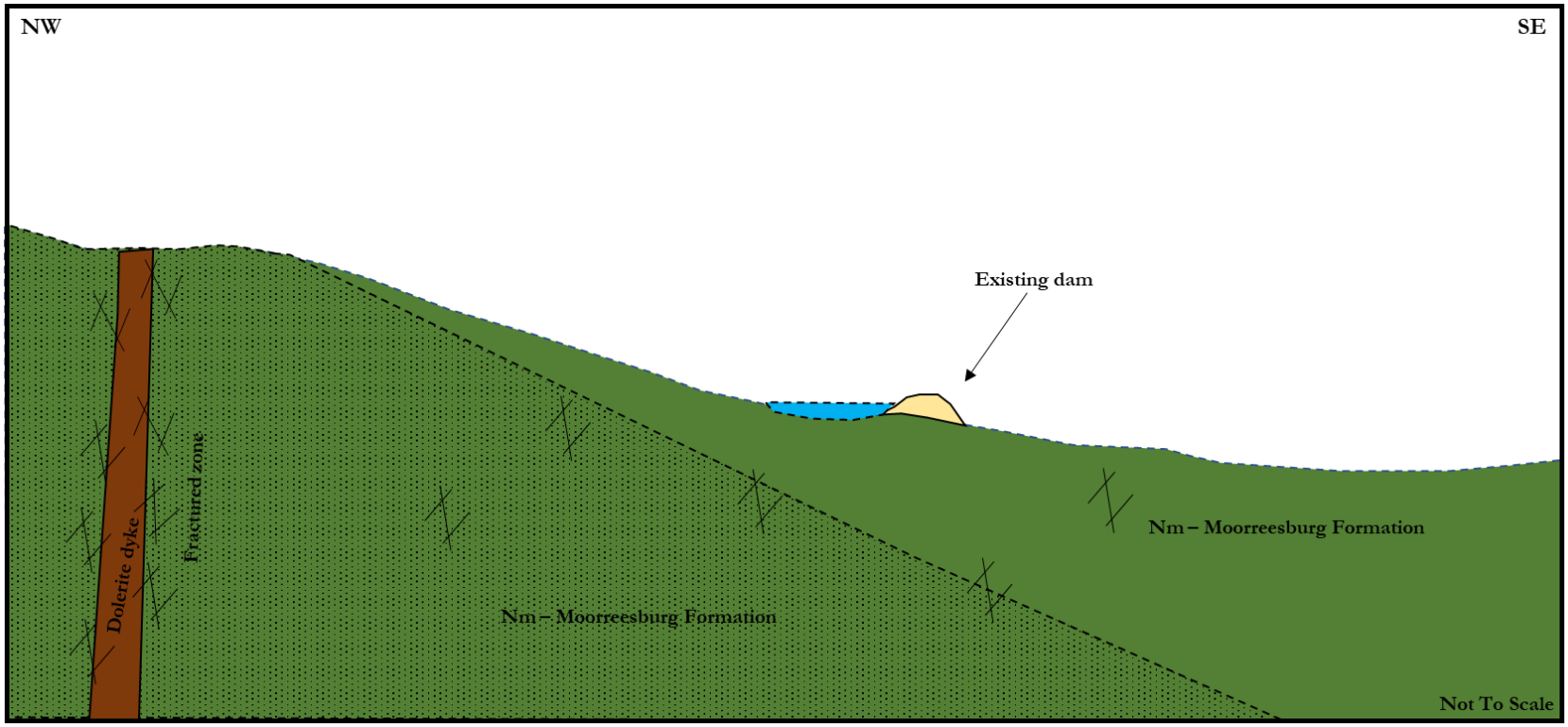

Figure 3: Geological cross-section (as shown on Figure 2) across the dam site.

4. SITE VISIT

The field work was conducted on the 4th of March 2020. This included field structural mapping and a geophysical survey. The geophysical survey was conducted using the electrical resistivity tomography method (ERT) to identify areas in the subsurface that may be associated with leakage/fractured zones below the proposed new dam wall sites. A total of three ERT traverses have been completed below the dam wall, across the dam wall from the south towards the north and a single traverse across the northern flank of the dam wall The area investigated along with trial pit locations from a previous assessment are shown in **Figure 4**.

4.1 Resistivity Tomography Method

Resistivity is a non-invasive geophysical tool that can provide cost-effective solutions to geological questions. The bulk resistivity of different geological units varies mostly because of changes in water saturation or porosity and/or salinity of the pore fluid (Telford et al, 1990). The Syscal Pro system is a completely automated resistivity tomography data acquisition system. The resistivity tomography method provides a pseudo-section of change in electrical properties in the subsurface along a specified profile line. Six multi-core cables with 8 electrode take-outs every 10 m were used. These cables were laid out on the ground end to end in a straight line (where possible). An electrode (metal stake) is inserted into the ground next to every electrode take-out on the cable, using a hammer. The electrode take-out is then connected to the electrode with a short cable jumper. The multi-core cables are connected to the Syscal Pro unit that controls the measurement sequence and takes the apparent resistivity measurements. The data were collected using a standard protocol with the Wenner array. All data were acquired for n = 1 to 8 and 10, 12, 14 and 16 where "n" is the electrode separation multiplication factor.

The apparent resistivity data acquired in the field were inverted using the RES2DINV software (Loke and Barker, 1996) to provide a true-depth resistivity section. The only pre-processing done was to erase obviously erratic data points (minimal). The resulting true resistivity pseudo-sections are used for the interpretation.

The inverted data acquired during the resistivity tomography survey (Res_Line_1) is shown in

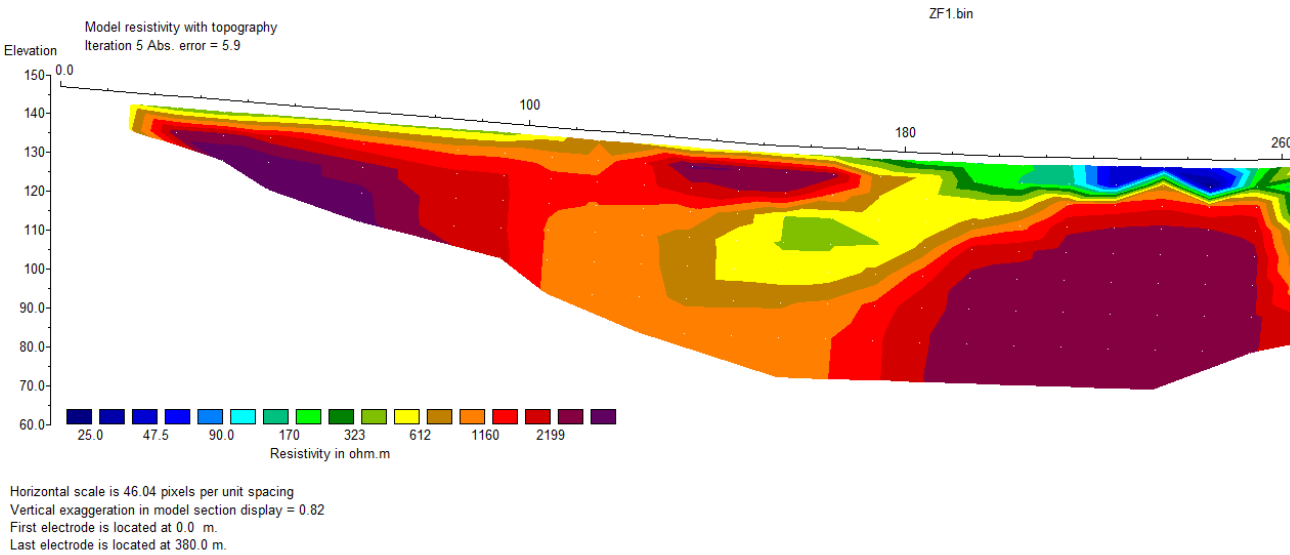

Figure 5. From the measured resistivity values the subsurface can be divided into homogeneous zones with similar physical characteristics. The resistivity values are interpreted as follows:

4.1.1 Res_Line_1

- Dark blue to light blue contour (**25 - 90 ohm.m**) values at shallow depth is likely indicative of semi water saturated alluvial material just below the existing dam wall (stations 210 – 260). This correlates well with the dam outlet and a drainage area.
- Light green to dark green contour (**91 – 323 ohm.m**) values at shallow depth is likely indicative of unconsolidated clay rich material and weathered bedrock. At depths >20 mbgl this is likely indicative of moderately weathered shale bedrock. Around stations 255 – 290 this zone extends up to depth of 30 mbgl which is likely indicative of less competent weathered bedrock with signs of fracturing. At shallow depth around stations 250 – 260 this is likely indicative of bedrock with signs of fracturing.
- Yellow to orange contour (**324 – 1160 ohm.m**) values at shallow depth is likely indicative of weathered bedrock, grading into competent bedrock with depth.
- Red to purple contour (**1161 –2200 ohm.m**) values is likely indicative competent bedrock extending from shallow depth to the full depth of investigation.

4.1.2 Res_Line_2

- Dark blue to light blue contour (**25 - 90 ohm.m**) values at shallow depth is likely indicative of clay rich unconsolidated material and or clay rich material used during the dam wall construction Around stations 0 – 30 this correlates well with the dam outlet and a drainage area (this correlates well with the data from Res_Line_1).

- Light green to dark green contour (**91 – 323 ohm.m**) values at shallow depth is likely indicative of unconsolidated clay rich material and weathered bedrock. At depths >20 mbgl this is likely indicative of slightly weathered shale bedrock.
- Yellow to orange contour (**324 – 1160 ohm.m**) values at shallow depth is likely indicative of material used during the construction of the dam wall (stations 120 – 160). At depths >20 meters this is likely indicative of shale bedrock.
- Red to purple contour (**1161 –2200 ohm.m**) values is likely indicative of material used during the construction of the dam wall, grading into bedrock with depth.

4.1.3 Res_Line_3

- Dark blue to light blue contour (**25 - 90 ohm.m**) values at shallow depth is likely indicative of moist clay rich unconsolidated material. The degree of water saturation is anticipated to increase with depth This extends to depths of 25 mbgl around stations 160 – 240. This is likely semi water saturated as a result of regular irrigation of orchards upgradient of ERT traverse.
- Light green to dark green contour (**91 – 323 ohm.m**) values at shallow depth is likely indicative of unconsolidated clay rich material and weathered bedrock. At depths >20 mbgl this is likely indicative of moderately weathered clay rich bedrock. Around stations 0 – 130 this is anticipated to be clay rich unconsolidated material and moderately weathered bedrock at depths >10 meters, grading into competent bedrock. Around stations 230 – 250 this is anticipated to be competent fractured bedrock (this correlates well with profiles of TP_8B, showing fractured bedrock).
- Yellow to orange contour (**324 – 1160 ohm.m**) values at shallow depth is likely indicative of bedrock with signs of weathering. Degree of weathering is anticipated to decrease with an increase in depth.
- Red to purple contour (**1161 –2200 ohm.m**) values is likely indicative competent bedrock extending from shallow depth to the full depth of investigation. Around stations 110 – 190 this can be associated with hard competent bedrock.

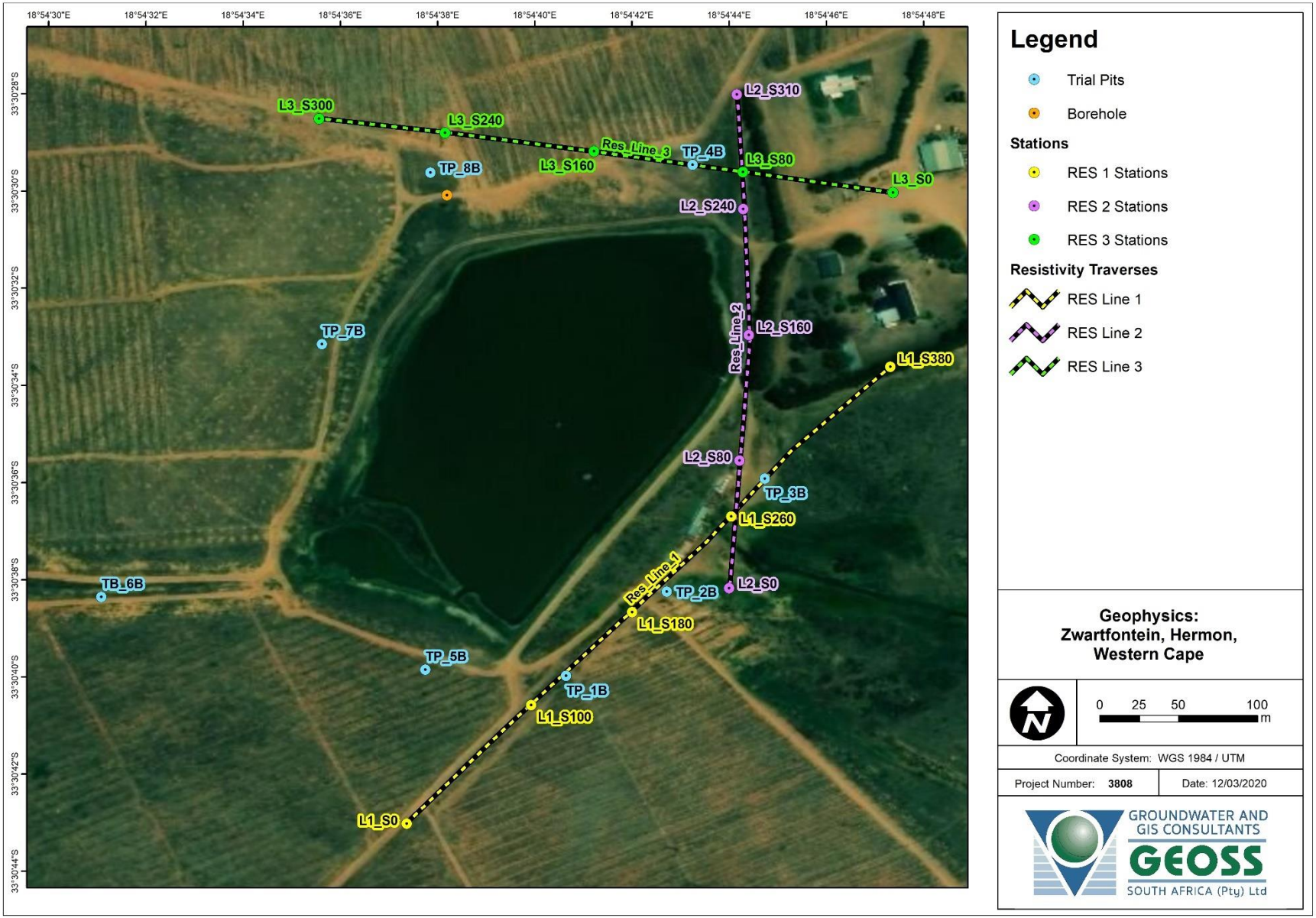

Figure 4: Areas investigated during the geophysical survey along with trial pit locations.

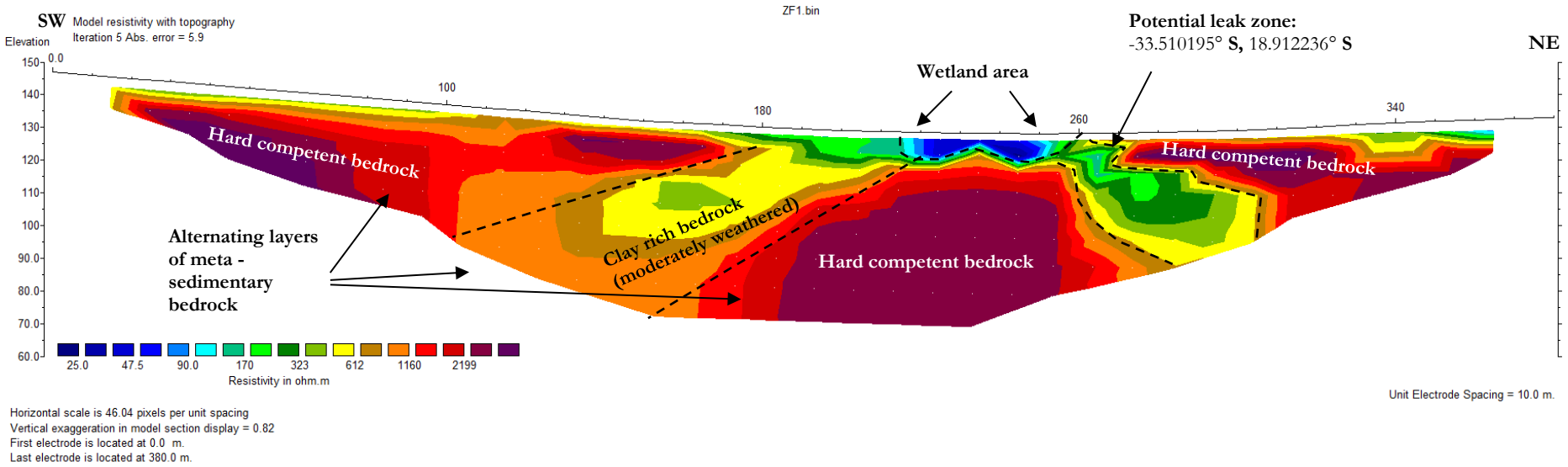

Figure 5: Inverted resistivity profile Res_Line_1 showing investigation depth as elevation (mamsl)

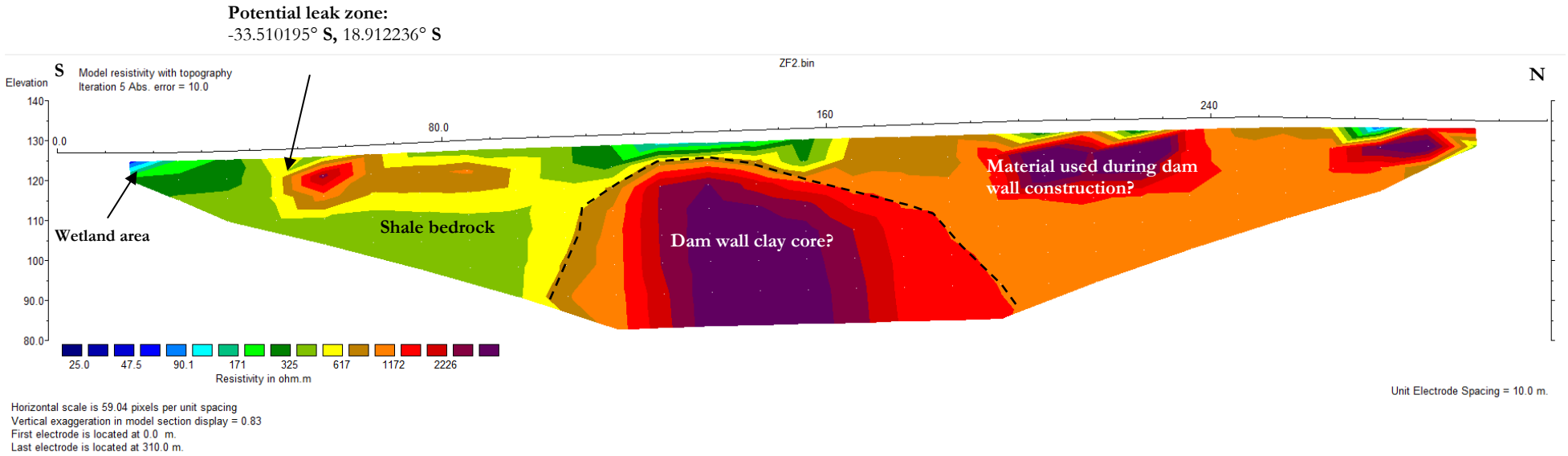

Figure 6: Inverted resistivity profile Res_Line_2 showing investigation depth as elevation (mamsl).

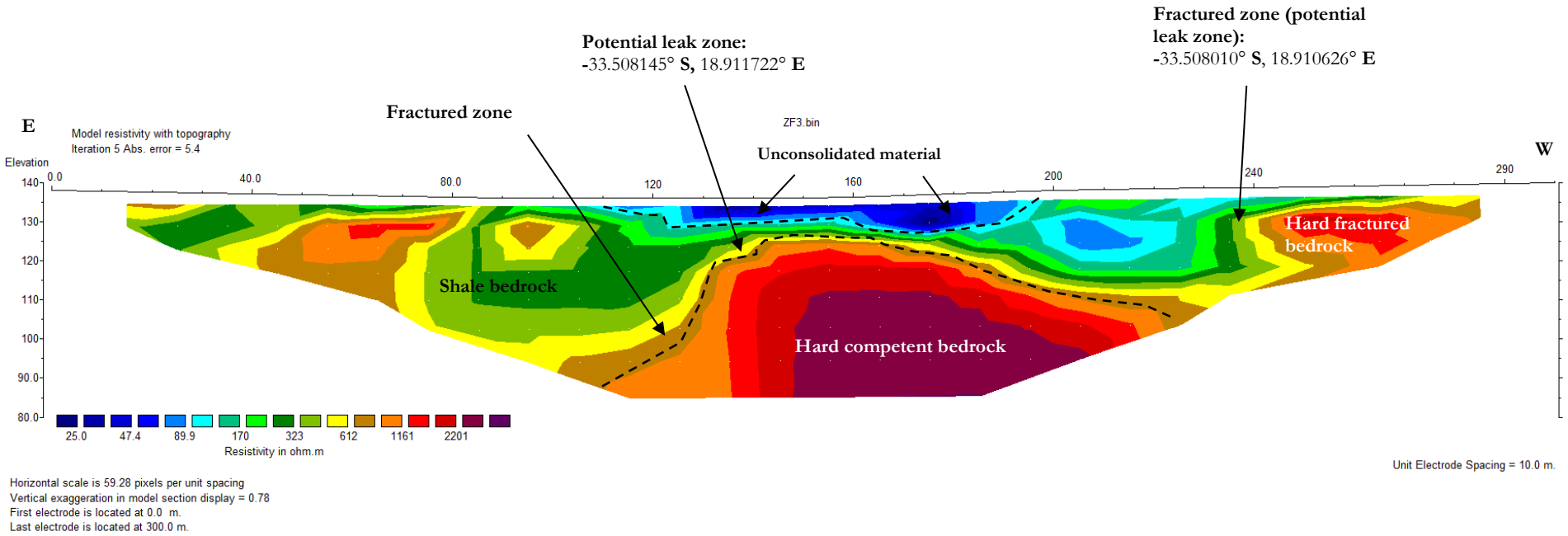

Figure 7: Inverted resistivity profile Res_Line_3 showing investigation depth as elevation (mamsl).

5. DISCUSSION AND CONCLUSION

GEOSS successfully completed an ERT survey at the new proposed dam on the Zwartfonteint Farm, southwest of Hermon. Three ERT traverses have been completed across the study area to delineate areas that may be associated with fractured and less competent bedrock, hence leakage.

The data from all of the ERT traverses completed shows a relatively shallow depth to bedrock and the area would require fairly shallow excavations to reach hard bedrock. From the ERT survey conducted and field observations, potential leakage is expected through fractured zones in the shallow bedrock. Leakage is expected to decrease over time with silt and clay build up. Several areas were identified where the bedrock is expected to be fractured, correlating with fractured bedrock in the trial pits dug during a previous investigation, which may act as preferential follow paths for water. Several areas have been identified with a high risk for leakage through fractured bedrock. The data from Res_Line_1 indicates that there is a potential existing leak zone below the dam wall due to fractured bedrock (around stations 250 – 270). Where two anomalies have been delineated from the data of Res_Line_3 (around stations 130 – 140 and 230 – 240) that have a high risk of leakage due to shallow unconfined fractured bedrock.

For the structural integrity of the dam wall it is recommended that excavations are made to a depth where competent bedrock is intersected.

6. REFERENCES

CGS, (1979). The 1:250 000 geological map series. Map number: 3318 Cape Town.

Loke M.H. and Barker R.D., (1996). Rapid least-squares inversion of apparent resistivity pseudo-sections by a quasi-Newton method. Geophysical Prospecting, Volume 44, Issue 1, pp 131-152.

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