KOKSTAD ADDITIONAL WORKS
(Access Road and Culvert)
GEOTECHNICAL INVESTIGATION REPORT

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REVISION 00

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SYNOPSIS :

Geotechnical Investigation for the proposed access road and culvert.

KEY WORDS :

Geotechnical Investigation, Hillwash, Alluvium, Residual Mudstone, Mudstone Bedrock, Sandstone Bedrock, Culvert, Foundation.

QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2008 which has been independently certified by DEKRA Certification under certificate number 90906882

Verification	Capacity	Name	Signature	Date
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Authorised by	Director	Jan Norris		29/07/2019

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1 INTRODUCTION

Terratest (Pty) Ltd was appointed by JG Afrika to undertake additional geotechnical investigation work for the proposed NRA-N002-210-2009/2D-SS2 Intersection of the N2 and R56 in Kokstad, hereafter called the Kokstad N2 Interchange Development. The additional components to the investigation include an access road and culvert to link the Trade Centre with the R56.

An invasive geotechnical investigation was conducted to establish the in-situ subgrade conditions, assess the bearing pressures of the subsoil and bedrock for culvert foundation and to assess the construction materials available to aid in the design of the access road.

2 SCOPE OF WORKS

The work carried out at the proposed site included:

- A desktop study of available information of the area including but not restricted to published literature, topographical and geological maps, air photos and existing reports.
- The mechanical excavation and profiling of six (6. No) trial pits labelled TP1 to TP6. TP1 and TP2 are at the culvert site while the remainder of the trial pits are located along the centreline of the proposed access road.
- Profiling trial pits in accordance with the specifications set out in "Guidelines for Soil and Rock Logging in SA (2nd Impression, 2002)".
- Retrieval of soil samples from the trial pits and submitting them to Soilco (Pty) Ltd, a civil engineering materials testing laboratory, located in Pietermaritzburg. The following testing was undertaken: -
    - Roads and Foundation Indicators (Particle Size Distribution and Atterberg Limits).
    - Modified AASHTO Compaction Testing and
    - California Bearing Ratio (CBR) Measurements.
- Conducting four (4. No) Dynamic Cone Penetrometer (DCP) tests along the centre line of the proposed roads. The DCPs conducted adjacent to the trial pits are referenced TP3 to TP6 and these correspond to the numbered trial pit position.

The positions of the trial pits are shown in Figure 4-1 in Section 4 of this report.

3 SITE DESCRIPTION

3.1 General Site Location, Topography and Drainage Conditions

The site is located off the R56 road into Kokstad and the proposed access road links the Trade Centre with the R56 road. The approximate length of the proposed access road is 383m and the alignment slopes gently in a north eastern direction towards the stream. At present, a large portion of the site is covered by short grass and a dense strand of eucalyptus trees between chainages Km0 and Km0+200.

These trees will need to be cleared to pave way for construction. A stream flows in a north westerly direction and crosses the proposed road alignment at chainage Km0+330. Figure 3-1 below shows the general location and alignment of the proposed access road in relation to the town of Kokstad and the surrounding environs.

Figure 3-1: General Site Locality Plan and Access Road Alignment

3.2 Site Geology

According to the 1:250 000 scale geological map sheet (Map Reference 3028, Kokstad), the site is underlain by a dolerite sill, as well as grey and reddish brown, mudstone and grey fine-grained sandstone of the Adelaide Subgroup which forms part of the Beaufort Group. Figure 3-2 below shows the geology map extract which covers the proposed access road site.

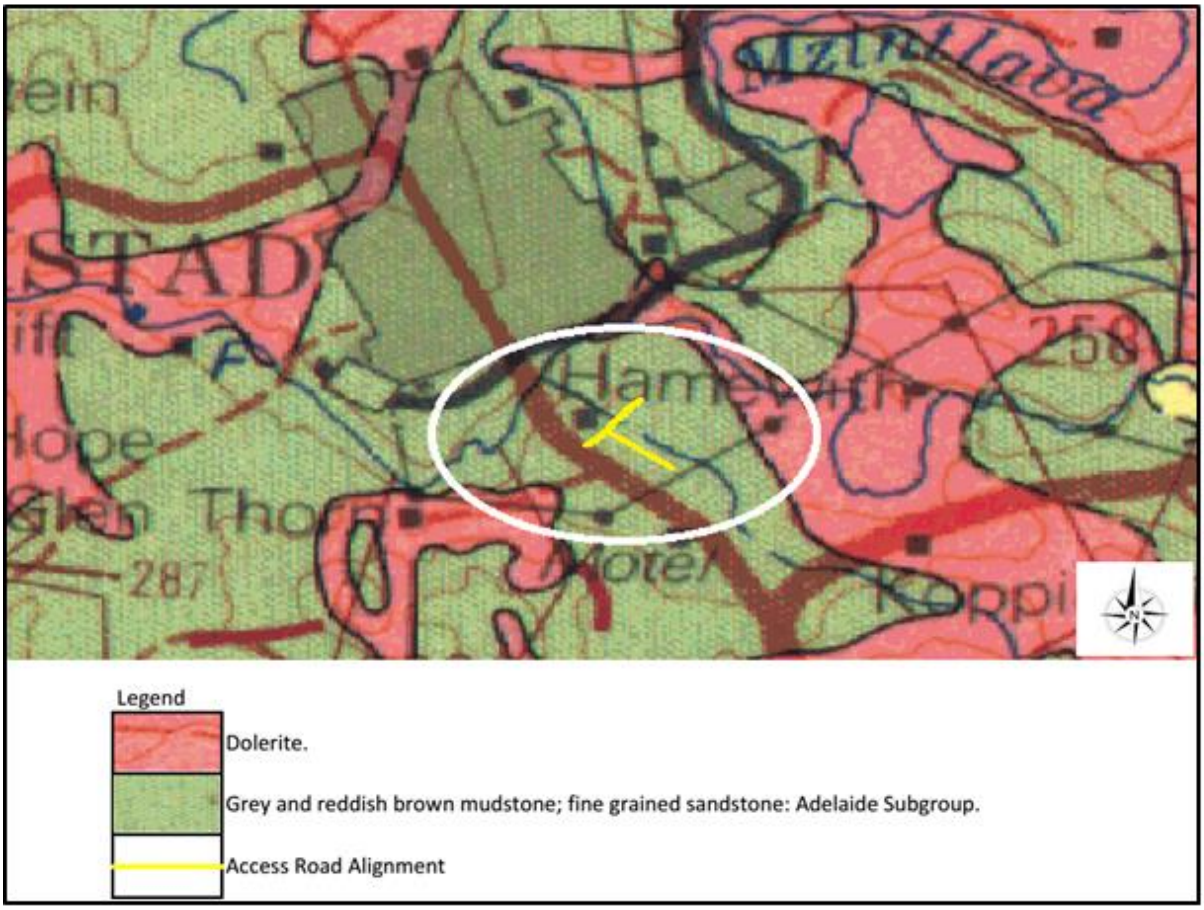

Figure 3-2: Local Geology Map (Reproduced from Map Reference 3028, Kokstad)

During the invasive geotechnical investigation, a transported horizon was observed overlying residual mudstone soil, mudstone and sandstone bedrocks.

4 MATERIALS AND FOUNDATION INVESTIGATION

4.1 Access Road and Culvert Trial Pits

Six (6. No) trial pits presented in Table 4-1 below were excavated along the proposed access road centreline, the locations of which are indicated on the site plan, presented as Figure 4-1 overleaf.

Figure 4-1: Trial Pit Plan

A summary of the ground profiles encountered in the trial pits is presented in Table 4-1 below.

Table 4-1: Summary of Ground Profiles

Trial pit ID.	Depth to Top of Horizon in m (Thickness in M)				
	Transported	Residual Mudstone	Mudstone Bedrock	Sandstone Bedrock	Water Table
TP1	0.00 – 1.10			1.10 – 1.20(+)	1.00
TP2	0.00 – 1.20			1.20 – 1.30(+)	1.00
TP3	0.00 – 1.20	1.20 – 1.70	1.70 – 1.80(+)		-
TP4	0.00 – 0.40	0.40 – 2.00(+)			-
TP5	0.00 – 0.80	0.80 – 2.20(+)			-
TP6	0.00 – 0.50	0.50 – 2.50(+)			-

(+) horizon extends further.

The materials encountered in the trial pits excavated on site include, transported soils, residual mudstone, mudstone and sandstone bedrocks and these are discussed briefly below.

4.1.1 Transported Soils

- Hillwash

The section of the road alignment between chainage km0 to km0+160, is covered by a hillwash horizon. The thickness of the horizon varies between 0.50m and 0.80m. The relevant trial pits are referenced TP4, TP5 and TP6. The material was described as slightly moist, brown, loose, intact silty sand.

- Alluvium

Between chainage km0+160 to km0+383, the section of the proposed access road alignment is covered by an alluvial horizon and this was described as slightly moist to moist, stiff, fissured, micro-shattered and slicknesided, sandy clay silt. The relevant trial pits are referenced TP1, TP2 and TP3. The average thickness of the alluvium is approximately 1.20m.

4.1.2 Residual Mudstone

The transported soils where underlain by a residual mudstone soil horizon. The latter was described as slightly moist, grey to brown, dense/stiff, intact, with a composition varying from clayey silty sand to sandy clayey silt. The thickness of the residual mudstone is generally not known as the horizon was not fully exposed during the investigation.

4.1.3 Mudstone and Fine-Grained Sandstone Bedrocks

The sandstone and mudstone bedrock units which make up part of the Adelaide Subgroup were encountered at varying depths across the study area. The mudstone was intersected in TP3 and was described as grey to yellowish brown, highly weathered, thinly bedded, with a soft rock hardness, mudstone. The mudstone was observed intercalated with thin sandstone lenses. The sandstone bedrock was intersected at an average depth of 1.20m at the culvert position and it was profiled as grey brown, moderately weathered, highly fractured, medium grained, with a hard rock strength.

The detailed trial pit logs are presented in Appendix A.

4.2 Dynamic Cone Penetrometer (DCP) Tests

DCP tests were conducted adjacent to the test pits, from the surface to 1.0m depth. The readings of DCP penetration resistance have been used to empirically derive the subgrade consistency and strength. The DCP test results indicate that the approximate in-situ California Bearing Ratio (CBR) values of the in-situ soils are uniform. The in-situ CBR values vary between 7% and 46%, which is indicative of the relatively uniform subgrade ground conditions across the study area. These approximate in-situ CBR values for the different horizons encountered in each trial pit are presented in Appendix A of this report.

It should be noted that the results of DCP testing are affected by the moisture content of the soil profile, as well as any pebbles or cobbles that may be struck. A horizon saturated due to heavy rainfall will provide a lower set of results than a similar test in the dry season. Most of the horizons profiled during the course of the investigation were recorded as exhibiting slightly moist to moist, natural moisture contents. Lower in-situ CBR’s may be recorded under higher soil moisture conditions.

4.3 Groundwater Conditions

Groundwater seepage was noted in TP1 and TP2 at 1.00m depth below the current ground level. In addition, mottled colours and the evidence of limited pedogenesis were observed within the soil profile at some locations along the road alignment and these suggest poor drainage conditions and a fluctuating water table respectively.

5 LABORATORY TESTING

For a more accurate determination of the material properties for classification purposes, particle size distribution, Atterberg Limits, hydrometer analysis, California Bearing Ratio (CBR), and dry density/moisture relationship tests were conducted on representative disturbed soil samples retrieved from the trial pits. These results have been summarized in the tables below:

Table 5-1: Summary of Index Test Results

TP N0	Sample Depth (m)	Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	LS (%)	LL (%)	PI (%)	Soil classification		PE
										AASHTO	USCS	
1	0.50-1.00	Clayey sandy silt; Alluvium.	1	34	36	29	6.5	31	14	A.6(8)	CL	Low
2	0.10-0.90	Sandy clayey silt; Alluvium.	2	21	46	31	6	32	13	A.6(9)	CL	Low
3	0.10-1.20	Clayey silt; Alluvium.	-	10	52	38	5.5	31	11	A.6(8)	CL	Low
3	1.20-1.70	Clayey silty sand GRAVEL: Residual Mudstone.	47	21	18	14	5.0	31	12	A.2.6(0)	SC	Low
4	0.40-1.60	Sandy clayey silt; Residual Mudstone.	-	23	47	30	5.0	28	10	A.4(9)	CL	Low
5	0.80-1.60	Sandy clayey silt; Residual Mudstone.	1	24	38	37	5	34	12	A.6(9)	CL	Low
6	0.50-1.50	Silty sandy clay; Residual Mudstone.	3	32	28	37	6.5	41	13	A.7.6(7)	CL	Low

Table 5-2: Summary of Compaction and Strength Tests Results

TP ID	Depth Range	Description	GM	LL %	PI %	LS %	OMC %	MDD, Kg/m³	CBR @% MOD					TH14	COLTO
									90	93	95	98	100		
2	0.10-0.90	Sandy clayey silt; Alluvium.	0.29	32	14	6.5	14.6	1791	4	6	7	10	13	n/a	n/a
3	0.10-1.20	Clayey silt; Alluvium.	0.12	31	11	5.5	10.8	1722	2	3	3	5	7	n/a	n/a
4	0.40-1.60	Sandy clayey silt; Residual Mudstone.	0.34	28	10	5.0	11.9	1811	4	5	6	7	9	G10	n/a
5	0.80-1.60	Sandy clayey silt; Residual Mudstone.	0.37	34	12	5.0	13.1	1634	2	3	4	5	7	n/a	n/a

TP ID	Depth Range	Description	GM	LL %	PI %	LS %	OMC %	MDD, Kg/m³	CBR @% MOD					TH14	COLTO
									90	93	95	98	100		
6	0.50-1.50	Silty sandy clay; Residual Mudstone.	0.69	41	13	6.5	11.7	1684	4	6	7	9	11	G10	n/a

The following abbreviations have been used:

PI: Plasticity index; GM: Grading Moduli; LL: Liquid Limit; LS: Linear Shrinkage; TP: Trial Pit; PE: Potential Expansiveness; MDD: Maximum Dry Density; OMC: Optimum Moisture Content; MOD: Modified AASHTO Density; CBR: California Bearing Ratios; AASHTO: American Association of State Highway and Transportation Officials: USCS: Unified Soil Classification System; COLTO: Committee of Land and Transportation Officials and TRH: Technical Recommendations for Highways.

6 GEOTECHNICAL EVALUATION

The project area is predominantly underlain by sandy clayey silt soils of alluvial and residual mudstone origin. The engineering properties of the materials vary within narrow limits. The soils along the proposed access road and culvert site returned low to moderate plasticity indices which vary between 10% and 14%. The linear shrinkage limit values are generally moderate and range between 5.0% and 6.5%. The soils also returned liquid limits that vary between 28% and 41%. Based on the liquid limit values and clay fractions returned by samples, the calculated Activity Index according to Skempton (1953), vary between 0.29 and 0.48, with an outlier value of 0.85 from a sample retrieved from TP3 at a depth range of 1.20m to 1.70m. Therefore, the soils found within the road bed depths along the centreline, classify as “INACTIVE”. Furthermore, the soils show a low potential expansiveness according to Van der Merwe (1964).

The soils classify as lean clay, CL, according to the Unified Soils Classification System (USCS) and as A.4(9) to A.7.6(7) Group materials, according to AASHTO classification system. Therefore, the materials rank poorly as subgrade materials. In addition, the soils fall outside the classification limits according to COLTO classification system and classify as G10 and poorer than G10 according to TRH14(1985). The poor-quality is as a result of the fine-grained nature (low grading moduli) of the soils and moderate plasticity.

7 RECOMMENDATIONS

7.1 Roadbed and Subgrade Conditions

The in-situ soils classify poorly according to AASHTO, TRH14 and COLTO classification systems and therefore cannot be utilised for subgrade construction as they fall outside the specification limits. During the field investigation and preparation of this report, no vertical alignment for the access road had been provided. However, it is assumed that a fill embankment will be constructed between chainage km0+100 to km0+383. In view of this and coupled with low activity indices and low plasticity indices which suggest low compressibility and low swell potential, the soils can be prepared as road bed and subsequent fill layers constructed on top.

On sections where no fill embankment will be constructed, it is recommended that the soils be cut to spoil by at least 300mm and replaced with materials that meet subgrade quality (G10 and better) or materials of suitable classification according to the pavement design.

7.2 Culvert Foundation Conditions

The relevant trial pit holes are referenced TP1 and TP2. The culvert position is generally underlain by stiff clayey sandy silt, alluvium. The alluvium is underlain by medium hard rock strength sandstone bedrock at an average depth of 1.20m. Considering the shallow depth to bedrock, the alluvium must be excavated entirely, spoiled and replaced with granular material of G7 quality or better, compacted in 150mm layers to at least 93% Modified AASHTO density at OMC +/-2 to the invert of the proposed culvert. Normal construction can follow thereafter.

7.3 Stream Re-Alignment

The culvert location is not on a straight section of the stream, therefore minimal river training works are recommended during the construction phase to realign the stream, to improve the hydraulics and minimize erosion.

8 CONSTRUCTION CONSIDERATIONS

8.1 Construction Monitoring

8.1.1 Excavation Inspection

It is recommended that, the foundation excavation for the proposed culvert structure be inspected and approved by the resident engineer or engineer's representative prior to placing any concrete. This is to ensure that the founding materials are of the required consistency.

8.1.2 Earthworks

It is recommended that all earthworks be supervised by a competent person. Adequate supervision and the correct use of equipment during construction are required for satisfactory results and regular checks on the quality and compaction should be made.

8.2 Construction Problems

The major construction challenges are likely to be: -

- Poor access around the site for conventional rubber tyred vehicles during the wet summer months.
- Possible long-haul distances for construction materials.

8.3 Additional Investigations

No additional investigations are considered necessary for the assessment of the near surface soils and founding conditions.

9 CONCLUSIONS

From the geotechnical investigation data, it was noted that the proposed access road alignment is underlain by generally firm to stiff sandy clayey silt, residual mudstone and alluvial soils. The soils along the access road alignment are generally of poor quality. They classify poorly as subgrade material according to AASHTO classification system and classify outside the specification limits of COLTO classification system and as G10 and poor according to TRH14 (1985). These soils are deemed not suitable for subgrade construction in their natural state. They can be replaced by better quality materials meeting the subgrade quality or the pavement design specification. Where the section of the road is on a fill embankment the soils can be treated as roadbed materials and prepared as such and covered by subsequent fill layers.

The alluvium overlying the sandstone bedrock at the culvert position must be undercut and spoiled. An engineered fill must be constructed from the bedrock surface to the culvert invert and normal construction to follow.

All embankment slopes must be protected to curb wasting through soil erosion. This can be achieved by re-grassing.

Ease of excavation is expected to be “SOFT” to an average depth of 2.00m along the centre line of the access road and to an average depth of 1.20 at the culvert position. All excavations beyond 1.20m must be supported.

REFERENCES

1. South African Institute of Engineering Geologists, South African Institute of Civil Engineers, Geotechnical Division, 2nd Impression. *Guidelines for Soil and Rock Logging in SA.* (2002).
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3. Waltham A.C. (1994), "Foundations of Engineering Geology" Blackie Academic & Professional.

Appendix A: TRIAL PIT LOGS AND DCP PROFILES

Appendix B: LABORATORY TEST RESULTS