



GEOHYDROLOGY

GEOTECHNICAL

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SOCIAL DEVELOPMENT

**Technical Report**  
2018 / 07 / 18 GTEC



**EAST LONDON INDUSTRIAL DEVELOPMENT ZONE**  
**Soils investigation for the proposed block development between**  
**Umzimbithi Road and Mdubu Road at the East London IDZ, Buffalo**  
**City Metropolitan Municipality**

Prepared for: **BVI Border (Pty) Ltd**  
Document version 1.0 – Draft 1  
Compiled by **F.N. DE JAGER**

August 2018



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**TECHNICAL REPORT:**

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**EAST LONDON INDUSTRIAL DEVELOPMENT ZONE**

**Soils investigation for the proposed block development between Umzimbithi Road and Mdubu Road at the East London IDZ, Buffalo City Metropolitan; Eastern Cape Province**

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August 2018

**Conducted on behalf of:**

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## **1 INTRODUCTION**

### **1.1 General**

AGES Omega (Pty) Ltd was appointed by BVI Border (Pty) Ltd to conduct a soils investigation for the proposed block development between Umzimbithi Road and Mdubu Road at the East London Industrial Development Zone, with the aim of determining and evaluating the engineering geological characteristics of the in-situ soil and rock material underlying the project area with regard to the proposed development of the area.

### **1.2 Terms of reference**

The investigation was requested by Mr. Werner de Lange of the firm BVI Border (Pty) Ltd on behalf of their client the ELIDZ. AGES was appointed following the submission of a detailed project quotation. Appointment was received on the 4<sup>th</sup> of June 2018 (Ref: 33441.00 – L – 012).

### **1.3 Specifications for the investigation**

The following specifications were given regarding the proposed development and information required from the geotechnical investigation of the project area:

- Platform A, B and C
  - Structural Engineering Requirements
    - Foundation indicators
    - Safe bearing capacity
    - Activity of material
    - Foundation classifications
  - Civil Engineering Requirements
    - Generalised soil profiles
    - Water tables
    - Compaction characteristics
  - Mechanical Electrical Requirements
    - Resistivity testing
    - Corrosivity testing

### **1.4 Nature of the investigation**

The investigation was conducted over approximately 2 weeks of fieldwork as required in order to finalise required specifications. The investigation was conducted as follows:

- Site walk over survey and geological mapping.
- Test pit excavation and profiling.
- Dynamic Cone Penetrometer testing.
- Geophysical profiling for Resistivity testing.

### 1.5 Location of the project area

The project area is located between Umzimbithi Road and Mdubu Road in the East London Industrial Development Zone in Buffalo City Metropolitan Municipality. The locality of the project area is indicated in Figure 1 below, as exported from Google Earth Professional Edition. The central point of the project is defined by the following coordinate (Decimal Degrees, WGS84):

- ❑ Latitude: -33.057153° S
- ❑ Longitude: 27.851551° E



Figure 1: Regional site locality as observed in Google Earth

### 1.6 Available information

The following sources of information were used during the investigation:

- ❑ Geological maps
  - 3327BB EAST LONDON, scale 1 : 50 000.
- ❑ Hydrogeology map
  - 3126 QUEENSTOWN; scale 1 : 500 000.
- ❑ Electronic maps
  - Site development plan supplied by BVI Border (Pty) Ltd

## 1.7 Geological Setting

The geological setting of the project area was determined by means of published 1:50 000 scale geological map and the study of aerial imagery.

The project area is underlain by sedimentary rocks of the Middleton and Balfour Formations of the Adelaide Subgroup of the Beaufort Group that is part of the Karoo Supergroup sequence. The lithology comprises of mudstone and sandstone that is locally overlain by soil > 1 m thick.



Figure 2: Geological setting of project area (Pa – Adelaide Subgroup)

Dolerite dykes and sills have intruded the sedimentary strata of the Karoo Supergroup during the late Karoo volcanism. The geology map does not indicate the presence of any dolerite dyke or sill intrusions in the project area. A thin dolerite dyke with a basic east-west trend direction was encountered in previous investigations in the area. The dyke was not intersected in any of the test pits that was excavated as part of this investigation.

No other prominent geological structures such as fault zones or LANDSAT derived lineaments occur in the project area.

*The area does not reflect any risk for the formation of sinkholes or subsidence caused by the presence of water-soluble rocks (for example: dolomite or limestone).*

## 1.8 Regional Seismic Hazard

According to Fernandez *et al* (1979) the regional seismic hazard in the project area can be defined as follows:

- The area exhibits a 90 % probability of the occurrence of a seismic event not exceeding Class VII-intensity<sup>1</sup> (i.e.: equivalent to a seismic event registering 5.5 to 6.1 on the Richter Scale) within a period of 500 years.

In this light, the natural seismic risk of the project area can be classified as SLIGHT to LOW, and as such requires that Masonry Class B design and construction measures be implemented, incorporating good workmanship and reinforced mortar work, but specific design and construction measures to resist the effect of lateral forces on the proposed development is not deemed necessary.

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1 The effects of a Class VII-intensity event (categorized as strong to very strong) can be summarized as follows:

- Difficult to stand
- Noticed by drivers of motorcars
- Hanging objects quiver
- Furniture broken
- Damage to weak materials (such as adobe: poor mortar; low standards of workmanship; weak horizontally) including cracks
- Weak chimneys broken at roof line
- Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments
- Some cracks in ordinary workmanship and mortar
- Small slides and caving-in along sand or gravel banks and concrete irrigation ditches will be damaged

## 2 SITE INVESTIGATIONS

### 2.1 Test Pit Excavation

A total of 100 test pits were excavated utilising a JCB 3CX 4x4 TLB-type excavator fitted with a 300-rock bucket. Test pits were excavated in June 2018 at positions indicated by the client up to a required depth of 1.5 mbgl or refusal. In general all test pits were excavated to maximum reach or refusal of the TLB. Several test pits could not be excavated due to very dense and prominent indigenous vegetation that was requested by the ELIDZ not to be cleared as part of the geotechnical investigation. Test pits were excavated as follow:

- Block A - 28 test pits
- Block B - 32 test pits
- Block C - 40 test pits

Test pits were profiled according to the Guidelines for Soil and Rock logging in South Africa. Selected samples were taken of prominent soil horizons for detailed laboratory analysis. Generalised soil conditions encountered during the investigation are discussed in Chapter 4 of the report with detailed soil profile logs and photographs attached in Appendix A.

### 2.2 Dynamic Cone Penetrometer Testing

Dynamic Cone Penetrometer (DCP) tests were conducted adjacent to all test pits and in the bottom of selected test pits based on encountered soil conditions.

The DCP testing gives an estimation on the expected excavation conditions and in-situ bearing capacity of the soil materials, with the Unconfined Compressive Strength of the material calculated from the obtained CBR values and mm penetration per blow. The testing is useful to get a basic estimation of existing in-situ soil conditions, but it must be noted that the results are highly influenced by larger soil particles in profile, such as cobbles to boulders, and also by moisture content.

Please note:

- *The moisture content of the soil material is expected to influence the bearing capacity of the material to a large extent, with significant decreases in bearing expected with an increase in material moisture content.*
- *The indicated kPa ranges of the materials are highly influenced by the DCP cone intersecting cobbles and boulders within the alluvium material, that will result in a much higher kPa value than the actual bearing of the material.*

DCP data is discussed in Chapter 4 of the report with detailed data and results attached in Appendix B.



### 2.3 Resistivity Testing

In order to characterize the soil resistivity, resistivity sounding surveys were conducted utilizing a G41 DC resistivity meter manufactured by Geotron. Wenner-configuration soundings were conducted at 1m, 2m, 4m and 10m electrode spacing intervals at selected stations. The positions where readings could be obtained was highly influenced by the vegetation and accessibility of the project area as the equipment setup requires linear setup lengths of between 3 m (1 m depth) and 30 m (10 m depth). The varying electrode spacing enables the determination of resistivity with depth corresponding to the electrode spacing.

The survey results for each sounding electrode spacing was interpolated to identify the high and low resistive zones over the entire project area. Resistivity contour maps were constructed utilizing the interpolated data and are indicated in the figures below. Detailed results are tabled and discussed in Chapter 4 of the report.

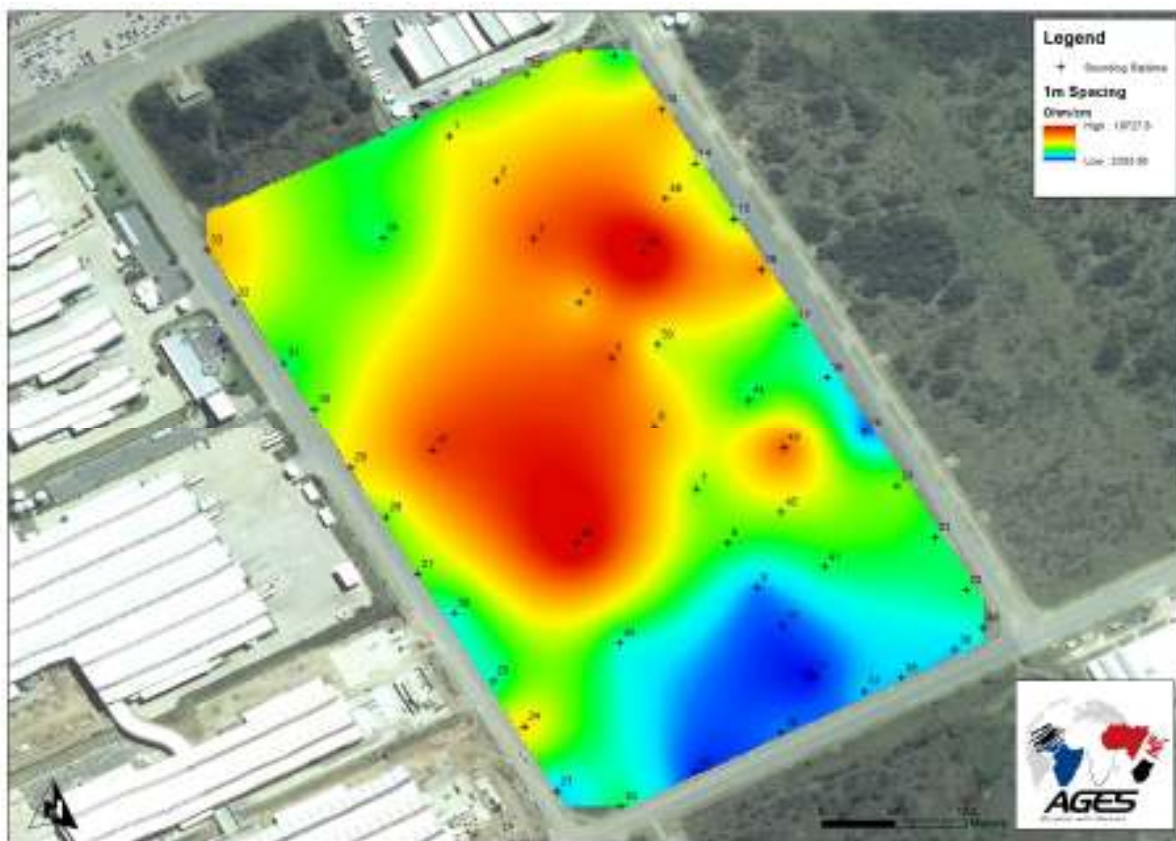


Figure 3: Resistivity contour data – 1m depth

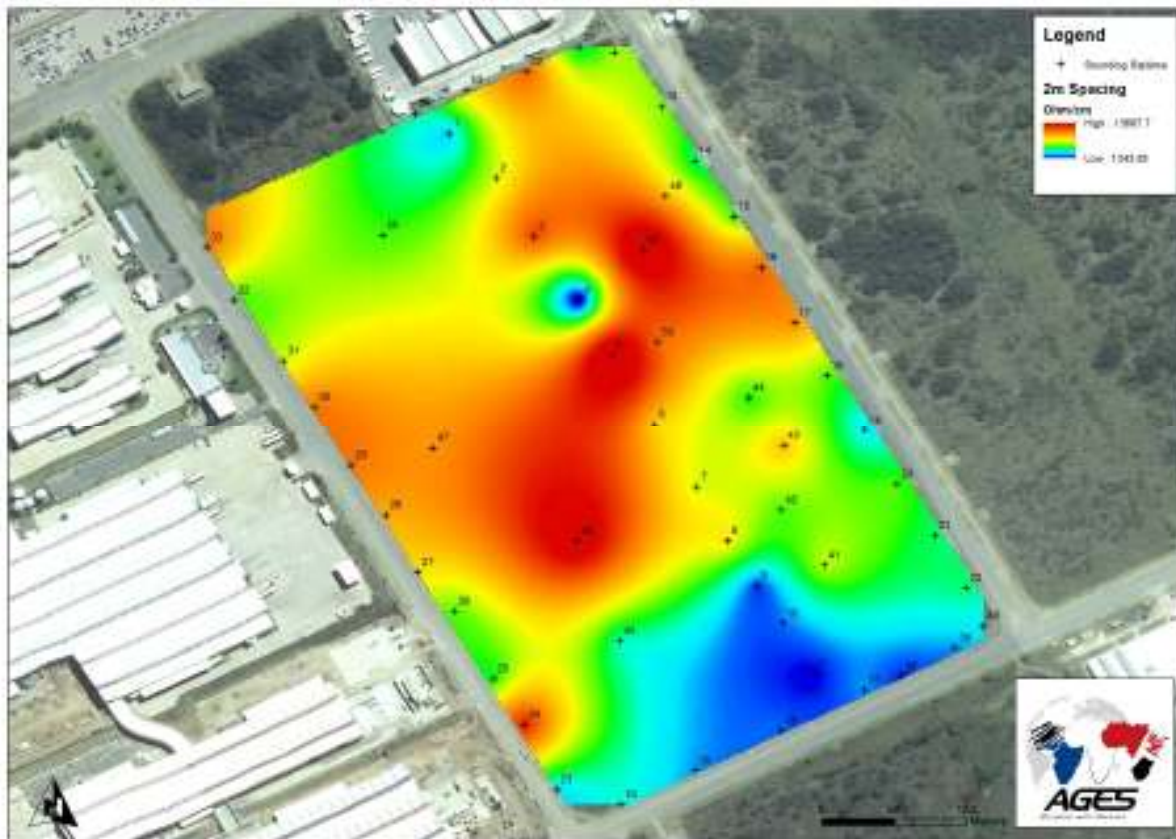


Figure 4: Resistivity contour data – 2m depth

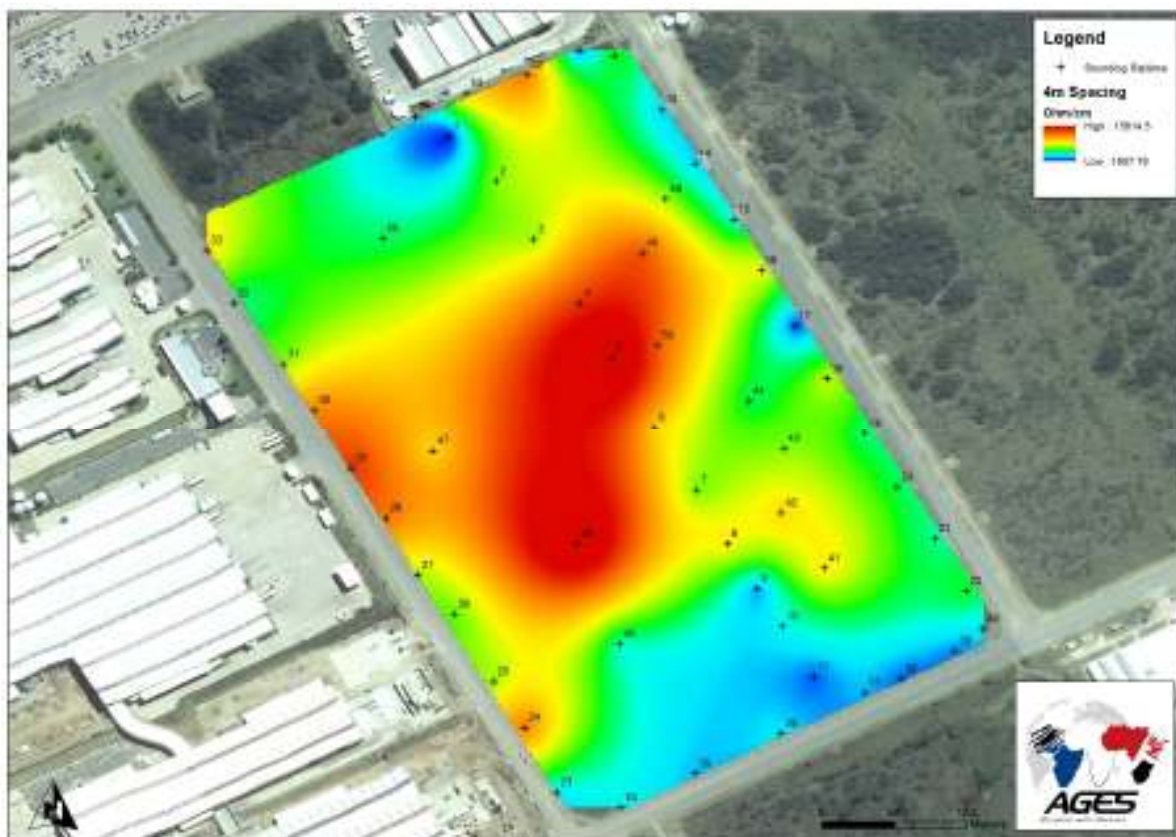


Figure 5: Resistivity contour data – 4m depth



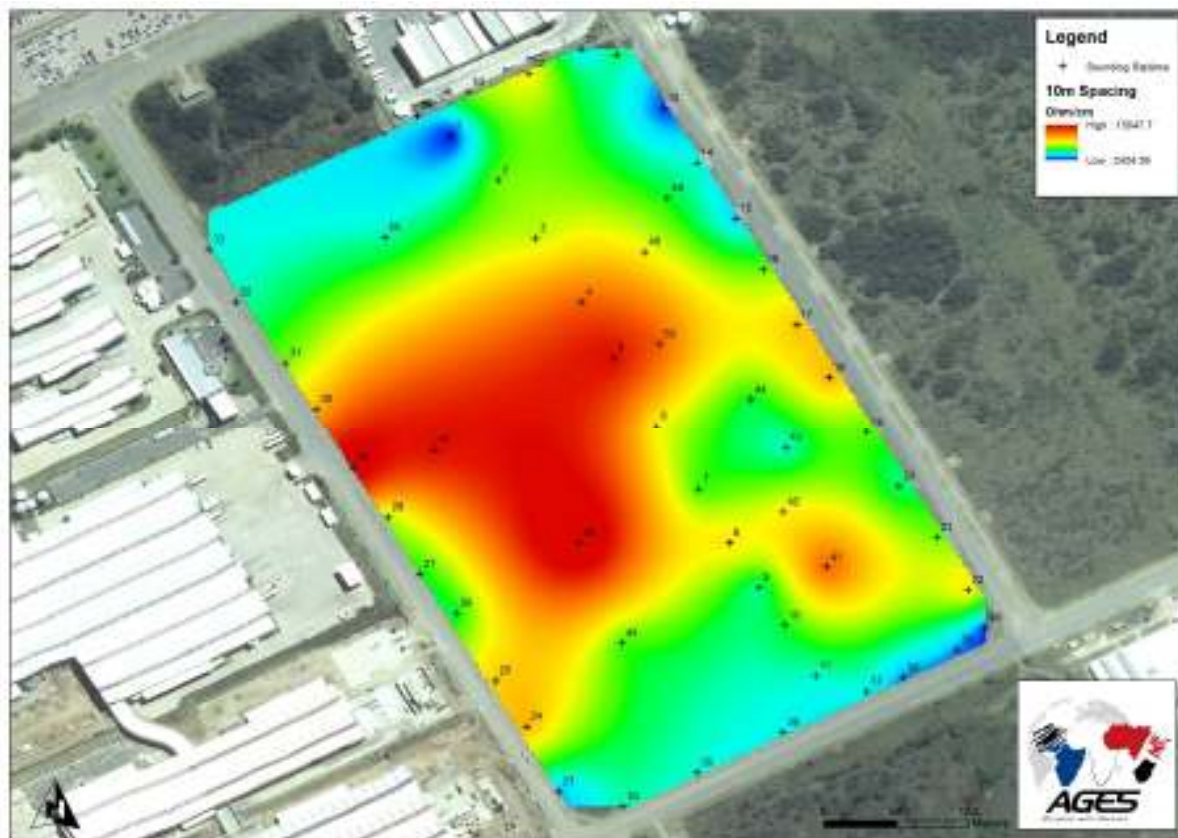


Figure 6: Resistivity contour data – 10m depth

## 2.4 Groundwater Survey

An existing borehole, EC/033/AM was identified near the south eastern boundary of the project area. The borehole is utilised for groundwater quality monitoring by the ELIDZ. The static groundwater level recorded in 2012 was measured at 3.24 mbgl.



Figure 7: Groundwater survey – Position and water level of borehole EC/033/AM



### 3 LABORATORY ANALYSIS

Selected samples were taken of the prominent soil horizons identified during the site investigation for detailed laboratory analysis. The samples were submitted to Messrs. Controlab South Africa (Pty) Ltd, Civil engineering material and geotechnical laboratory on the on the 3<sup>rd</sup> of July 2018 (batch 1) and 13<sup>th</sup> of July 2018 (Batch 2) for detailed analysis of the following:

- Disturbed soil samples (21 samples)
  - Sieve Analysis including Hydrometer to determine % clay
  - Atterberg Limits
  - Moisture Content,
  - pH
  - Electrical Conductivity
- Disturbed bulk soil samples (12 samples)
  - Road Indicators
  - Maximum Dry Density
  - Optimum Moisture Content
  - CBR tests 90% to 100%
  - % Swell
  - TRH14 Classification
  - TRH20 Classification
- Undisturbed soil samples (3 samples)
  - Consolidation testing

Processed laboratory results are summarised in the Tables below and discussed in Chapter 4. Analysis certificates are attached in Appendix D for reference.

Table 1: Processed laboratory results – Hillwash Material

| SAMPLE INFORMATION |                  |                 | GRADING ANALYSES |           |           |           | ATTERBERG LIMITS |    |      | LS  | SOIL CHEMISTRY |                        |                             |                     | ASTM                        | POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS |                               |                               |   |  |
|--------------------|------------------|-----------------|------------------|-----------|-----------|-----------|------------------|----|------|-----|----------------|------------------------|-----------------------------|---------------------|-----------------------------|--|-------------------------------|-------------------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin | Gravel<br>%      | Sand<br>% | Silt<br>% | Clay<br>% | LL<br>%          | PI | PI'  | %   | pH             | Conductivity<br>(mS/m) | Soil Resistivity<br>(Ohm/m) | Moisture<br>Content | Soil<br>Classification      | Expansiveness                                    | Collapse /<br>Compressibility | Erodibility /<br>Dispersivity | Soil pH Class & Soil<br>Corrosiveness<br>(Conductivity) | Cathodic Protection<br>Classification & Remarks<br>(Resistivity) |
| A19/1              | 0.00 - 0.45      | Hillwash        | 5                | 28        | 39        | 28        | 26               | 11 | 10.0 | 5.0 | 6.28           | 0.983                  | 1017                        | 32.9                | CL: Sandy lean clay         | Low Risk   | Low Risk                      | High Risk                     | Slightly Acid / Generally not<br>corrosive              | Not generally corrosive / Not<br>generally required              |
| A14/1              | 0.40 - 0.70      | Hillwash        | 0                | 60        | 30        | 10        | CBD              | NP | NP   | 0.0 | 5.99           | 0.515                  | 1942                        | 2.0                 | SM: Silty sand              | Low Risk   | Very High Risk                | High Risk                     | Moderately Acid / Generally<br>not corrosive            | Not generally corrosive / Not<br>generally required              |
| B31/1              | 0.00 - 0.30      | Hillwash        | 1                | 53        | 36        | 10        | CBD              | NP | NP   | 0.0 | 6.61           | 0.505                  | 1980                        | 31.6                | SM: Silty sand              | Low Risk   | Very High Risk                | High Risk                     | Neutral / Generally not<br>corrosive                    | Not generally corrosive / Not<br>generally required              |
| C25/1              | 0.00 - 0.70      | Hillwash        | 2                | 35        | 43        | 20        | 21               | 6  | 5.7  | 3.0 | 6.98           | 1.274                  | 785                         | 32.6                | CL-ML: Sandy silty clay     | Low Risk   | Medium Risk                   | High Risk                     | Neutral / Generally not<br>corrosive                    | Not generally corrosive / Not<br>generally required              |
| C10/1              | 0.0 - 0.45       | Hillwash        | 21               | 52        | 12        | 15        | 33               | 16 | 5.6  | 7.5 | 6.01           | 0.509                  | 1965                        | 35.6                | SC: Clayey sand with gravel | Low Risk   | Low Risk                      | High Risk                     | Moderately Acid / Generally<br>not corrosive            | Not generally corrosive / Not<br>generally required              |

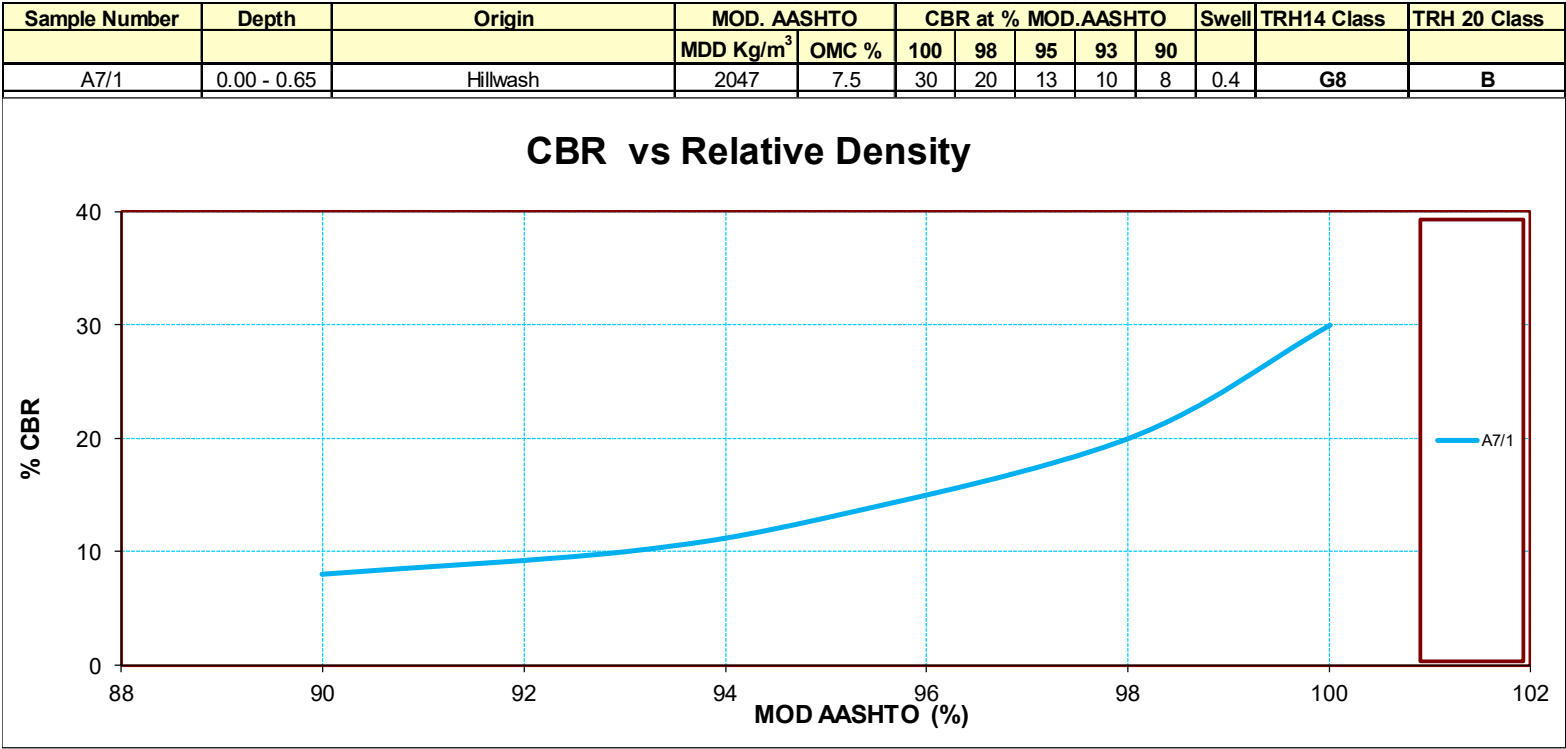


Table 2: Processed laboratory results – Pebble Marker Horizon Material

| SAMPLE INFORMATION |                  |  | GRADING ANALYSES |           |           |           | ATTERBERG LIMITS |    |     | LS  | SOIL CHEMISTRY |                        |                             |                     | ASTM                        | POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS |                               |                               |   |  |
|--------------------|------------------|--|------------------|-----------|-----------|-----------|------------------|----|-----|-----|----------------|------------------------|-----------------------------|---------------------|-----------------------------|--|-------------------------------|-------------------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin  | Gravel<br>%      | Sand<br>% | Silt<br>% | Clay<br>% | LL<br>%          | PI | PI' | %   | pH             | Conductivity<br>(mS/m) | Soil Resistivity<br>(Ohm/m) | Moisture<br>Content | Soil<br>Classification      | Expansiveness                                    | Collapse /<br>Compressibility | Erodibility /<br>Dispersivity | Soil pH Class & Soil<br>Corrosiveness<br>(Conductivity) | Cathodic Protection<br>Classification & Remarks<br>(Resistivity) |
| A1/1               | 0.55 - 0.75      | Ferruginised Residual Siltstone /<br>Pebble Marker Horizon | 15               | 48        | 23        | 14        | 26               | 9  | 5.3 | 4.5 | 6.08           | 0.612                  | 1634                        | 23.6                | SC: Clayey sand with gravel | Low Risk   | High Risk                     | High Risk                     | Moderately Acid / Generally<br>not corrosive            | Not generally corrosive / Not<br>generally required              |
| B8/1               | 0.75 - 1.05      | Pebble Marker Horizon                                      | 15               | 53        | 25        | 7         | 39               | 14 | 5.6 | 7.0 | 7.64           | 1.028                  | 973                         | 27.6                | SC: Clayey sand with gravel | Low Risk   | Low Risk                      | High Risk                     | Slightly Alkaline / Generally<br>not corrosive          | Not generally corrosive / Not<br>generally required              |

Table 3: Processed laboratory results – Residual Siltstone Material

| SAMPLE INFORMATION |                  |                    | GRADING ANALYSES |           |           |           | ATTERBERG LIMITS |    |      | LS<br>% | SOIL CHEMISTRY |                        |                             |                     | ASTM                                   | POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS |                               |                               |   |  |
|--------------------|------------------|--------------------|------------------|-----------|-----------|-----------|------------------|----|------|---------|----------------|------------------------|-----------------------------|---------------------|--|--|-------------------------------|-------------------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin    | Gravel<br>%      | Sand<br>% | Silt<br>% | Clay<br>% | LL<br>%          | PI | PI'  |         | pH             | Conductivity<br>(mS/m) | Soil Resistivity<br>(Ohm/m) | Moisture<br>Content | Soil<br>Classification                 | Expansiveness                                    | Collapse /<br>Compressibility | Erodibility /<br>Dispersivity | Soil pH Class & Soil<br>Corrosiveness<br>(Conductivity) | Cathodic Protection<br>Classification & Remarks<br>(Resistivity) |
| A19/2              | 0.45 - 0.70      | Residual Siltstone | 15               | 19        | 27        | 39        | 35               | 17 | 13.1 | 8.0     | 6.12           | 0.618                  | 1618                        | 21.6                | CL: Sandy lean clay with gravel        | Low Risk   | Medium Risk                   | High Risk                     | Slightly Acid / Generally not<br>corrosive              | Not generally corrosive / Not<br>generally required              |
| A10/1              | 0.60 - 0.80      | Residual Siltstone | 14               | 39        | 27        | 20        | 34               | 14 | 7.3  | 6.5     | 6.63           | 0.681                  | 1468                        | 24.6                | SC: Clayey sand                        | Low Risk   | Low Risk                      | High Risk                     | Neutral / Generally not<br>corrosive                    | Not generally corrosive / Not<br>generally required              |
| B31/2              | 0.75 - 1.10      | Residual Siltstone | 32               | 39        | 19        | 10        | 24               | 7  | 3.8  | 3.5     | 6.20           | 1.310                  | 763                         | 28.6                | SC- SM: Silty, clayey sand with gravel | Low Risk   | Low Risk                      | High Risk                     | Slightly Acid / Generally not<br>corrosive              | Not generally corrosive / Not<br>generally required              |
| B21/1              | 0.75 - 1.05      | Residual Siltstone | 7                | 28        | 47        | 18        | 27               | 8  | 6.2  | 4.0     | 6.64           | 1.001                  | 999                         | 29.6                | CL- ML: Sandy silty clay               | Low Risk   | Medium Risk                   | High Risk                     | Neutral / Generally not<br>corrosive                    | Not generally corrosive / Not<br>generally required              |
| C33/1              | 1.25 - 1.50      | Residual Siltstone | 5                | 49        | 19        | 27        | 28               | 8  | 7.3  | 4.0     | 7.90           | 0.786                  | 1272                        | 33.6                | SC: Clayey sand                        | Low Risk   | Very High Risk                | High Risk                     | Moderately Alkaline /<br>Generally not corrosive        | Not generally corrosive / Not<br>generally required              |
| C1/2               | 0.85 - 1.40      | Residual Siltstone | 4                | 23        | 46        | 27        | 33               | 13 | 10.8 | 7.0     | 6.86           | 1.121                  | 892                         | 36.6                | CL: Lean clay with sand                | Low Risk   | Low Risk                      | High Risk                     | Neutral / Generally not<br>corrosive                    | Not generally corrosive / Not<br>generally required              |
| C35/1              | 0.60 - 1.15      | Residual Siltstone | 0                | 23        | 38        | 39        | 33               | 17 | 16.8 | 8.5     | 7.40           | 1.990                  | 503                         | 37.6                | CL: Lean clay with sand                | Low Risk   | Low Risk                      | High Risk                     | Slightly Alkaline / Generally<br>not corrosive          | Not generally corrosive / Not<br>generally required              |

| Sample Number | Depth       | Origin             | MOD. AASHTO           |       | CBR at % MOD.AASHTO |    |    |    |    | Swell | TRH14 Class | TRH 20 Class |
|---------------|-------------|--------------------|-----------------------|-------|---------------------|----|----|----|----|-------|-------------|--------------|
|               |             |                    | MDD Kg/m <sup>3</sup> | OMC % | 100                 | 98 | 95 | 93 | 90 |       |             |              |
| A10/1         | 0.60 -0.80  | Residual Siltstone | 1860                  | 10.8  | 5                   | 4  | 3  | 3  | 2  | 2.3   | G10         | C            |
| B31/2         | 0.75 - 1.10 | Residual Siltstone | 1994                  | 10.4  | 27                  | 22 | 16 | 13 | 9  | 1.1   | G7/G8       | E            |
| C1/2          | 0.85 - 1.40 | Residual Siltstone | 1810                  | 15.6  | 4                   | 3  | 2  | 2  | 1  | 1.8   | <G10        | D            |

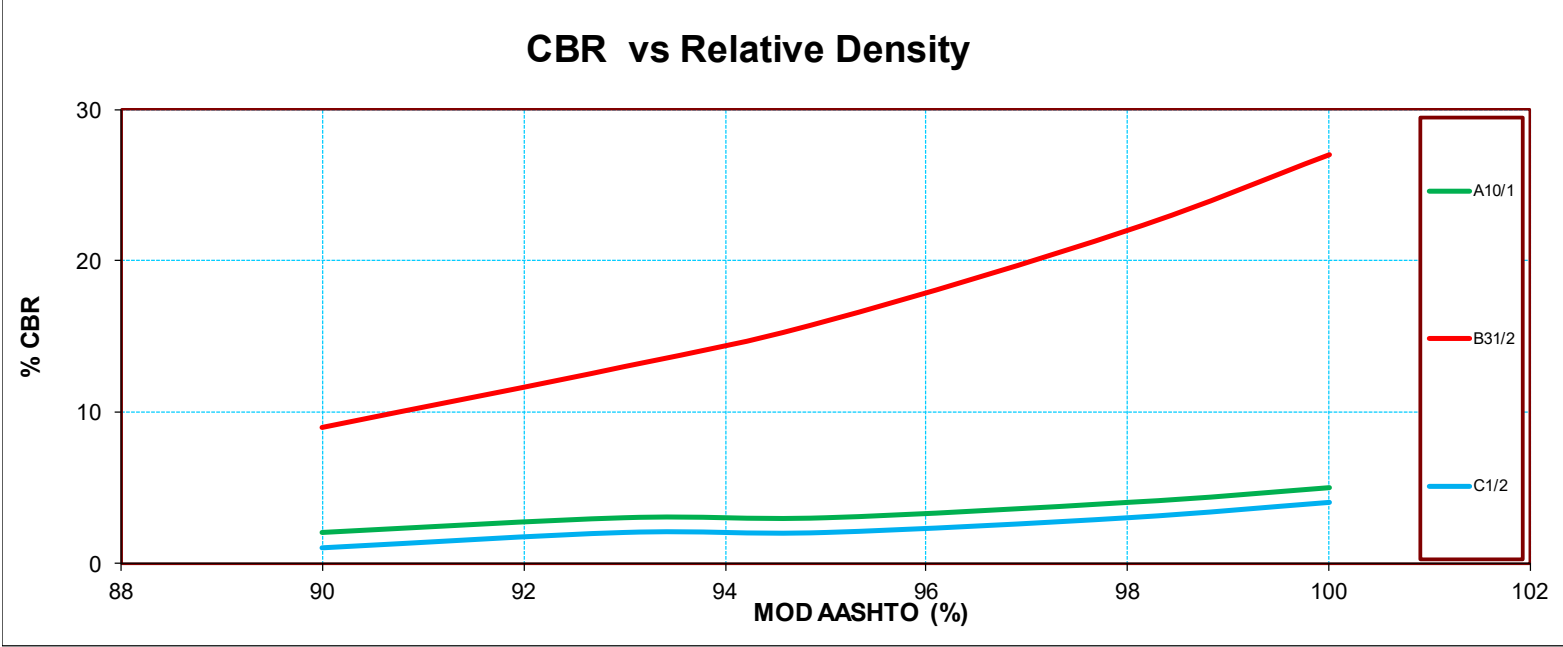


Table 4: Processed laboratory results – Ferruginised Residual Siltstone Material

| SAMPLE INFORMATION |                  |  | GRADING ANALYSES |           |           |           | ATTERBERG LIMITS |    |      | LS<br>% | SOIL CHEMISTRY |                     |                          |                  | ASTM                        | POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS |                            |                            |   |  |
|--------------------|------------------|--|------------------|-----------|-----------|-----------|------------------|----|------|---------|----------------|---------------------|--------------------------|------------------|-----------------------------|--|----------------------------|----------------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin                          | Gravel<br>%      | Sand<br>% | Silt<br>% | Clay<br>% | LL<br>%          | PI | PI'  |         | pH             | Conductivity (mS/m) | Soil Resistivity (Ohm/m) | Moisture Content | Soil Classification         | Expansiveness                                    | Collapse / Compressibility | Erodibility / Dispersivity | Soil pH Class & Soil Corrosiveness (Conductivity) | Cathodic Protection Classification & Remarks (Resistivity) |
| A25/1              | 0.80 - 1.15      | Slightly Ferruginised Residual Siltstone | 0                | 41        | 35        | 24        | 19               | 8  | 7.6  | 4.0     | 6.77           | 0.609               | 1642                     | 22.6             | CL: Sandy lean clay         | Low Risk   | High Risk                  | High Risk                  | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| A30/1              | 0.60 - 0.80      | Ferruginised Residual Siltstone          | 3                | 63        | 26        | 8         | CBD              | NP | NP   | 0.0     | 5.40           | 0.539               | 1855                     | 25.6             | SM: Silty sand              | Low Risk   | Very High Risk             | High Risk                  | Strongly Acid / Generally not corrosive           | Not generally corrosive / Not generally required           |
| A3/1               | 0.80 - 1.10      | Ferruginised Residual Siltstone          | 7                | 48        | 37        | 8         | CBD              | SP | SP   | 1.5     | 7.10           | 0.702               | 1425                     | 26.6             | SM: Silty sand              | Low Risk   | Very High Risk             | High Risk                  | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| B23/1              | 0.10 - 0.40      | Ferruginised Residual Siltstone          | 12               | 52        | 20        | 16        | 26               | 10 | 5.5  | 5.0     | 6.45           | 0.525               | 1905                     | 30.6             | SC: Clayey sand             | Low Risk   | Low Risk                   | High Risk                  | Slightly Acid / Generally not corrosive           | Not generally corrosive / Not generally required           |
| C1/1               | 0.40 - 0.85      | Ferruginised Residual Siltstone          | 10               | 45        | 30        | 15        | 24               | 8  | 5.4  | 4.0     | 7.08           | 0.685               | 1460                     | 34.6             | SC: Clayey sand             | Low Risk   | High Risk                  | High Risk                  | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C15/1              | 0.20 - 0.85      | Ferruginised Residual Siltstone          | 10               | 29        | 29        | 32        | 39               | 20 | 15.8 | 10.0    | 6.97           | 1.142               | 876                      | 38.6             | CL: Sandy lean clay         | Medium Risk                                      | Low Risk                   | High Risk                  | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C23/1              | 0.35 - 0.60      | Ferruginised Residual Siltstone          | 55               | 23        | 14        | 8         | 28               | 13 | 3.9  | 6.0     | 7.35           | 0.705               | 1418                     | 39.6             | GC: Clayey gravel with sand | Low Risk   | Low Risk                   | High Risk                  | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |

| Sample Number | Depth       | Origin                          | MOD. AASHTO           |       | CBR at % MOD.AASHTO |    |    |    |    |     | Swell | TRH14 Class | TRH 20 Class |
|---------------|-------------|---------------------------------|-----------------------|-------|---------------------|----|----|----|----|-----|-------|-------------|--------------|
|               |             |                                 | MDD Kg/m <sup>3</sup> | OMC % | 100                 | 98 | 95 | 93 | 90 |     |       |             |              |
| A3/1          | 0.80 - 1.10 | Ferruginised Residual Siltstone | 2053                  | 8.9   | 7                   | 5  | 4  | 3  | 2  | 0.8 |       | G10         | E            |
| A24/1         | 0.70 - 1.60 | Ferruginised Residual Siltstone | 2027                  | 8.1   | 9                   | 8  | 6  | 5  | 4  | 0.8 |       | G10         | A            |
| B32/1         | 0.50 - 0.75 | Ferruginised Residual Siltstone | 1948                  | 10.3  | 22                  | 15 | 9  | 6  | 3  | 1.4 |       | G9          | E            |
| C15/1         | 0.30 - 0.85 | Ferruginised Residual Siltstone | 1782                  | 16.9  | 2                   | 2  | 2  | 2  | 1  | 3   |       | <G10        | E            |

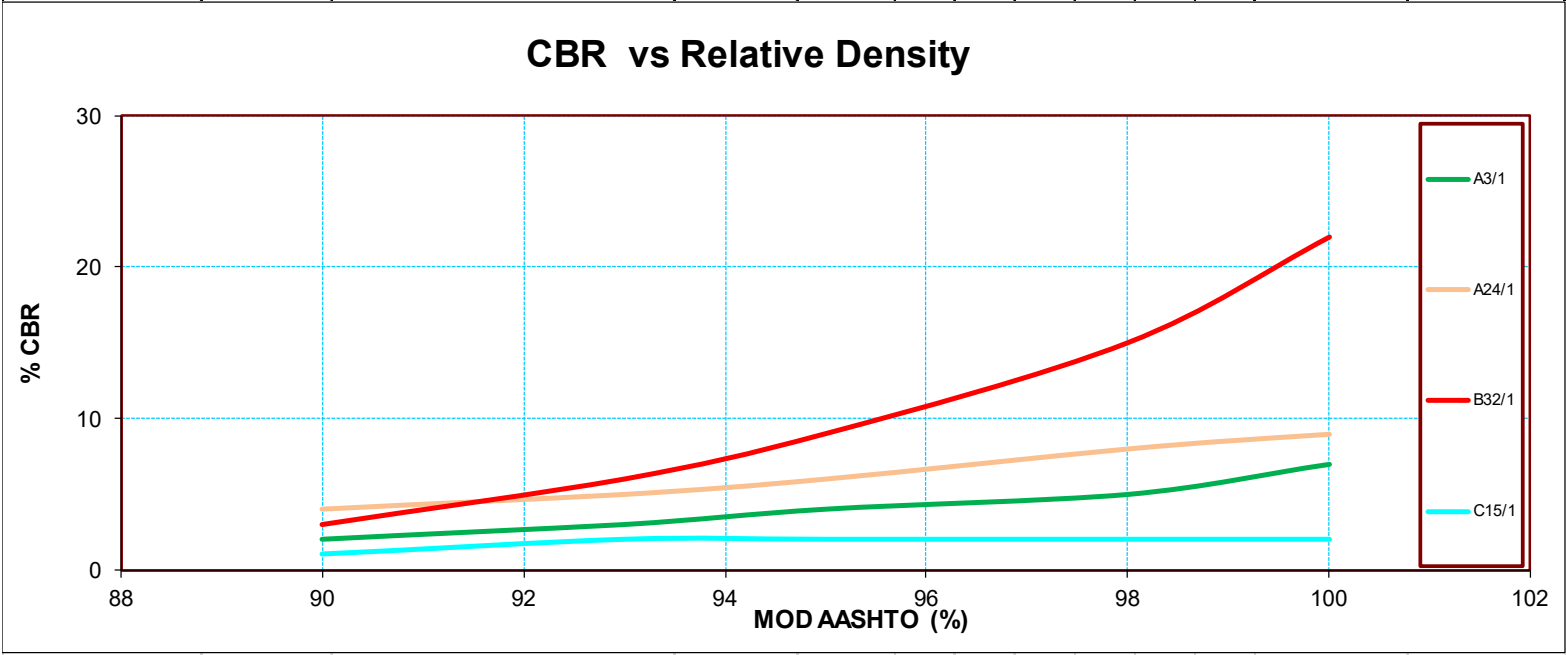


Table 5: Processed laboratory results – Siltstone Bedrock Material

| SAMPLE INFORMATION |                  |                   | GRADING ANALYSES |           |                  | ATTERBERG LIMITS |    |     | LS<br>% | ASTM   | POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS |                               |                               |   |  |
|--------------------|------------------|-------------------|------------------|-----------|------------------|------------------|----|-----|---------|--|--|-------------------------------|-------------------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin   | Gravel<br>%      | Sand<br>% | Silt & Clay<br>% | LL<br>%          | PI | PI' |         | Soil<br>Classification                         | Expansiveness                                    | Collapse /<br>Compressibility | Erodibility /<br>Dispersivity | Soil pH Class & Soil<br>Corrosiveness<br>(Conductivity) | Cathodic Protection<br>Classification & Remarks<br>(Resistivity) |
| A8/1               | 0.90 - 1.30      | Siltstone Bedrock | 62               | 18.6      | 19.4             | 30               | 15 | 3.9 | 7.0     | GC: Clayey gravel with sand                    | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| A14/2              | 0.90 - 1.25      | Siltstone Bedrock | 68               | 20.3      | 11.7             | 26               | 12 | 2.2 | 6.5     | GP-GC: Poorly graded gravel with clay and sand | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| A29/1              | 1.00 - 1.25      | Siltstone Bedrock | 51               | 32.4      | 16.6             | 23               | 4  | 1.4 | 2.0     | GC-GM: Silty, clayey gravel with sand          | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| B14/1              | 1.30 - 1.45      | Siltstone Bedrock | 46               | 28.7      | 25.3             | 25               | 8  | 3.0 | 4.0     | GC: Clayey gravel with sand                    | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| C40/1              | 1.55 - 2.30      | Siltstone Bedrock | 33               | 30.1      | 36.9             | 28               | 14 | 8.0 | 6.0     | GC: Clayey gravel with sand                    | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| C1/3               | 1.40 - 1.50      | Siltstone Bedrock | 47               | 25.4      | 27.6             | 30               | 15 | 5.0 | 7.5     | GC: Clayey gravel with sand                    | Low Risk   | Low Risk                      | High Risk                     | -   | -  |
| C21/1              | 0.75 - 0.90      | Siltstone Bedrock | 52               | 25.9      | 22.1             | 29               | 8  | 2.5 | 4.0     | GC: Clayey gravel with sand                    | Low Risk   | Low Risk                      | High Risk                     | -   | -  |

| Sample Number | Depth       | Origin            | MOD. AASHTO           |       | CBR at % MOD.AASHTO |    |    |    |    | Swell | TRH14 Class | TRH 20 Class |
|---------------|-------------|-------------------|-----------------------|-------|---------------------|----|----|----|----|-------|-------------|--------------|
|               |             |                   | MDD Kg/m <sup>3</sup> | OMC % | 100                 | 98 | 95 | 93 | 90 |       |             |              |
| A8/1          | 0.90 - 1.30 | Siltstone Bedrock | 2110                  | 10    | 33                  | 26 | 18 | 14 | 10 | 0.7   | G7          | E            |
| A14/2         | 0.90 - 1.25 | Siltstone Bedrock | 2120                  | 6.2   | 52                  | 36 | 21 | 15 | 8  | 0.6   | G7          | E            |
| A29/1         | 1.00 - 1.25 | Siltstone Bedrock | 2006                  | 11.2  | 42                  | 34 | 24 | 19 | 14 | 0.6   | G7          | B            |
| B14/1         | 1.30 - 1.45 | Siltstone Bedrock | 2082                  | 6.4   | 71                  | 54 | 36 | 27 | 18 | 0.5   | G6          | E            |
| C40/1         | 1.55 - 2.30 | Siltstone Bedrock | 2110                  | 8.4   | 28                  | 21 | 14 | 10 | 7  | 1.1   | G8          | D            |
| C1/3          | 1.40 - 1.50 | Siltstone Bedrock | 1983                  | 8.8   | 10                  | 8  | 6  | 5  | 4  | 1.7   | G10         | E            |
| C21/1         | 0.75 - 0.90 | Siltstone Bedrock | 2106                  | 9     | 36                  | 29 | 20 | 15 | 11 | 0.7   | G7          | E            |

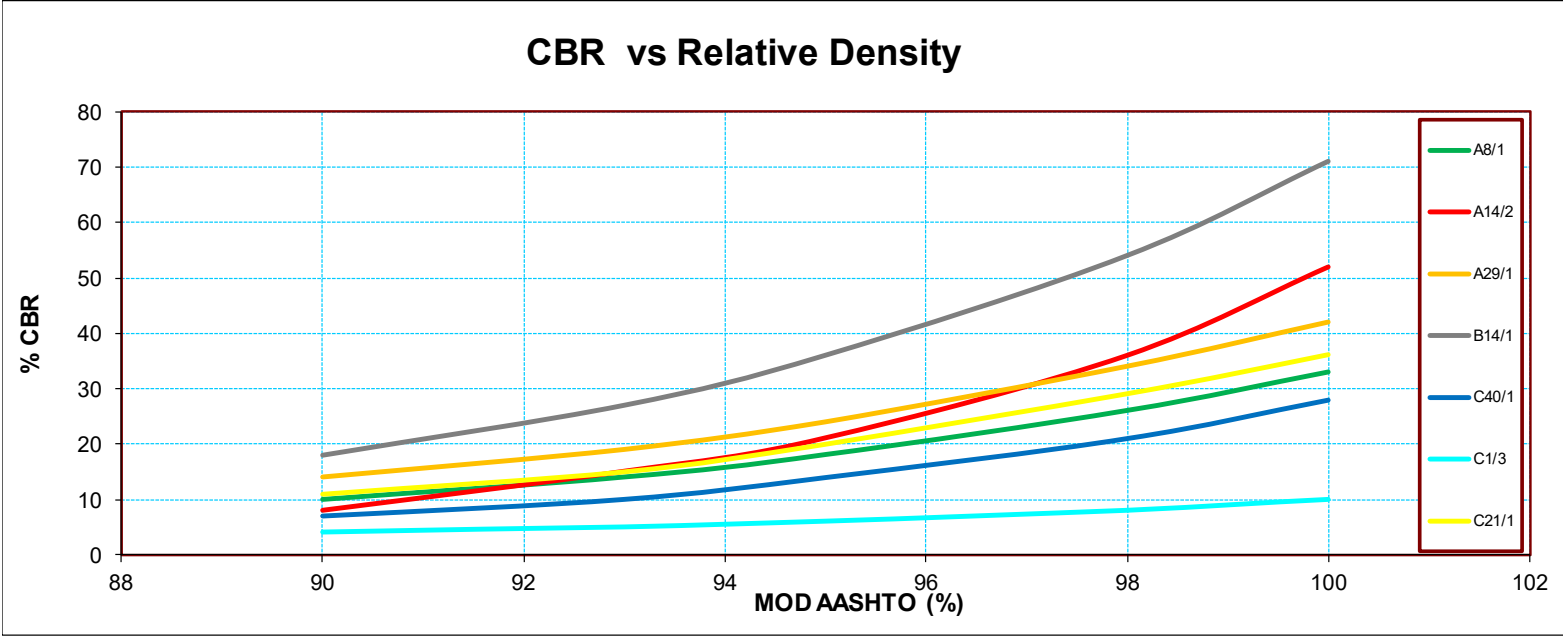
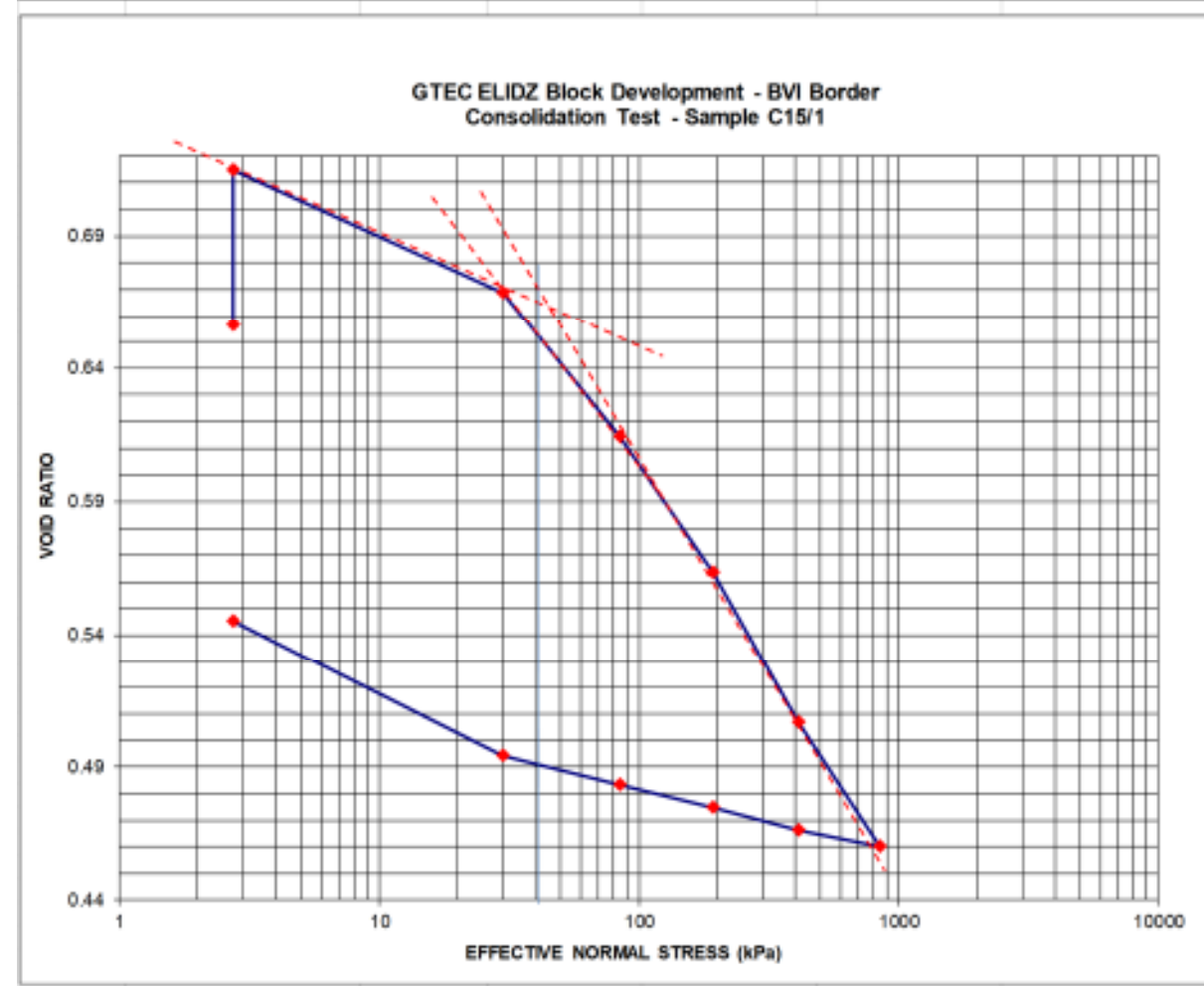
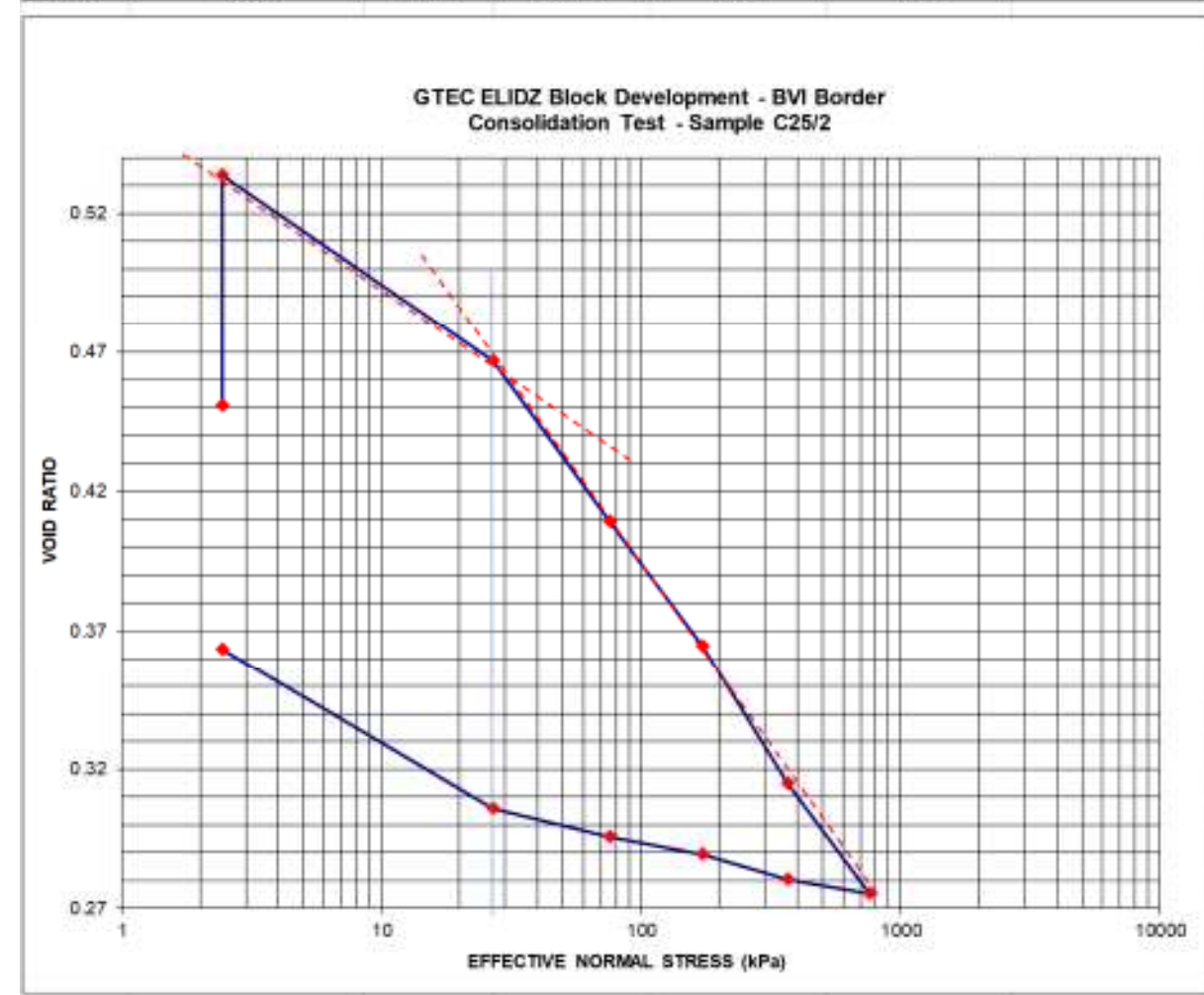


Figure 8: Consolidation test results – Residual soil materials

| CONSOLIDATION TEST RESULTS SUMMARY SHEET             |                                 |                    |                |  |                        |                                     |
|--|---------------------------------|--------------------|----------------|--|------------------------|-------------------------------------|
| Project: GTEC - ELIDZ Block Development - BVI Border |                                 |                    |                |  |                        |                                     |
| Specific Gravity                                     | 2.69 (Estimated)                |                    |                |  |                        |                                     |
| Dry Density  | 1624 kg/m <sup>3</sup>          |                    |                |  |                        |                                     |
| Final moisture content                               | 27.60 %                         |                    |                |  |                        |                                     |
| % Consolidation                                      | 8.8 %                           |                    |                |  |                        |                                     |
| Layer thickness                                      | 0.65 m                          |                    | 57 mm          |  |                        |                                     |
| Material   | Ferruginised Residual Siltstone |                    |                |  |                        |                                     |
| Est Preconsolidation pressure                        | 40 kPa                          |                    |                |  |                        |                                     |
| PRESSURE kPa   | DIAL READING (mm)               | HEIGHT CHANGE (mm) | VOID RATIO (e) | COEFFICIENT OF VOLUME COMPRESSIBILITY (Mv) | COMPRESSION INDEX (Cc) | CONSOLIDATION SETTLEMENT (Sc) in mm |
| 2.73   | 5.760                           | 19.700             | 0.6563         |  |                        |                                     |
| 2.73   | 5.064                           | 20.396             | 0.7148         | 0.46                                       | 0.082                  |                                     |
| 29.98  | 5.612                           | 19.848             | 0.6687         | 0.30                                       | 0.095                  |                                     |
| 84.49  | 6.260                           | 19.200             | 0.6142         | 0.18                                       | 0.102                  |                                     |
| 193.51   | 6.860                           | 18.600             | 0.5638         | 0.00                                       | 0.000                  | 57                                  |
| 411.56   | 7.538                           | 17.922             | 0.5068         | 0.00                                       | 0.000                  | 79                                  |
| 847.65   | 8.096                           | 17.364             | 0.4599         | 0.01                                       | 0.020                  | 97                                  |
| 411.56   | 8.022                           | 17.438             | 0.4661         | 0.03                                       | 0.027                  |                                     |
| 193.51   | 7.918                           | 17.542             | 0.4748         | 0.05                                       | 0.023                  |                                     |
| 84.49  | 7.820                           | 17.640             | 0.4831         | 0.13                                       | 0.024                  |                                     |
| 29.98  | 7.690                           | 17.770             | 0.494          | 1.26                                       | 0.049                  |                                     |
| 2.73   | 7.078                           | 18.382             | 0.5454         | 0.00                                       | 0.000                  |                                     |



| CONSOLIDATION TEST RESULTS SUMMARY SHEET             |                        |                    |                |  |                        |                                     |
|--|------------------------|--------------------|----------------|--|------------------------|-------------------------------------|
| Project: GTEC - ELIDZ Block Development - BVI Border |                        |                    |                |  |                        |                                     |
| Specific Gravity                                     | 2.69 (Estimated)       |                    |                |  |                        |                                     |
| Dry Density  | 1855 kg/m <sup>3</sup> |                    |                |  |                        |                                     |
| Final moisture content                               | 21.50 %                |                    |                |  |                        |                                     |
| % Consolidation                                      | 11.0 %                 |                    |                |  |                        |                                     |
| Layer thickness                                      | 0.5 m                  |                    | 55 mm          |  |                        |                                     |
| Material   | Residual Siltstone     |                    |                |  |                        |                                     |
| Est Preconsolidation pressure                        | 25 kPa                 |                    |                |  |                        |                                     |
| PRESSURE kPa   | DIAL READING (mm)      | HEIGHT CHANGE (mm) | VOID RATIO (e) | COEFFICIENT OF VOLUME COMPRESSIBILITY (Mv) | COMPRESSION INDEX (Cc) | CONSOLIDATION SETTLEMENT (Sc) in mm |
| 2.44   | 17.717                 | 19.000             | 0.4505         |  |                        |                                     |
| 2.44   | 18.807                 | 20.090             | 0.5337         | 0.65                                       | 0.091                  |                                     |
| 26.87  | 17.931                 | 19.214             | 0.4668         | 0.39                                       | 0.100                  |                                     |
| 75.72  | 17.176                 | 18.459             | 0.4092         | 0.22                                       | 0.104                  |                                     |
| 173.42   | 16.589                 | 17.872             | 0.3844         | 0.00                                       | 0.000                  | 55                                  |
| 368.83   | 15.941                 | 17.224             | 0.3149         | 0.00                                       | 0.000                  | 71                                  |
| 759.64   | 15.419                 | 16.702             | 0.2751         | 0.01                                       | 0.017                  | 84                                  |
| 368.83   | 15.488                 | 16.771             | 0.2803         | 0.04                                       | 0.027                  |                                     |
| 173.42   | 15.605                 | 16.888             | 0.2893         | 0.05                                       | 0.018                  |                                     |
| 75.72  | 15.691                 | 16.974             | 0.2958         | 0.16                                       | 0.022                  |                                     |
| 26.87  | 15.823                 | 17.106             | 0.3059         | 1.80                                       | 0.055                  |                                     |
| 2.44   | 16.575                 | 17.858             | 0.3833         | 0.00                                       | 0.000                  |                                     |





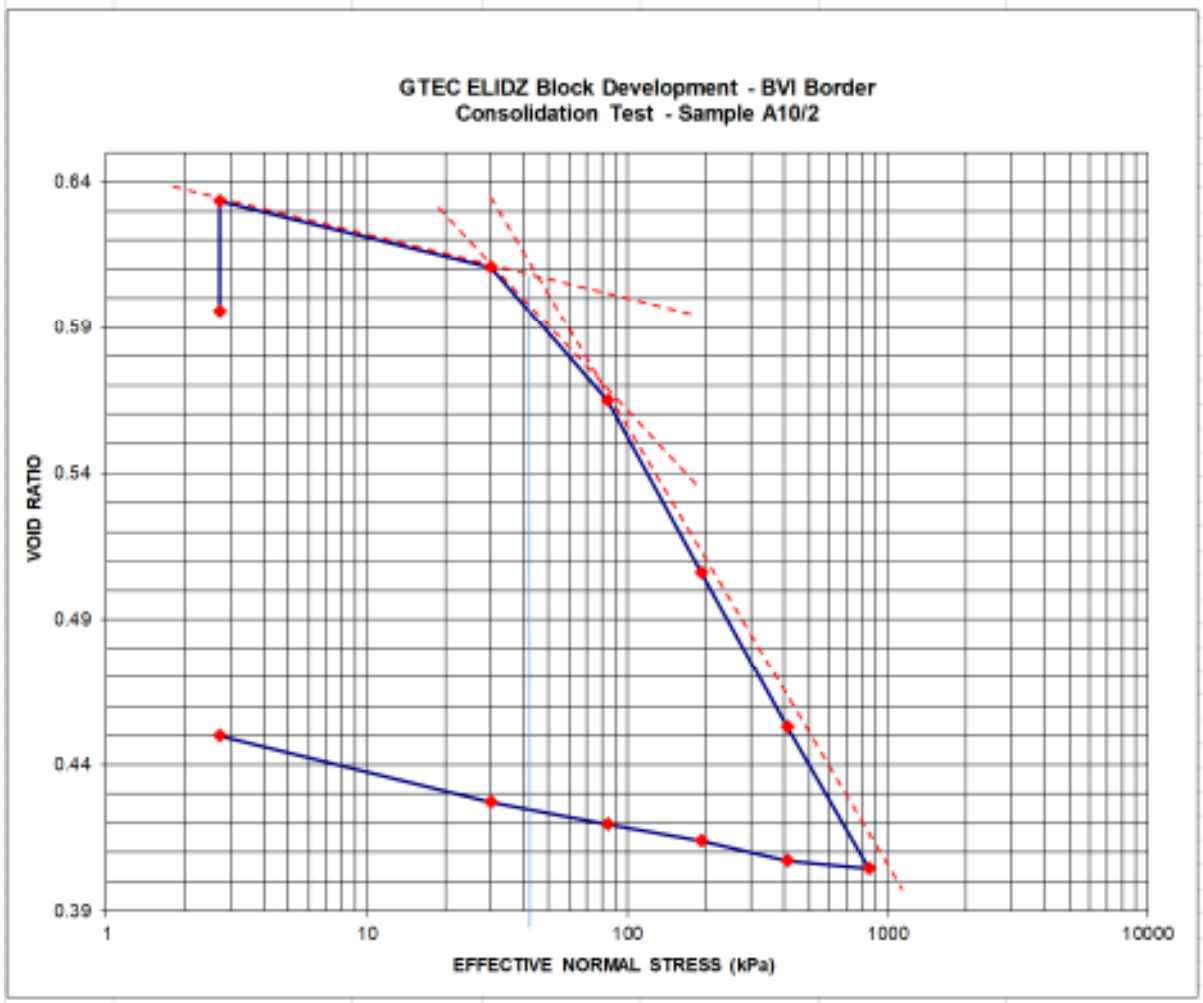
**CONSOLIDATION TEST RESULTS SUMMARY SHEET**

Project: GTEC - ELIDZ Block Development - BVI Border

Specific Gravity 2.69 (Estimated)  
 Dry Density 1886 kg/m<sup>3</sup>  
 Final moisture content 27.10 %  
 % Consolidation 7.8 % 31 mm  
 Layer thickness 0.4 m  
 Material Residual Siltstone  
 Est Preconsolidation pressure 40 kPa



| PRESSURE<br>kPa | DIAL READING (mm) | HEIGHT<br>CHANGE<br>(mm) | VOID RATIO (e) | COEFFICIENT OF<br>VOLUME<br>COMPRESSIBILITY<br>(Mv) | COMPRESSION<br>INDEX (Cc) | CONSOLIDATION<br>SETTLEMENT (Sc) in<br>mm |
|-----------------|-------------------|--------------------------|----------------|---|---------------------------|---|
| 2.73            | 6.172             | 19.700                   | 0.5955         |   |                           |   |
| 2.73            | 5.704             | 20.168                   | 0.6334         | 0.41  | 0.069                     |   |
| 29.98           | 5.986             | 19.886                   | 0.6106         | 0.27  | 0.083                     |   |
| 84.49           | 6.554             | 19.318                   | 0.5646         | 0.17  | 0.092                     |   |
| 193.51          | 7.28              | 18.592                   | 0.5058         | 0.00  | 0.000                     | 31  |
| 411.56          | 7.934             | 17.938                   | 0.4528         | 0.00  | 0.000                     | 44  |
| 847.65          | 8.532             | 17.340                   | 0.4044         | 0.00  | 0.009                     | 56  |
| 411.56          | 8.496             | 17.376                   | 0.4073         | 0.02  | 0.020                     |   |
| 193.51          | 8.416             | 17.456                   | 0.4138         | 0.04  | 0.016                     |   |
| 84.49           | 8.344             | 17.528                   | 0.4196         | 0.10  | 0.016                     |   |
| 29.98           | 8.252             | 17.620                   | 0.4270         | 0.58  | 0.022                     |   |
| 2.73            | 7.974             | 17.898                   | 0.4496         | 0.00  | 0.000                     |   |



## 4 RESULTS

### 4.1 Platform A

#### 4.1.1 Test pit excavation and profiling

A total of 28 test pits, numbered Test Pit A1 to A31 were excavated in the most northern portion of the project area designated for Platform A and future expansions. A total of 19 of the 28 test pits were excavated within the proposed footprint of Platform A.

The positions of the test pits are indicated in the Figure below, with detailed test pit logs attached in Appendix A. Please note that several test pits could not be excavated in the required positions due to very dense vegetation. ELIDZ officials did not give permission that the more prominent trees could be cut down to gain access to these positions.



Figure 9: Detailed layout of test pits – Platform A area

#### 4.1.2 Excavatability Conditions

It was possible to excavate the test pits utilising a JCB 3CX 4x4 TLB-type excavator, fitted with a 300 rock-bucket, to a depth between 1.15 and 2.60 mbgl (mean 1.70 mbgl) after which excavation refused in all test pits on moderately hard rock to hard rock siltstone and mudstone bedrock material.

Siltstone or mudstone bedrock material was encountered in all test pits from between 0.80 and 1.75 mbgl (mean 1.23 mbgl).



Excavatability conditions can be summarised as follow:

- From Surface to 1.0 mbgl - Soft Excavation Class
- From 1.0 mbgl to 2.5 mbgl - Intermediate Excavation Class with pockets of Hard Rock

Table 6: Depth to rock, depth to refusal and seepage – Platform A

| TEST PIT | DEPTH TO ROCK (m)                       | DEPTH TO REFUSAL (m) | SEEPAGE (m) |
|----------|---|----------------------|-------------|
| A1       | 1.15                                    | 1.45                 | -           |
| A2       | Position not accessible - no excavation |                      | -           |
| A3       | 1.1                                     | 1.50                 | -           |
| A4       | 1.45                                    | 1.70                 | -           |
| A5       | 0.6                                     | 0.65                 | 0.65        |
| A6       | 1.1                                     | 1.50                 | -           |
| A7       | 0.9                                     | 1.40                 | -           |
| A8       | 0.9                                     | 1.30                 | -           |
| A9       | 1.25                                    | 1.45                 | -           |
| A10      | 0.8                                     | 1.35                 | -           |
| A11      | 0.8                                     | 1.15                 | -           |
| A12      | Position not accessible - no excavation |                      | -           |
| A13      | 1.6                                     | 1.7                  | -           |
| A14      | 0.9                                     | 1.25                 | -           |
| A15      | 1.3                                     | 2.45                 | -           |
| A16      | 1.65                                    | 1.75                 | -           |
| A17      | Position not accessible - no excavation |                      | -           |
| A18      | 0.75                                    | 0.85                 | -           |
| A19      | 0.7                                     | 1.2                  | -           |
| A20      | 1.30                                    | 1.70                 | -           |
| A21      | 1.4                                     | 1.95                 | -           |
| A22      | 1.05                                    | 2.05                 | -           |
| A23      | 1.4                                     | 2.55                 | -           |
| A24      | 1.6                                     | 1.65                 | -           |
| A25      | 1.15                                    | 1.45                 | -           |
| A26      | 1.75                                    | 2.60                 | -           |
| A27      | Position not accessible - no excavation |                      | -           |
| A28      | 1.65                                    | 2                    | -           |
| A29      | 0.7                                     | 1.25                 | -           |
| A30      | 1.05                                    | 1.75                 | -           |
| A31      | 1.1                                     | 1.8                  | -           |

#### 4.1.3 Generalised soil conditions

The following generalised soil conditions can be expected based on limited point source test pit information obtained from test pits.

The area is generally covered by hillwash material that is composed of sandy clay that exhibits a firm consistency and intact soil structure. Plant roots were recorded in this material over the entire site. The hillwash material becomes ferruginised at depth in localised portions of the area, characterised in profile by the occurrence of ferricrete nodules. The hillwash material extends to a maximum depth of

approximately 1.20 mbgl.

The transported material is underlain by residual siltstone / mudstone that is composed of sandy clay to clayey sand with scattered to occasional siltstone / mudstone gravel to cobbles. The material exhibits a firm to stiff consistency and fractured and inherent structure, with a maximum thickness of approximately 1.0 m. The upper portion of the residual materials are generally ferruginised, characterised in profile by scattered to abundant ferricrete nodules.

Siltstone or mudstone bedrock material was encountered in all test pits from a depth between 0.80 to 1.75 mbgl (mean 1.23 mbgl). The material is highly to moderately weathered, fine grained, medium jointed with a soft rock to moderately hard rock hardness.

The generalised soil profile and sections are indicated in the figures below.



Figure 10: Cross section and test pit layout – Platform A

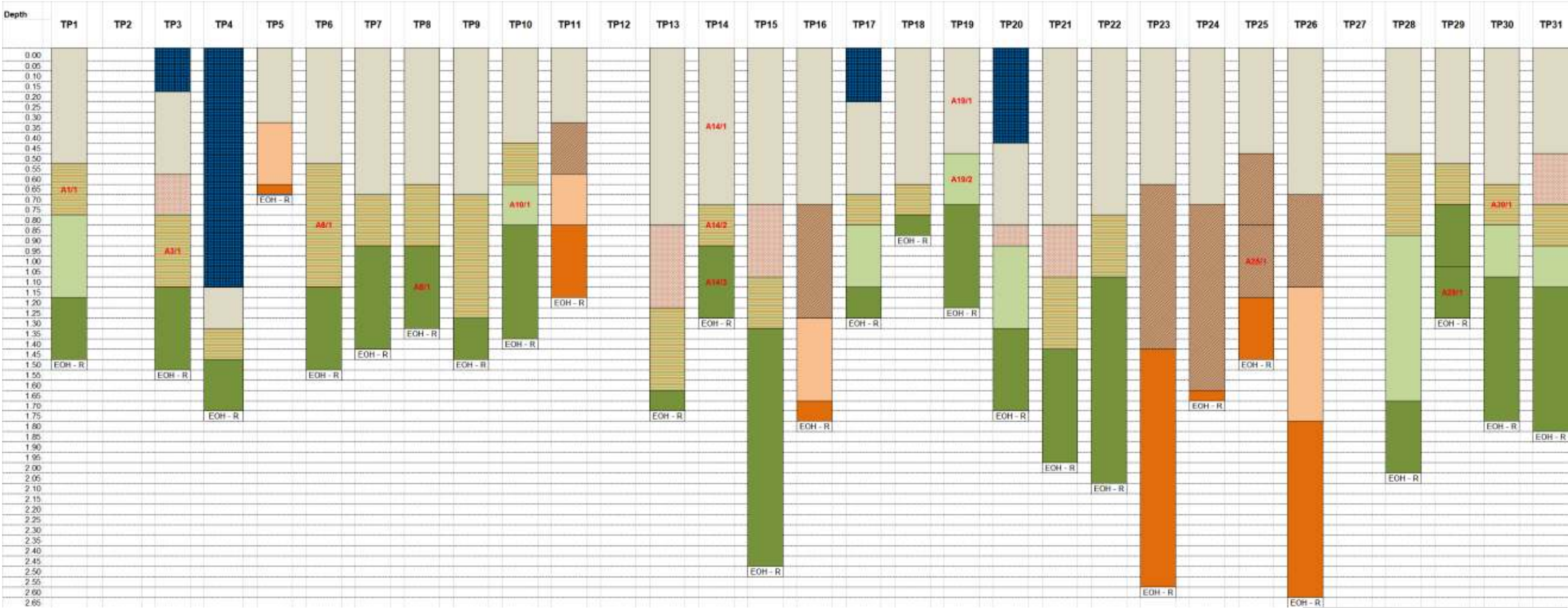


Figure 11: Platform A – Generalised soil conditions – All test pits

| LEGEND |                    |
|--------|--------------------|
|        | Fill               |
|        | Hillwash           |
|        | Ferr Hillwash      |
|        | Ferr Res SiltSt    |
|        | Residual Siltstone |
|        | Siltstone Bedrock  |
|        | Ferr Res Mudstone  |
|        | Residual Mudstone  |
|        | Mudstone Bedrock   |



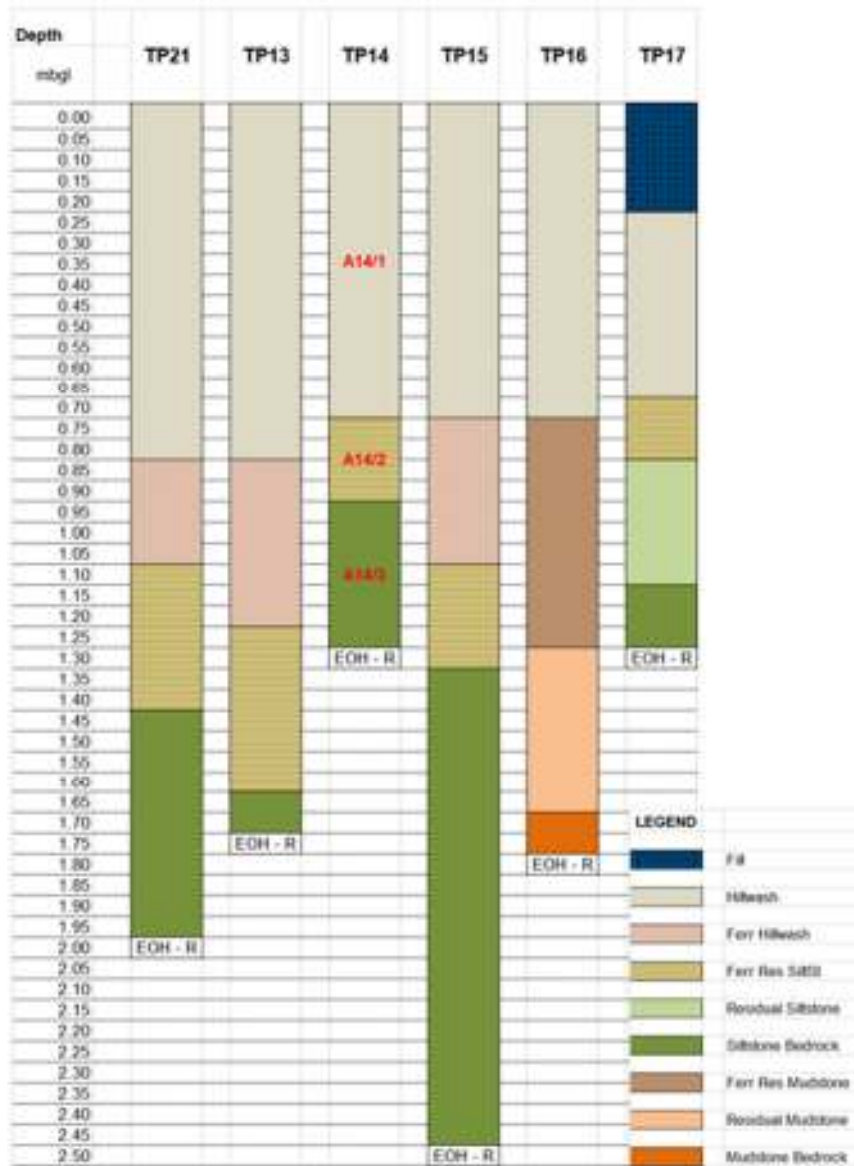


Figure 12: Platform A Section A-B – Generalised soil conditions

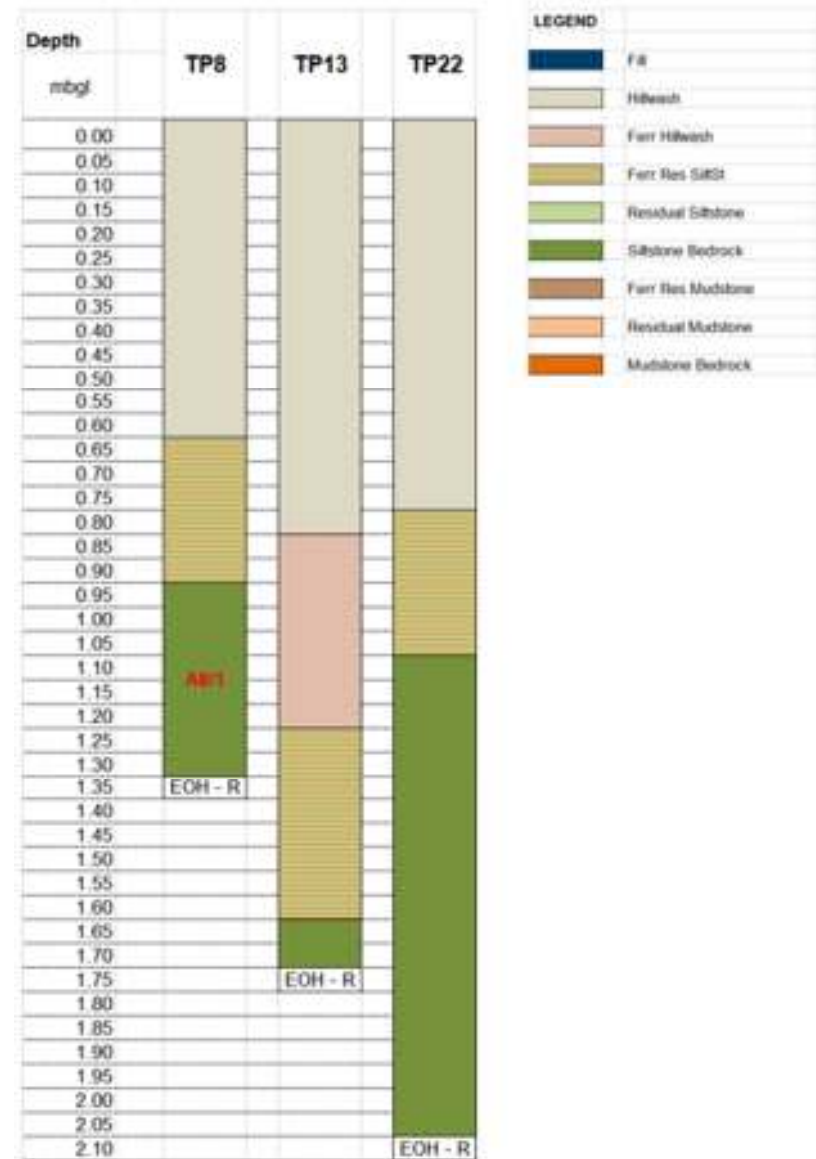


Figure 13: Platform A Section C-D – Generalised soil conditions

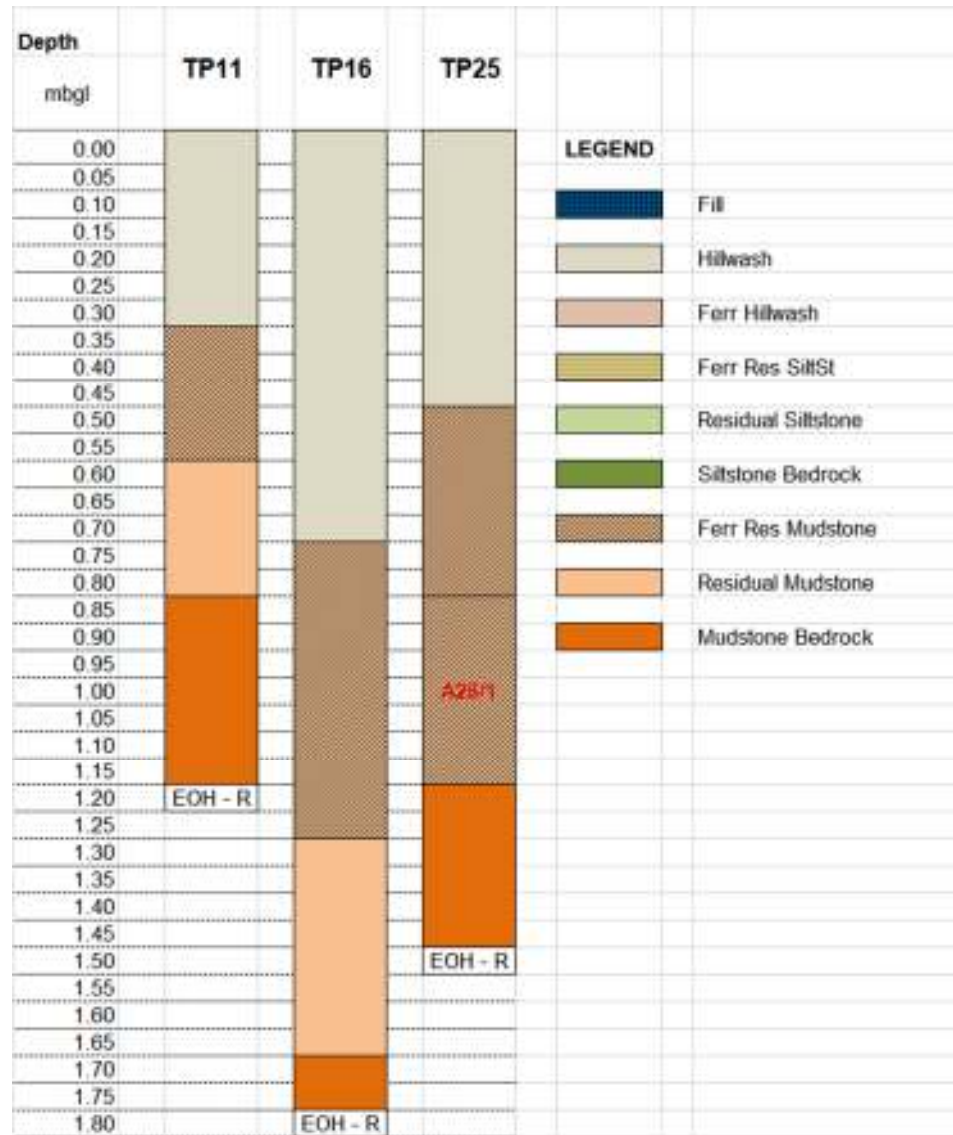


Figure 14: Platform A Section E-F – Generalised soil conditions

#### 4.1.4 Groundwater Occurrences

Slight groundwater seepage was encountered in 1 test pit, i.e. Test Pit A5, at a depth of 0.65 mbgl. No groundwater seepage was encountered in any of the remaining test pits.

Pedogenic soil in the form of ferricrete was encountered all the test pits. The pedogenic soil material is indicative that the soils are poorly drained and that the seasonal occurrence of perched groundwater conditions is highly likely to occur over the site. Suitable subsoil drainage and dampness measures will have to be implemented.

#### 4.1.5 Dynamic Cone Penetrometer (DCP) testing

Dynamic Cone Penetrometer (DCP) tests were conducted adjacent to all test pits and in the bottom of selected test pits based on encountered soil conditions.

The DCP testing gives an estimation on the expected excavation conditions and in-situ bearing capacity of the soil materials that was intersected with the test. The calculated Unconfined Compressive Strength of the materials as obtained from the penetration of the cone in mm per blow is averaged and can be summarised as follow:

- Fill material has a UCS of 186 to 577 kPa (average 411 kPa)
- Hillwash material has a UCS of 37 to 1000 kPa (average 625 kPa)
- Ferruginised hillwash material has a UCS of 236 to 1000 kPa (average 590 kPa)
- Residual siltstone material has a UCS of 74 to 1000 kPa (average 585 kPa)
- Ferruginised residual siltstone material has a UCS of 70 to 1000 kPa (average 609 kPa)
- Residual mudstone material has a UCS of 212 to 1000 kPa (average 705 kPa)
- Ferruginised residual mudstone material has a UCS of 236 to 1000 kPa (average 733 kPa)

#### 4.1.6 Resistivity testing

Resistivity sounding surveys was conducted utilizing a G41 DC resistivity meter manufactured by Geotron. Wenner-configuration soundings were conducted at 1m, 2m, 4m and 10m electrode spacing intervals at selected stations. The positions where readings could be obtained was highly influenced by the vegetation and accessibility of the project area as the equipment setup requires linear setup lengths of between 3 m (1 m depth) and 30 m (10 m depth). The varying electrode spacing enables the determination of resistivity with depth corresponding to the electrode spacing. The readings obtained are summarised in the table below for reference.

Table 7: Summarised resistivity data – Platform A

| Platform A |                        |           |                             |                             |                             |                              |
|------------|------------------------|-----------|-----------------------------|-----------------------------|-----------------------------|------------------------------|
| Station    | Coordinates (dd.ddddd) |           | 1m Wenner<br>Spacing (Ω/cm) | 2m Wenner<br>Spacing (Ω/cm) | 4m Wenner<br>Spacing (Ω/cm) | 10m Wenner<br>Spacing (Ω/cm) |
|            | Latitude               | Longitude |                             |                             |                             |                              |
| 1          | -33.05485              | 27.85076  | 9333                        | 2996                        | 1864                        | 2370                         |
| 2          | -33.05518              | 27.85111  | 10832                       | 6212                        | 6124                        | 6262                         |
| 3          | -33.05561              | 27.85139  | 14080                       | 9730                        | 6369                        | 7001                         |
| 12         | -33.05425              | 27.85199  | 5774                        | 5790                        | 5363                        | 5057                         |
| 13         | -33.05465              | 27.85234  | 11402                       | 5580                        | 3197                        | 2786                         |
| 14         | -33.05505              | 27.85259  | 8625                        | 4367                        | 3217                        | 4489                         |
| 31         | -33.05653              | 27.84953  | 6130                        | 6166                        | 6173                        | 6319                         |
| 32         | -33.05608              | 27.84916  | 9475                        | 4906                        | 4312                        | 4615                         |
| 33         | -33.05569              | 27.84896  | 11510                       | 9092                        | 7886                        | 4464                         |
| 48         | -33.05531              | 27.85237  | 10629                       | 7712                        | 6349                        | 5506                         |
| 51         | -33.05421              | 27.85173  | 9007                        | 4177                        | 2598                        | 3839                         |
| 52         | -33.05439              | 27.85134  | 7856                        | 9283                        | 9972                        | 7777                         |
| 53         | -33.05453              | 27.85089  | 6691                        | 7035                        | 7983                        | 6402                         |
| 54         | -33.05470              | 27.85051  | 5576                        | 4210                        | 3273                        | 4135                         |
| 55         | -33.05560              | 27.85027  | 6205                        | 5072                        | 4795                        | 4712                         |
| Min        |                        |           | 5576                        | 2996                        | 1864                        | 2370                         |
| Max        |                        |           | 14080                       | 9730                        | 9972                        | 7777                         |
| Ave        |                        |           | 8875                        | 6155                        | 5298                        | 5049                         |

#### 4.1.7 Corrosivity testing

Corrosivity testing was conducted on selected soil samples. The measured pH and Electrical Conductivity values of the soil materials are summarised in the Table below. The soils in platform A are moderately acidic to neutral with a pH between 5.40 and 7.10 and generally not corrosive with a conductivity well below 50 mS/m.

Table 8: Summarised soil corrosivity data – Platform A

| SAMPLE INFORMATION |               |   | SOIL CHEMISTRY |                     |                          |                  | SOIL CORROSIVITY                                  |  |
|--------------------|---------------|---|----------------|---------------------|--------------------------|------------------|---|--|
| Number             | Depth (m - m) | Material Origin   | pH             | Conductivity (mS/m) | Soil Resistivity (Ohm/m) | Moisture Content | Soil pH Class & Soil Corrosiveness (Conductivity) | Cathodic Protection Classification & Remarks (Resistivity) |
| A19/1              | 0.00 - 0.45   | Hillwash  | 6.28           | 0.983               | 1017                     | 32.9             | Slightly Acid / Generally not corrosive           | Not generally corrosive / Not generally required           |
| A16/1              | 0.40 - 0.70   | Hillwash  | 5.99           | 0.515               | 3942                     | 2.0              | Moderately Acid / Generally not corrosive         | Not generally corrosive / Not generally required           |
| A19/2              | 0.45 - 0.70   | Residual Siltstone                                      | 6.12           | 0.618               | 1618                     | 21.6             | Slightly Acid / Generally not corrosive           | Not generally corrosive / Not generally required           |
| A25/1              | 0.80 - 1.15   | Slightly Ferruginised Residual Siltstone                | 6.77           | 0.609               | 1642                     | 22.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| A1/1               | 0.55 - 0.75   | Ferruginised Residual Siltstone / Pebble Marker Horizon | 6.08           | 0.612               | 1634                     | 23.6             | Moderately Acid / Generally not corrosive         | Not generally corrosive / Not generally required           |
| A10/1              | 0.60 - 0.80   | Residual Siltstone                                      | 6.63           | 0.681               | 1468                     | 24.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| A30/1              | 0.60 - 0.80   | Ferruginised Residual Siltstone                         | 5.40           | 0.539               | 1855                     | 25.6             | Strongly Acid / Generally not corrosive           | Not generally corrosive / Not generally required           |
| A3/1               | 0.80 - 1.10   | Ferruginised Residual Siltstone                         | 7.10           | 0.702               | 1425                     | 26.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |

#### 4.1.8 Construction materials

The materials encountered and tested exhibit highly variable qualities. It is essential that proper quality control be conducted on all in-situ materials utilised during construction. Based on laboratory analysis the materials exhibit the following general properties:

- The hillwash material classifies as G8 according to TRH14 and is marginally suitable for use during construction.
- The residual siltstone classifies as G10 according to TRH14 and is not suitable for any use during construction.
- The ferruginised residual siltstone classifies as G10 according to TRH14 and is not suitable for any use during construction.
- The siltstone bedrock material classifies as G7 according to TRH14 and is suitable for use during construction. The material is non-durable and prone to slaking and will break down rapidly when exposed to changing moisture conditions, with a resulting decreasing strength and downgraded classification.

Utilisation of any of the materials can be discussed based on design requirements.

#### 4.1.9 Safe bearing pressures

The following safe bearing capacities are estimated based on the site investigation and interpretation of DCP results.

- Transported materials (Hillwash and Pebble Marker) - 50 kPa
- Residual materials (natural and ferruginised) - 75 kPa
- Siltstone bedrock (very soft rock) - 100 to 150 kPa
- Siltstone bedrock (refusal of TLB) - >450 kPa

#### 4.1.10 Heave potential

The results indicated that the materials encountered in Platform A area all have low expansive properties, indicating that these materials will have a low potential for heave on wetting up or shrinkage on drying out.

Experience of other nearby sites indicate that the residual siltstone and ferruginised residual siltstone materials can be medium expansive (as encountered in test pit C15 in Platform C). Although potential heave of the residual materials cannot be completely ruled out, the general problems with heave and shrinkage of these materials are expected to be minor.



#### 4.1.11 Collapse / compressibility settlement potential

The transported and residual soil materials are potentially moderately to very highly compressible / collapsible, with general settlement of 8% of layer thickness expected.

A consolidation test was conducted on the residual siltstone material to measure the expected compressibility settlement of the material under load. Test results are indicated in Chapter 3 and summarised as follow:

- The material is normally consolidated with a pre-consolidation pressure of 40 kPa
- 200 kPa load – settlement of 8 – 11 % of layer thickness
- 400 kPa load – settlement of 11 – 14 % of layer thickness

#### 4.1.12 Site Classification

Based on the results of the investigation the platform can be classified as follow:

- C2 – expected collapse / consolidation settlement > 10 mm
- H – potential heave / expansiveness up to 7.5 mm
- P(perched gw) – seasonal perched groundwater conditions expected
- [R] – shallow bedrock conditions < 1.20 mbgl [in localised portions]
- The transported and residual soil materials are potentially moderately to very highly compressible / collapsible.

**The site classification is C2 – H – P – [R]**

## 4.2 Platform B

### 4.2.1 Test pit excavation and profiling

A total of 32 test pits, numbered Test Pit B1 to B32 were excavated in the central portion of the project area designated for Platform B and future expansions. The positions of the test pits are indicated in the Figure below, with detailed test pit logs attached in Appendix A for reference.



Figure 15: Detailed layout of test pits – Platform B area

### 4.2.2 Excavatability Conditions

It was possible to excavate the test pits utilising a JCB 3CX 4x4 TLB-type excavator, fitted with a 300 rock-bucket, to a depth between 1.15 and 1.90 mbgl (mean 1.52 mbgl) after which excavation refused in all test pits on moderately hard rock to hard rock siltstone and mudstone bedrock material.

Siltstone or mudstone bedrock material was encountered in all test pits from between 0.60 and 1.65 mbgl (mean 1.09 mbgl).

Excavatability conditions can be summarised as follow:

- From Surface to 1.0 mbgl - Soft Excavation Class
- From 1.0 mbgl to 2.5 mbgl - Intermediate Excavation Class with pockets of Hard Rock

Table 9: Depth to rock, depth to refusal and seepage – Platform B

| TEST PIT | DEPTH TO ROCK (m) | DEPTH TO REFUSAL (m) | SEEPAGE (m) |
|----------|-------------------|----------------------|-------------|
| B1       | 1.25              | 1.75                 | -           |
| B2       | 1.45              | 1.70                 | -           |
| B3       | 1.20              | 1.70                 | -           |
| B4       | 0.85              | 1.15                 | -           |
| B5       | 0.85              | 1.25                 | -           |
| B6       | 1.00              | 1.80                 | -           |
| B7       | 1.05              | 1.75                 | -           |
| B8       | 1.30              | 1.90                 | -           |
| B9       | 1.00              | 1.35                 | -           |
| B10      | 1.25              | 1.45                 | -           |
| B11      | 1.25              | 1.70                 | -           |
| B12      | 1.20              | 1.55                 | -           |
| B13      | 1.15              | 1.30                 | -           |
| B14      | 1.30              | 1.45                 | -           |
| B15      | 0.90              | 1.60                 | -           |
| B16      | 0.95              | 1.55                 | -           |
| B17      | 0.90              | 1.60                 | -           |
| B18      | 0.90              | 1.55                 | -           |
| B19      | 1.20              | 1.40                 | -           |
| B20      | 1.15              | 1.35                 | -           |
| B21      | 1.05              | 1.45                 | -           |
| B22      | 1.05              | 1.60                 | -           |
| B23      | 0.60              | 1.35                 | -           |
| B24      | 1.00              | 1.40                 | -           |
| B25      | 0.95              | 1.70                 | -           |
| B26      | 1.00              | 1.75                 | -           |
| B27      | 1.35              | 1.50                 | -           |
| B28      | 1.65              | 1.75                 | -           |
| B29      | 0.90              | 1.60                 | -           |
| B30      | 1.05              | 1.35                 | -           |
| B31      | 1.00              | 1.25                 | -           |
| B32      | 1.10              | 1.15                 | -           |

#### 4.2.3 Generalised soil conditions

The following generalised soil conditions can be expected based on limited point source test pit information obtained from test pits.

The area is generally covered by hillwash material that is composed of sandy clay that exhibits a firm consistency and intact soil structure. The hillwash material becomes ferruginised at depth in localised portions of the site, characterised in profile by the occurrence of ferricrete nodules. Plant roots were recorded in this material over the entire site. The hillwash material extends to a maximum depth of 1.10 mbgl.

The transported material is underlain by residual siltstone that is composed of sandy clay with scattered to occasional siltstone gravel to cobbles. The material exhibits a firm to stiff consistency and fractured and inherent structure, with a maximum thickness of approximately 1.0 m. The upper portion of the residual material is generally ferruginised, characterised in profile by scattered to abundant ferricrete nodules.

Siltstone bedrock material was encountered in all test pits from a depth between 0.60 to 1.65 mbgl (mean 1.09 mbgl). The material is highly to moderately weathered, fine grained, medium jointed with a soft rock to moderately hard rock hardness.

The generalised soil profile and sections are indicated in the figures below.



Figure 16: Cross section and test pit layout – Platform B



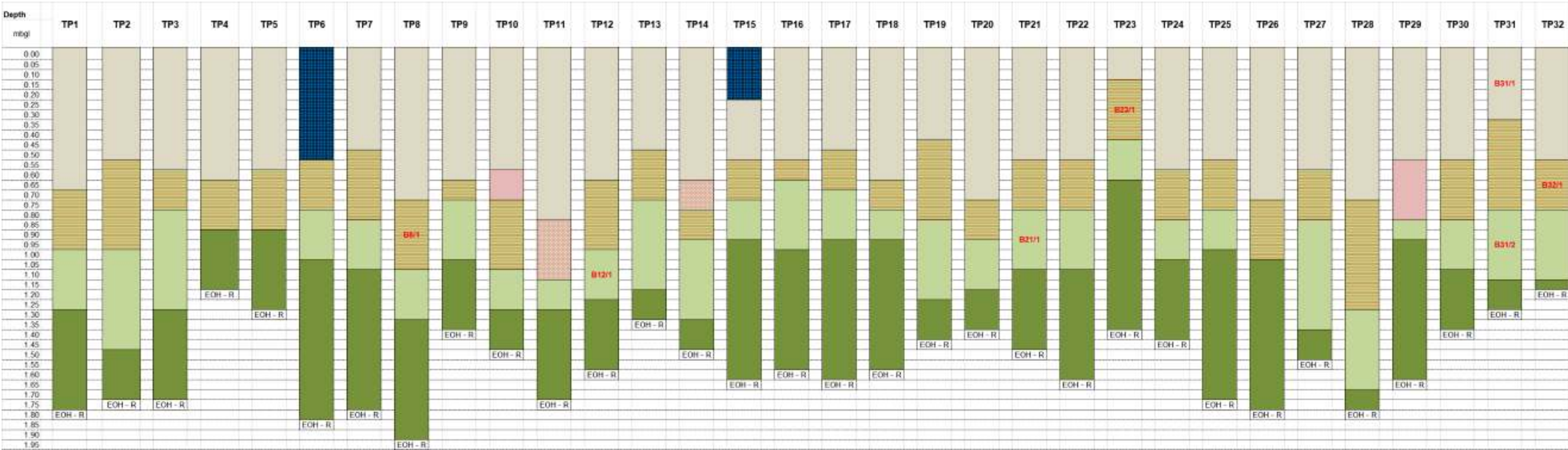


Figure 17: Platform B – Generalised soil conditions – All test pits

| LEGEND |                    |
|--------|--------------------|
|        | Fill               |
|        | Hillwash           |
|        | Ferr Hillwash      |
|        | Ferr Res SiltSt    |
|        | Residual Siltstone |
|        | Siltstone Bedrock  |
|        | Ferr Res Mudstone  |
|        | Residual Mudstone  |
|        | Mudstone Bedrock   |



Figure 18: Platform B Section A-B – Generalised soil conditions

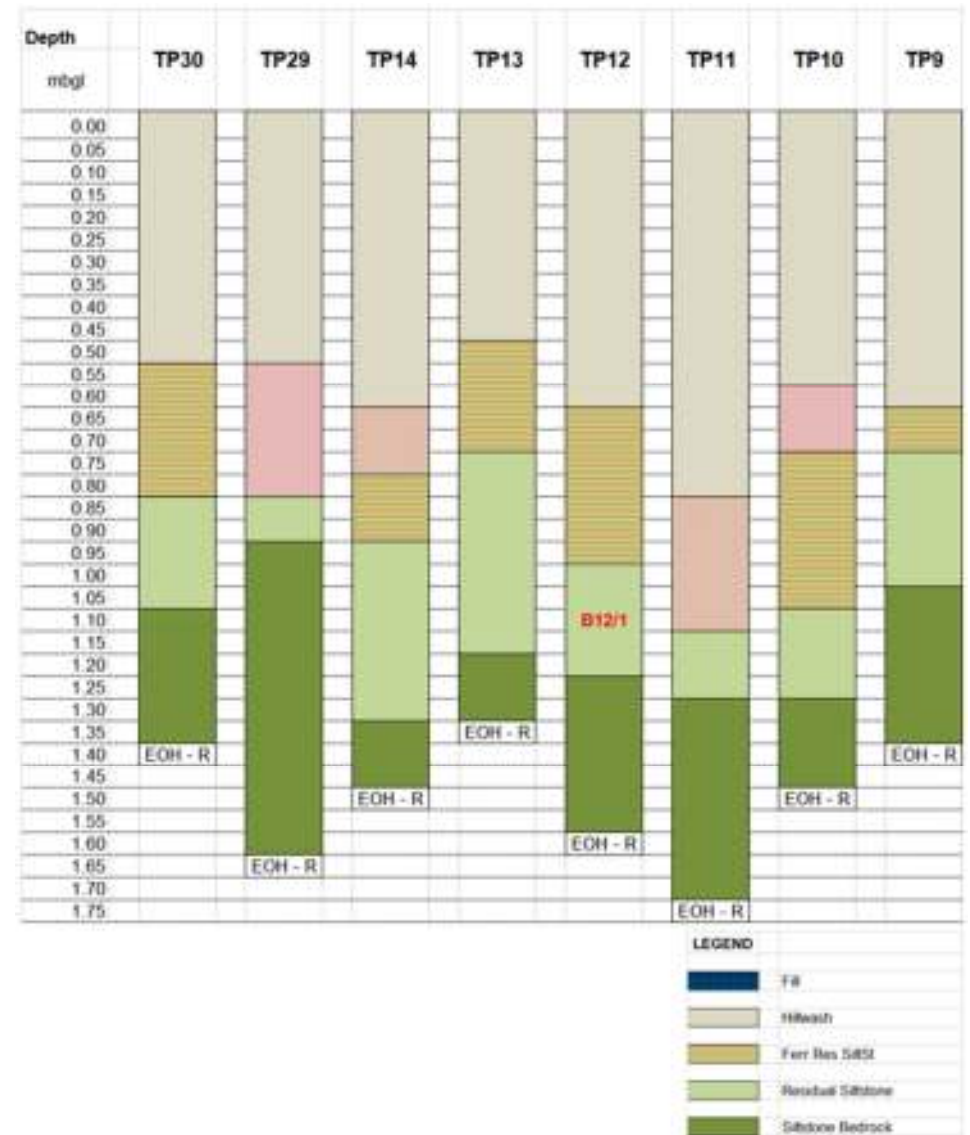


Figure 19: Platform B Section C-D – Generalised soil conditions

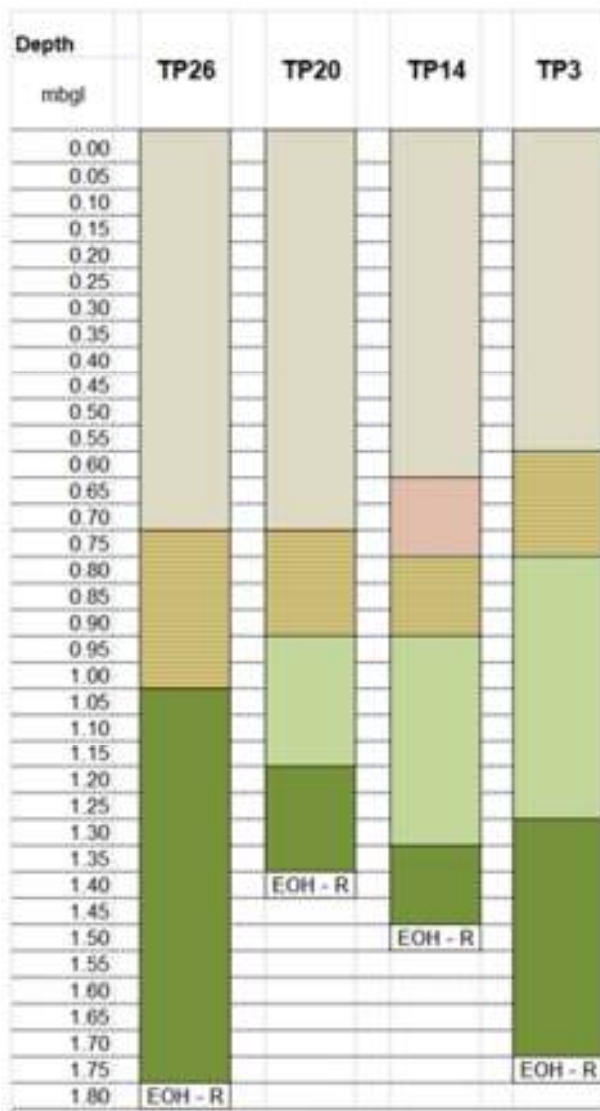


Figure 20: Platform B Section E-F – Generalised soil conditions

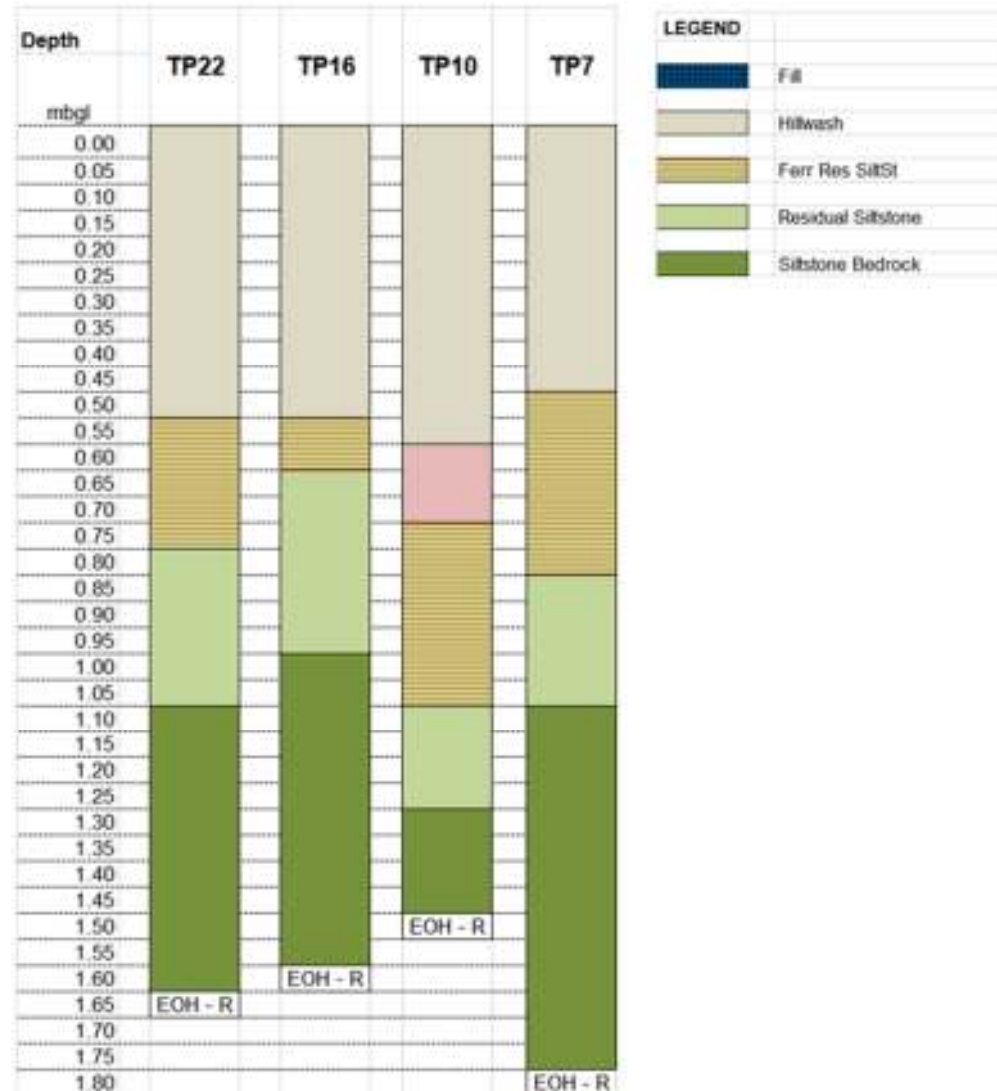


Figure 21: Platform B Section G-H – Generalised soil conditions

#### 4.2.4 Groundwater Occurrences

No groundwater seepage was encountered in any of excavated test pits.

Pedogenic soil in the form of ferricrete was encountered all the test pits. The pedogenic soil material is indicative that the soils are poorly drained and that the seasonal occurrence of perched groundwater conditions is highly likely to occur over the site. Suitable subsoil drainage and dampness measures will have to be implemented.

#### 4.2.5 Dynamic Cone Penetrometer (DCP) testing

Dynamic Cone Penetrometer (DCP) tests were conducted adjacent to all test pits and in the bottom of selected test pits based on encountered soil conditions.

The DCP testing gives an estimation on the expected excavation conditions and in-situ bearing capacity of the soil materials that was intersected with the test. The calculated Unconfined Compressive Strength of the materials as obtained from the penetration of the cone in mm per blow is averaged and can be summarised as follow:

- Fill material has a UCS of 104 to 1000 kPa (average 752 kPa)
- Hillwash material has a UCS of 52 to 1000 kPa (average 700 kPa)
- Ferruginised hillwash material has a UCS of 285 to 1000 kPa (average 598 kPa)
- Pebble Marker Horizon material has a UCS of 640 to 1000 kPa (average 901 kPa)
- Residual siltstone material has a UCS of 163 to 1000 kPa (average 674 kPa)
- Ferruginised residual siltstone material has a UCS of 80 to 1000 kPa (average 694 kPa)

#### 4.2.6 Resistivity testing

Resistivity sounding surveys was conducted utilizing a G41 DC resistivity meter manufactured by Geotron. Wenner-configuration soundings were conducted at 1m, 2m, 4m and 10m electrode spacing intervals at selected stations.

The positions where readings could be obtained was highly influenced by the vegetation and accessibility of the project area as the equipment setup requires linear setup lengths of between 3 m (1 m depth) and 30 m (10 m depth). The varying electrode spacing enables the determination of resistivity with depth corresponding to the electrode spacing. The readings obtained are summarised in the table below for reference.



Table 10: Summarised resistivity data – Platform B

| Platform B |                        |           |                             |                             |                             |                              |
|------------|------------------------|-----------|-----------------------------|-----------------------------|-----------------------------|------------------------------|
| Station    | Coordinates (dd.ddddd) |           | 1m Wenner<br>Spacing (Ω/cm) | 2m Wenner<br>Spacing (Ω/cm) | 4m Wenner<br>Spacing (Ω/cm) | 10m Wenner<br>Spacing (Ω/cm) |
|            | Latitude               | Longitude |                             |                             |                             |                              |
| 4          | -33.05608              | 27.85173  | 10564                       | 1172                        | 11444                       | 10642                        |
| 5          | -33.05649              | 27.85197  | 14075                       | 13724                       | 15834                       | 12526                        |
| 6          | -33.05700              | 27.85229  | 12066                       | 7283                        | 8215                        | 7596                         |
| 7          | -33.05748              | 27.85260  | 7534                        | 6233                        | 5970                        | 5774                         |
| 15         | -33.05546              | 27.85288  | 7783                        | 5050                        | 3864                        | 3626                         |
| 16         | -33.05584              | 27.85308  | 12294                       | 9226                        | 7243                        | 6225                         |
| 17         | -33.05625              | 27.85333  | 6022                        | 8310                        | 2339                        | 8602                         |
| 18         | -33.05664              | 27.85357  | 4940                        | 5260                        | 6688                        | 8860                         |
| 19         | -33.05705              | 27.85385  | 3084                        | 3325                        | 4621                        | 5995                         |
| 26         | -33.05840              | 27.85080  | 5110                        | 5154                        | 5707                        | 5364                         |
| 27         | -33.05811              | 27.85053  | 7256                        | 7024                        | 6354                        | 5458                         |
| 28         | -33.05769              | 27.85029  | 7464                        | 7924                        | 10141                       | 6688                         |
| 29         | -33.05732              | 27.85003  | 9941                        | 8950                        | 11469                       | 14192                        |
| 30         | -33.05687              | 27.84976  | 7446                        | 9005                        | 9793                        | 8893                         |
| 43         | -33.05717              | 27.85325  | 13899                       | 7548                        | 6073                        | 4474                         |
| 44         | -33.05680              | 27.85299  | 6098                        | 4823                        | 4892                        | 5378                         |
| 46         | -33.05788              | 27.85171  | 18870                       | 12496                       | 15726                       | 15090                        |
| 47         | -33.05719              | 27.85064  | 14659                       | 8313                        | 8001                        | 12511                        |
| 49         | -33.05571              | 27.85220  | 19992                       | 13353                       | 10838                       | 7697                         |
| 50         | -33.05639              | 27.85231  | 8493                        | 9122                        | 10634                       | 10717                        |
| Min        |                        |           | 3084                        | 1172                        | 2339                        | 3626                         |
| Max        |                        |           | 19992                       | 13724                       | 15834                       | 15090                        |
| Ave        |                        |           | 9879.5                      | 7664.75                     | 8292.3                      | 8315.4                       |

#### 4.2.7 Corrosivity testing

Corrosivity testing was conducted on selected soil samples. The measured pH and Electrical Conductivity values of the soil materials are summarised in the Table below. The soils in platform B are slightly acid to slightly alkaline with a pH between 6.20 and 7.64 and generally not corrosive with a conductivity well below 50 mS/m.

Table 11: Summarised soil corrosivity data – Platform B

| SAMPLE INFORMATION |                  |                                 | SOIL CHEMISTRY |                     |                        |                  | SOIL CORROSIVITY                                |  |
|--------------------|------------------|---------------------------------|----------------|---------------------|------------------------|------------------|---|--|
| Number             | Depth<br>(m - m) | Material Origin                 | pH             | Conductivity (mS/m) | Soil Resistivity (Ω/m) | Moisture Content | Soil pH Class & Soil Consistency (Conductivity) | Cathodic Protection Classification & Remarks (Resistivity) |
| B8/1               | 0.75 - 1.05      | Pebble Marker Horizon           | 7.64           | 1.028               | 973                    | 27.6             | Slightly Alkaline / Generally not corrosive     | Not generally corrosive / Not generally required           |
| B3/2               | 0.75 - 1.10      | Residual Siltstone              | 6.20           | 1.310               | 763                    | 28.6             | Slightly Acid / Generally not corrosive         | Not generally corrosive / Not generally required           |
| B2/1               | 0.75 - 1.05      | Residual Siltstone              | 6.64           | 1.001               | 999                    | 29.6             | Neutral / Generally not corrosive               | Not generally corrosive / Not generally required           |
| B23/1              | 0.10 - 0.40      | Ferruginised Residual Siltstone | 6.45           | 0.525               | 1905                   | 30.6             | Slightly Acid / Generally not corrosive         | Not generally corrosive / Not generally required           |
| B31/1              | 0.00 - 0.30      | Hillwash                        | 6.61           | 0.505               | 1980                   | 31.6             | Neutral / Generally not corrosive               | Not generally corrosive / Not generally required           |

#### 4.2.8 Construction materials

The materials encountered and tested exhibit highly variable qualities. It is essential that proper quality control be conducted on all in-situ materials utilised during construction. Based on laboratory analysis the materials exhibit the following general properties:

- The hillwash material classifies is expected to classify as G8 according to TRH14 and is marginally suitable for use during construction.
- The residual siltstone classifies as G7/G8 according to TRH14 and is marginally suitable for use during construction depending on application, as the material may be potentially moderately expansive.
- The ferruginised residual siltstone classifies as G9 according to TRH14 and is not suitable for any use during construction.
- The siltstone bedrock material classifies as G6 to G7 according to TRH14 and is suitable for use during construction. The material is non-durable and prone to slaking and will break down rapidly when exposed to changing moisture conditions, with a resulting decreasing strength and downgraded classification.

Utilisation of any of the materials can be discussed based on design requirements.

#### 4.2.9 Safe bearing pressures

The following safe bearing capacities are estimated based on the site investigation and interpretation of DCP results.

- Transported materials (Hillwash and Pebble Marker) - 50 kPa
- Residual materials (natural and ferruginised) - 75 kPa
- Siltstone bedrock (very soft rock) - 100 to 150 kPa
- Siltstone bedrock (refusal of TLB) - >450 kPa

#### 4.2.10 Heave potential

The results indicated that the materials encountered in Platform B area all have low expansive properties, indicating that these materials will have a low potential for heave on wetting up or shrinkage on drying out.

Experience of other nearby sites indicate that the residual siltstone and ferruginised residual siltstone materials can be medium expansive (as encountered in test pit C15 in Platform C). Although potential heave of the residual materials cannot be completely ruled out, the general problems with heave and shrinkage of these materials are expected to be minor.

#### 4.2.11 Collapse / compressibility settlement potential

The transported and residual soil materials are potentially moderately to very highly compressible / collapsible, with general settlement of 8% of layer thickness expected.

A consolidation test was conducted on the residual siltstone material to measure the expected compressibility settlement of the material under load. Test results are indicated in Chapter 3 and summarised as follow:

- The material is normally consolidated with a pre-consolidation pressure of 25-40 kPa
- 200 kPa load – settlement of 8 – 11 % of layer thickness
- 400 kPa load – settlement of 11 – 14 % of layer thickness

#### 4.2.12 Site Classification

Based on the results of the investigation the platform can be classified as follow:

- C2 – expected collapse / consolidation settlement > 10 mm
- H – potential heave / expansiveness up to 7.5 mm
- P(perched gw) – seasonal perched groundwater conditions expected
- [R] – shallow bedrock conditions < 1.20 mbgl [in localised portions]
- The transported and residual soil materials are potentially moderately to very highly compressible / collapsible.

**The site classification is C2 – H – P – [R]**

### 4.3 Platform C

#### 4.3.1 Test pit excavation and profiling

A total of 40 test pits, numbered Test Pit C1 to C40 were excavated in the lower portion of the study area designated for Platform C and future expansions. A total of 24 of the 40 test pits were excavated within the proposed footprint of Platform C.

The positions of the test pits are indicated in the Figure below, with detailed test pit logs attached in Appendix A.



Figure 22: Detailed layout of test pits – Platform C area

#### 4.3.2 Excavatability Conditions

It was possible to excavate the test pits utilising a JCB 3CX 4x4 TLB-type excavator, fitted with a 300 rock-bucket, to a depth between 1.05 and 2.40 mbgl (mean 1.48 mbgl) after which excavation refused in all test pits on moderately hard rock to hard rock siltstone and mudstone bedrock material.

Siltstone bedrock material was encountered in all test pits from between 0.40 and 1.75 mbgl (mean 1.92 mbgl). Excavatability conditions can be summarised as follow:

- From Surface to 1.0 mbgl - Soft Excavation Class
- From 1.0 mbgl to 2.5 mbgl - Intermediate Excavation Class with pockets of Hard Rock

Table 12: Depth to rock, depth to refusal and seepage – Platform C

| TEST PIT | DEPTH TO ROCK (m) | DEPTH TO REFUSAL (m) | SEEPAGE (m) |
|----------|-------------------|----------------------|-------------|
| C1       | 1.40              | 1.50                 | -           |
| C2       | 0.90              | 1.40                 | -           |
| C3       | 1.05              | 1.50                 | -           |
| C4       | 1.05              | 1.75                 | -           |
| C5       | 0.90              | 1.40                 | -           |
| C6       | 0.90              | 1.50                 | -           |
| C7       | 0.90              | 1.35                 | -           |
| C8       | 1.20              | 1.85                 | -           |
| C9       | 0.90              | 1.45                 | -           |
| C10      | 0.85              | 1.70                 | -           |
| C11      | 0.65              | 1.20                 | -           |
| C12      | 0.70              | 0.75                 | -           |
| C13      | 0.90              | 1.35                 | -           |
| C14      | 0.80              | 1.40                 | -           |
| C15      | 0.85              | 1.25                 | -           |
| C16      | 0.40              | 1.10                 | -           |
| C17      | 0.50              | 1.50                 | -           |
| C18      | 0.50              | 1.40                 | -           |
| C19      | 0.95              | 1.35                 | -           |
| C20      | 0.85              | 1.20                 | -           |
| C21      | 0.75              | 1.35                 | -           |
| C22      | 0.60              | 0.90                 | -           |
| C23      | 0.60              | 0.75                 | -           |
| C24      | 0.90              | 1.10                 | -           |
| C25      | 1.20              | 1.45                 | -           |
| C26      | 0.95              | 1.10                 | -           |
| C27      | 0.95              | 1.15                 | -           |
| C28      | 0.40              | 1.05                 | -           |
| C29      | 1.75              | 2.40                 | -           |
| C30      | 0.80              | 1.65                 | -           |
| C31      | 0.80              | 1.45                 | -           |
| C32      | 1.10              | 1.85                 | -           |
| C33      | 1.50              | 2.50                 | -           |
| C34      | 1.10              | 1.30                 | -           |
| C35      | 1.15              | 1.80                 | -           |
| C36      | 0.70              | 1.20                 | -           |
| C37      | 0.60              | 1.30                 | -           |
| C38      | 1.15              | 1.75                 | -           |
| C39      | 0.90              | 1.60                 | -           |
| C40      | 1.30              | 2.30                 | -           |

#### 4.3.3 Generalised soil conditions

The following generalised soil conditions can be expected based on limited point source test pit information obtained from test pits.

The area is generally covered by hillwash material that is composed of sandy clay that exhibits a firm consistency and intact soil structure. Plant roots were recorded in this material over the entire site. The hillwash material extends to a maximum depth of 0.70 mbgl.

The transported material is underlain by residual siltstone / mudstone that is composed of sandy clay with scattered to occasional mudstone gravel to cobbles. The material exhibits a firm to stiff consistency and fractured and inherent structure, with a maximum thickness of approximately 1.30 m. The upper portion of the residual material is generally ferruginised, characterised in profile by scattered to



abundant ferricrete nodules.

Siltstone / mudstone bedrock material was encountered in all test pits from a depth between 0.40 to 1.75 mbgl (mean 0.92 mbgl). The material is highly to moderately weathered, fine grained, medium jointed with a soft rock to moderately hard rock hardness.

The generalised soil profile and sections are indicated in the figures below.



Figure 23: Cross section and test pit layout – Platform C

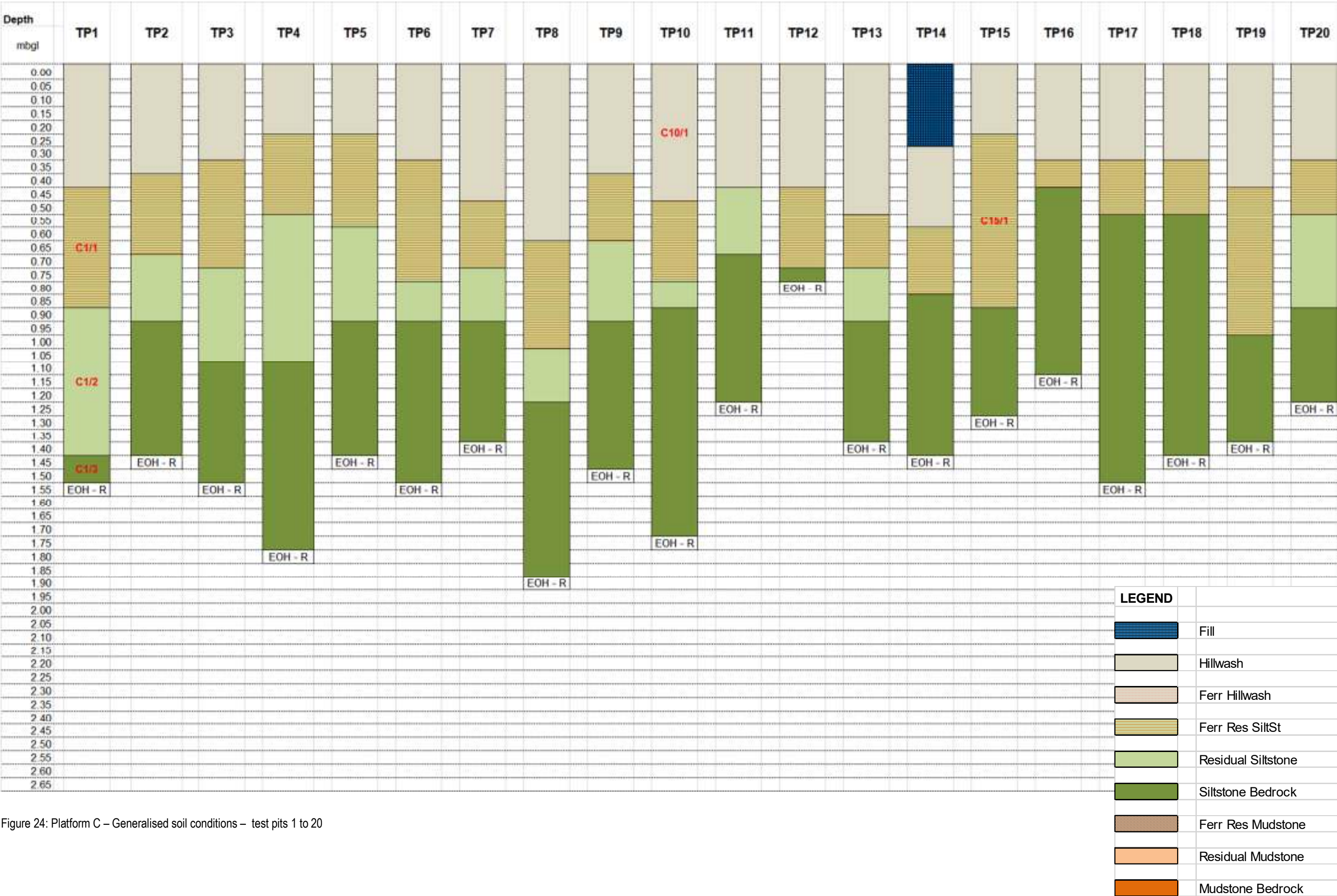
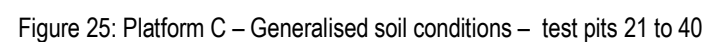


Figure 24: Platform C – Generalised soil conditions – test pits 1 to 20





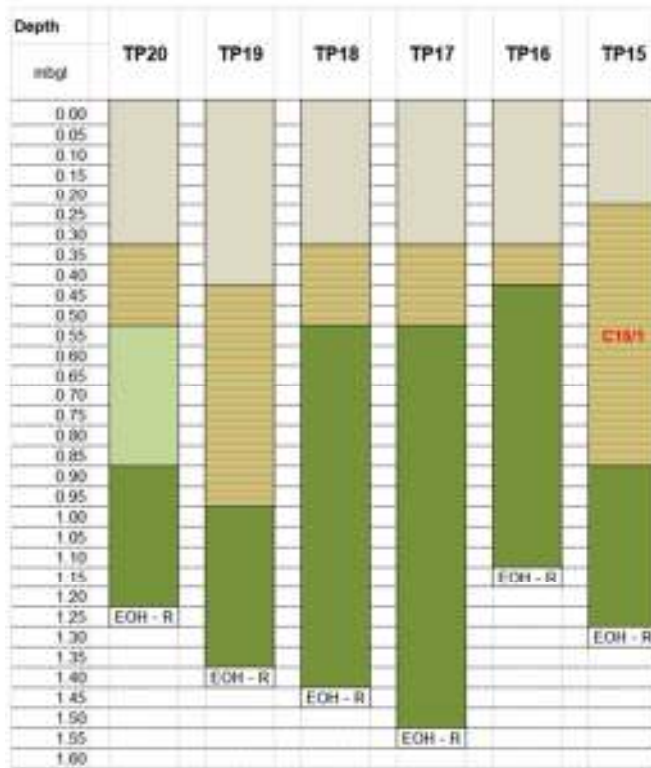


Figure 26: Platform C Section A-B – Generalised soil conditions

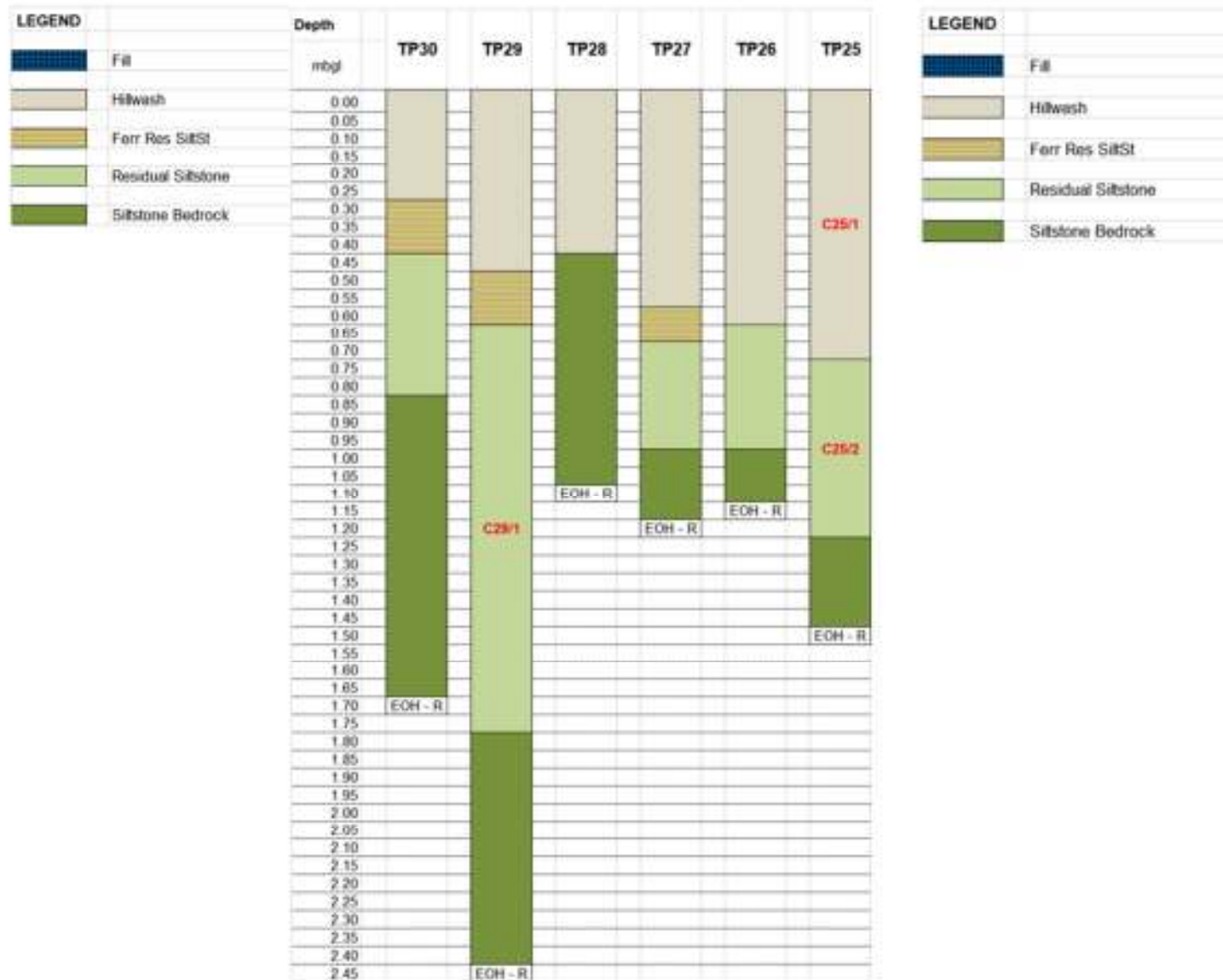


Figure 27: Platform C Section C-D – Generalised soil conditions



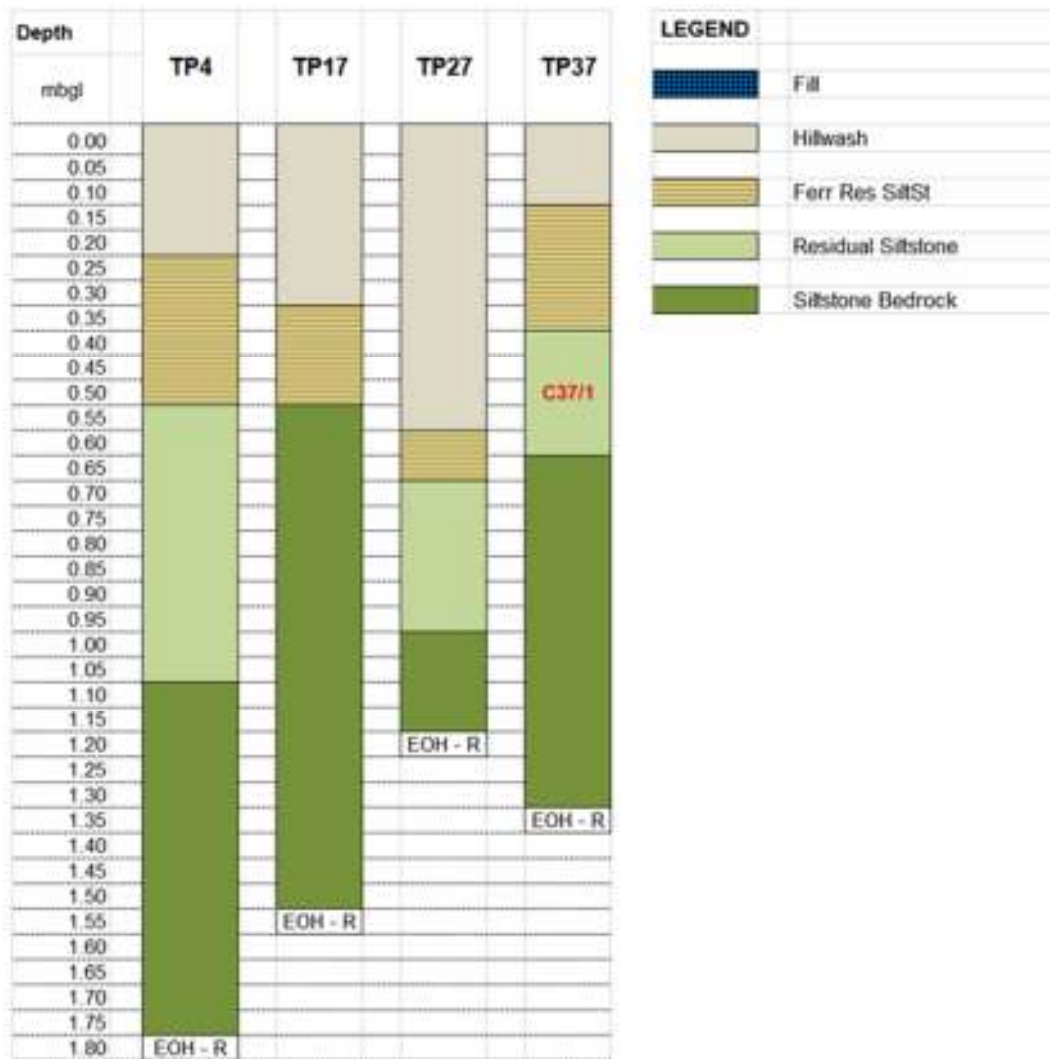


Figure 28: Platform C Section E-F – Generalised soil conditions

#### **4.3.4 Groundwater Occurrences**

Slight groundwater seepage was encountered in 1 test pit, i.e. Test Pit A5, at a depth of 0.65 mbgl. No groundwater seepage was encountered in any of the remaining test pits.

Pedogenic soil in the form of ferricrete was encountered all the test pits, with the exception of 4 test pits (C25, C26, C28 and C35). The pedogenic soil material is indicative that the soils are not suitably drained and that the seasonal occurrence of perched groundwater conditions is highly likely to occur over the site. Suitable subsoil drainage and dampness measures will have to be implemented.

#### **4.3.5 Dynamic Cone Penetrometer (DCP) testing**

Dynamic Cone Penetrometer (DCP) tests were conducted adjacent to all test pits and in the bottom of selected test pits based on encountered soil conditions.

The DCP testing gives an estimation on the expected excavation conditions and in-situ bearing capacity of the soil materials that was intersected with the test. The calculated Unconfined Compressive Strength of the materials as obtained from the penetration of the cone in mm per blow is averaged and can be summarised as follow:

- Fill material has a UCS of 80 to 1000 kPa (average 474 kPa)
- Hillwash material has a UCS of 58 to 1000 kPa (average 394 kPa)
- Residual siltstone material has a UCS of 54 to 1000 kPa (average 452 kPa)
- Ferruginised residual siltstone material has a UCS of 56 to 1000 kPa (average 556 kPa)

#### **4.3.6 Resistivity testing**

Resistivity sounding surveys was conducted utilizing a G41 DC resistivity meter manufactured by Geotron. Wenner-configuration soundings were conducted at 1m, 2m, 4m and 10m electrode spacing intervals at selected stations. The positions where readings could be obtained was highly influenced by the vegetation and accessibility of the project area as the equipment setup requires linear setup lengths of between 3 m (1 m depth) and 30 m (10 m depth). The varying electrode spacing enables the determination of resistivity with depth corresponding to the electrode spacing. The readings obtained are summarised in the table below for reference.

Table 13: Summarised resistivity data – Platform C

| Platform C |                        |           |                |                |                |                |
|------------|------------------------|-----------|----------------|----------------|----------------|----------------|
| Station    | Coordinates (dd.ddddd) |           | 1m Wenner      | 2m Wenner      | 4m Wenner      | 10m Wenner     |
|            | Latitude               | Longitude | Spacing (Ω/cm) | Spacing (Ω/cm) | Spacing (Ω/cm) | Spacing (Ω/cm) |
| 8          | -33.05788              | 27.85283  | 6890           | 6891           | 7582           | 8090           |
| 9          | -33.05821              | 27.85305  | 3423           | 2224           | 2821           | 4717           |
| 10         | -33.05849              | 27.85324  | 2812           | 2631           | 3829           | 5569           |
| 11         | -33.05886              | 27.85347  | 2338           | 1890           | 2507           | 4496           |
| 20         | -33.05746              | 27.85409  | 7788           | 5172           | 4907           | 4955           |
| 21         | -33.05784              | 27.85437  | 6126           | 4403           | 4342           | 6245           |
| 22         | -33.05823              | 27.85460  | 6054           | 4348           | 5230           | 7936           |
| 23         | -33.05972              | 27.85156  | 3849           | 3208           | 3549           | 3460           |
| 24         | -33.05924              | 27.85132  | 10412          | 10525          | 9884           | 8977           |
| 25         | -33.05890              | 27.85109  | 5244           | 4685           | 6332           | 8472           |
| 34         | -33.05983              | 27.85204  | 6143           | 3815           | 3707           | 4745           |
| 35         | -33.05958              | 27.85259  | 2537           | 2826           | 3026           | 4436           |
| 36         | -33.05928              | 27.85323  | 3326           | 2606           | 3393           | 4233           |
| 37         | -33.05898              | 27.85385  | 3997           | 2878           | 3060           | 4260           |
| 38         | -33.05888              | 27.85412  | 3970           | 2149           | 2520           | 3189           |
| 39         | -33.05867              | 27.85452  | 3982           | 2817           | 2705           | 3257           |
| 40         | -33.05851              | 27.85473  | 5236           | 3433           | 3405           | 2778           |
| 41         | -33.05806              | 27.85355  | 6115           | 6059           | 7664           | 10738          |
| 42         | -33.05765              | 27.85323  | 8155           | 5096           | 7862           | 7728           |
| 45         | -33.05862              | 27.85203  | 5182           | 3922           | 4092           | 5843           |
| Min        |                        |           | 2338           | 1890           | 2507           | 2778           |
| Max        |                        |           | 10412          | 10525          | 9884           | 10738          |
| Ave        |                        |           | 5178.95        | 4078.9         | 4620.85        | 5706.2         |

#### 4.3.7 Corrosivity testing

Corrosivity testing was conducted on selected soil samples. The measured pH and Electrical Conductivity values of the soil materials are summarised in the Table below. The soils in platform C are moderately acidic to moderately alkaline with a pH between 6.01 and 7.90 and generally not corrosive with a conductivity well below 50 mS/m.

Table 14: Summarised soil corrosivity data – Platform C

| SAMPLE INFORMATION |               |                                 | SOIL CHEMISTRY |                     |                        |                  | SOIL CORROSIVITY                                  |  |
|--------------------|---------------|---------------------------------|----------------|---------------------|------------------------|------------------|---|--|
| Number             | Depth (m - m) | Material Origin                 | pH             | Conductivity (mS/m) | Soil Resistivity (Ω/m) | Moisture Content | Soil pH Class & Soil Corrosiveness (Conductivity) | Cathodic Protection Classification & Remarks (Resistivity) |
| C25/1              | 0.00 - 0.70   | Hillwash                        | 6.98           | 1.274               | 785                    | 32.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C33/1              | 1.25 - 1.50   | Residual Siltstone              | 7.90           | 0.706               | 1272                   | 33.6             | Moderately Alkaline / Generally not corrosive     | Not generally corrosive / Not generally required           |
| C1/1               | 0.40 - 0.85   | Ferruginised Residual Siltstone | 7.08           | 0.685               | 1460                   | 34.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C10/1              | 0.0 - 0.45    | Hillwash                        | 6.01           | 0.503               | 1965                   | 35.6             | Moderately Acid / Generally not corrosive         | Not generally corrosive / Not generally required           |
| C1/2               | 0.85 - 1.40   | Residual Siltstone              | 6.86           | 1.121               | 892                    | 36.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C35/1              | 0.60 - 1.15   | Residual Siltstone              | 7.40           | 1.990               | 503                    | 37.6             | Slightly Alkaline / Generally not corrosive       | Not generally corrosive / Not generally required           |
| C15/1              | 0.20 - 0.85   | Ferruginised Residual Siltstone | 6.97           | 1.142               | 876                    | 38.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |
| C23/1              | 0.35 - 0.60   | Ferruginised Residual Siltstone | 7.35           | 0.705               | 1418                   | 39.6             | Neutral / Generally not corrosive                 | Not generally corrosive / Not generally required           |

#### 4.3.8 Construction materials

The materials encountered and tested exhibit highly variable qualities. It is essential that proper quality control be conducted on all in-situ materials utilised during construction. Based on laboratory analysis the materials exhibit the following general properties:

- The hillwash material classifies is expected to classify as G8 according to TRH14 and is marginally suitable for use during construction.
- The residual siltstone and ferruginised residual siltstone classify as <G10 according to TRH14 and is generally not suitable for use during construction. The material is also potentially slightly to moderately expansive.
- The siltstone bedrock material classifies as G7 to G10 according to TRH14 and is suitable to marginally suitable for use during construction. The material is non-durable and prone to slaking and will break down rapidly when exposed to changing moisture conditions, with a resulting decreasing strength and downgraded classification.

Utilisation of any of the materials can be discussed based on design requirements.

#### 4.3.9 Safe bearing pressures

The following safe bearing capacities are estimated based on the site investigation and interpretation of DCP results.

- Transported materials (Hillwash and Pebble Marker) - 50 kPa
- Residual materials (natural and ferruginised) - 75 kPa
- Siltstone bedrock (very soft rock) - 100 to 150 kPa
- Siltstone bedrock (refusal of TLB) - >450 kPa

#### 4.3.10 Heave potential

The results indicated that the materials encountered in Platform C area have low to medium expansive properties, indicating that these materials will have a medium potential for heave on wetting up or shrinkage on drying out.

The ferruginised residual siltstone tested moderately expansive and has a calculated heave / shrink according to the Van Der Merwe method up to 15 mm.

#### 4.3.11 Collapse / compressibility settlement potential

The transported and residual soil materials are potentially moderately to very highly compressible / collapsible, with general settlement of 8% of layer thickness expected.

A consolidation test was conducted on the residual siltstone material to measure the expected compressibility settlement of the material under load. Test results are indicated in Chapter 3 and summarised as follow:



- The material is normally consolidated with a pre-consolidation pressure of 25-40 kPa
- 200 kPa load – settlement of 8 – 11 % of layer thickness
- 400 kPa load – settlement of 11 – 14 % of layer thickness

#### **4.3.12 Site Classification**

Based on the results of the investigation the platform can be classified as follow:

- C2 – expected collapse / consolidation settlement > 10 mm
- H1 – potential heave / expansiveness up to 15 mm
- P(perched gw) – seasonal perched groundwater conditions expected
- [R] – shallow bedrock conditions < 1.20 mbgl [in localised portions]
- The transported and residual soil materials are potentially moderately to very highly compressible / collapsible.

**The site classification is C2 – H1 – P – [R]**

## 5 SUMMARY

- AGES Omega (Pty) Ltd was appointed by BVI Border (Pty) Ltd to conduct a soils investigation for the proposed block development between Umzimbithi Road and Mdubu Road at the East London Industrial Development Zone, with the aim of determining and evaluating the engineering geological characteristics of the in-situ soil and rock material underlying the project area with regard to the proposed development of the area.
- The following specifications were given regarding the proposed development and information required from the geotechnical investigation of the project area:
  - Platform A, B and C
    - Structural Engineering Requirements
      - Foundation indicators
      - Safe bearing capacity
      - Activity of material
      - Foundation classifications
    - Civil Engineering Requirements
      - Generalised soil profiles
      - Water tables
      - Compaction characteristics
    - Mechanical Electrical Requirements
      - Resistivity testing
      - Corrosivity testing
- A total of 100 test pits were excavated utilising a JCB 3CX 4x4 TLB-type excavator fitted with a 300-rock bucket. Test pits were excavated in June 2018 at positions indicated by the client up to a required depth of 1.5 mbgl or refusal. In general, all test pits were excavated to maximum reach or refusal of the TLB. Several test pits could not be excavated due to very dense and prominent indigenous vegetation that was requested by the ELIDZ not to be cleared as part of the geotechnical investigation. All test pits were backfilled after the soil profiling and sampling was completed. Test pits were excavated as follow:
  - Block A - 28 test pits
  - Block B - 32 test pits
  - Block C - 40 test pits.
- Disturbed and undisturbed soil samples was taken during the site investigation and submitted for detailed laboratory analysis for foundation indicators, atterberg limits, compaction characteristics, soil corrosivity and consolidation testing. Processed data is discussed in Chapter 3 of this report.
- In order to characterize the soil resistivity, resistivity sounding surveys was conducted utilizing a G41 DC resistivity meter manufactured by Geotron. Wenner-configuration soundings were conducted at 1m, 2m, 4m and 10m electrode spacing intervals at selected stations. The positions where readings could be obtained was highly influenced by the vegetation and accessibility of the project area as the equipment setup requires linear setup lengths of between 3 m (1 m depth) and 30 m (10 m depth). Results are discussed in Chapter 2.3 of the

report data per platform indicated in Chapter 4.

- An existing borehole, EC/033/AM was identified near the south eastern boundary of the project area. The borehole is utilised for groundwater quality monitoring by the ELIDZ. The static groundwater level recorded in 2012 was measured at 3.24 mbgl
- Results of the investigation are discussed per platform in Chapter 4 of the report.
- It is recommended that on-site inspections of piling solutions, open foundation trenches and excavations be carried out by AGES in order to identify and evaluate soil conditions at variance with those encountered during the investigation.

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# **APPENDIX A**

## Detailed test pit profile logs & photos



# **APPENDIX B**

## Dynamic Cone Penetrometer data

# **APPENDIX C**

## Resistivity geophysical profiling data

# **APPENDIX D**

## **Soil laboratory analysis certificates**