

---

# PART C5.1: GEOTECHNICAL INVESTIGATIONS

## C5.1-1: *SPECON PIPELINE REPLACEMENT PHASE 3*

## C5.1-2: REHABILITATION OF MEGORING AND THAKGALANG RIVER CROSSINGS

---

Contractor

Witness 1

Witness 2

Employer

Witness 1

Witness 2

---

**C5.1-1: SPECON PIPELINE REPLACEMENT PHASE 3**

---

Contractor

Witness 1

Witness 2

Employer

Witness 1

Witness 2

P.O. BOX 795  
FAUNA PARK  
0787

# MABU

DOCUMENT NO.  
M-21-146D  
10/05/2022

## GEO TECHNICAL CONSULTANCY

VAT NO. 4050248519 / REG NO. 2016/278015/07

**CENTERLINE AND MATERIALS INVESTIGATION  
OLIFANTSPOORT WATER SUPPLY SCHEME  
OLIFANTSPOORT WTW TO SPECON RESERVOIR  
LIMPOPO PROVINCE- SOUTH AFRICA**

**Investigation Conducted For:**



16 Blue Jay Street  
Rooihuiskraal, Centurion, 0157  
Tel: 012 661 0283  
[rostrowski@sigodimarah.co.za](mailto:rostrowski@sigodimarah.co.za)

## GEOTECHNICAL CONSULTANCY

VAT NO. 4050248519 / REG NO. 2016/278015/07

### Olifantspoort WTW to Specon Reservoir

#### Document Reference:

**Document Number:** M-21-146D

**Document Version:** Draft Report

**Document Description:** Centerline and Materials Investigation

#### Document Approval and Compilation Record:

Action	Name	Job Title	Date	Signature
Project Execution and Report Compilation	Johannes Heyneke	Professional Engineering Geologist (Pri.Sci.Nat.)	10/05/2022	
Report Review and Signatory	André Joubert	Professional Engineering Geologist (Pri.Sci.Nat. and MSAIEG)	10/05/2022	

#### Document Tracking:

Date	Document Number	Document Version	Issued to	Format
10/05/2022	M-21-146D	Draft Report	Robert Ostrowski Sigodi Marah Martin Management Support	Electronic (PDF.)

## COPYRIGHT AND DISCLAIMER

Mabu Geotechnical Consultancy (Pty) Ltd reserves the copyright to this document including the accompanying data, models, trade secrets, rules, any other applicable intellectual property rights and is protected by the copyright and intellectual property law of South Africa. The information within this document is considered confidential and may under no circumstances be reproduced, distributed or used by a third party without written consent of Mabu Geotechnical Consultancy (Pty) Ltd.

Mabu Geotechnical Consultancy (Pty) Ltd strives to deliver a service of the highest quality, adhering to the prescribed industry standards. It is for this reason Mabu exercises due care and diligence in the implementation of fieldwork, site assessment and the generation of detailed reports and models.

The information presented in this document is based on the information supplied by the Client prior to the commencement of the investigation; therefore, Mabu Geotechnical Consultancy (Pty) Ltd including its directors and employees shall not be held liable for, and is indemnified against all actions, claims, demands, losses, liabilities, costs, damages and expenses prompted by, or in connection with, inaccurately relayed information pertaining to the site and/or the development.

This report is exclusively compiled for **Sigodi Marah Martin Management Support**; with specific application to the proposed development.

## LIST OF ABBREVIATIONS AND DEFINITIONS

<b>Bearing Capacity</b>	Pressure acting over the foundation area which would cause shear failure of the supporting soil immediately below and adjacent to a foundation.
<b>CBR</b>	<b>California Bearing Ratio</b> CBR is a penetration test for the evaluation of the mechanical strength of road subgrades and base-courses. It was developed by the California Department of Transportation before World War II.
<b>Excavatability</b>	The excavatability of an earth (rock and regolith) material is a measure of the material to be excavated with conventional excavation equipment such as a bulldozer with rippers, light mechanical excavator or other grading equipment.
<b>Excavation Classification (SANS 1200 D)</b>	<p style="text-align: center;"><b>Restricted Excavation</b></p> <p style="text-align: center;"><b>Hard Rock:</b> Material that cannot be removed without blasting or wedging and splitting</p> <p><b>Intermediate:</b> Material which can be removed by a back-acting excavator having a fly wheel power &gt;0.10 kW for each mm of tined-bucket width, or with the use of pneumatic tools before removal by a machine capable of removing soft material.</p> <p><b>Soft:</b> Material which can be efficiently removed by a back-acting excavator of a fly wheel power &gt;0.10 kW for each mm of tined bucket width</p> <p style="text-align: center;"><b>Non-restricted Excavation</b></p> <p><b>Hard Rock:</b> Material that cannot be effectively ripped by a bulldozer having an approximate mass of 35 tonne and a fly wheel power of 220 kW</p> <p><b>Intermediate:</b> Material which can be effectively ripped by a bulldozer having an approximate mass of 35 tonne and a fly wheel power of 220 kW</p> <p><b>Soft:</b> Material which can be effectively removed or loaded, without prior ripping, by any of the following plant:</p> <ul style="list-style-type: none"> <li>• A bulldozer or track type front end loader having an approximate mass of 22 tonne and a fly wheel power of 145 kW.</li> <li>• A tractor-scraper unit having an approximate mass of 28 tonne and a fly wheel power of 245 kW, pushed during loading by a bulldozer equivalent to that described above.</li> </ul>
<b>Mod AASHTO</b>	<b>The Modified AASHTO</b> Soil Classification System which was developed by the American Association of State Highway and Transportation Officials, and is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes.
<b>Lateral Earth Pressure</b>	It is the pressure that soil exerts in the horizontal direction and is an important parameter for the design of different types of retaining walls.
<b>Pedocrete</b>	<p><b>Pedocretes</b> are surficial deposits formed from absolute enrichment (cementation or replacement) or relative enrichment (weathering residue) of soils by various cementing minerals. The various types of pedocretes and their associated cementing constituents include:</p> <p style="text-align: center;"><b>Ferricrete:</b> iron oxide enriched <b>Calcrete:</b> carbonate enriched <b>Gypcrete:</b> gypsum enriched <b>Silcrete:</b> silica enriched</p>
<b>Residual Soil</b>	Residual soils are soils that develop from the complete weathering of their underlying parent rocks (in-situ) and have the same general chemistry as those rocks.
<b>Transported Soil</b>	Soils which form through weathering and erosional processes and characterised by the transporting agent/agents through which the soil is formed. Transporting agents include wind, water, ice and/or gravity.
<b>TP</b>	<b>Test Pit</b> An excavation made to examine the subsurface conditions (stratigraphy and composition) on a potential construction site. Samples are taken at specified depths for lab analysis.

# TABLE OF CONTENTS

1	Project Introduction .....	1
1.1	General.....	1
1.2	Terms of Reference.....	1
1.3	Investigative Standard .....	1
1.4	Available Information.....	2
1.5	Scope of the Investigation .....	2
1.6	Investigative Methodology.....	3
2	Description of the Environment .....	5
2.1	Project Location and Breakdown .....	5
2.2	Topography.....	7
2.3	Drainage.....	9
2.4	Climate .....	10
2.5	Regional Vegetation.....	10
3	Regional Geological and Hydrogeological Setting.....	11
3.1	Regional Stratigraphic Setting.....	11
3.2	Prominent Geological Structures .....	12
3.3	Hydrogeological Setting.....	12
3.4	Seismic Risk.....	12
4	Geotechnical Setting.....	13
4.1.1	Generalised Site Character .....	13
4.1.2	Segment 1.....	16
4.1.3	Segment 2.....	17
4.1.4	Segment 3.....	19
4.1.5	Segment 4.....	21
4.1.6	Segment 5.....	23
4.1.7	Segment 6.....	24
4.1.8	Segment 7.....	26
4.1.9	Summarised Material Succession .....	26
4.2	Laboratory Test Results Analysis.....	44

4.3	Summarised Geotechnical Character .....	45
4.3.1	Groundwater Seepage .....	45
4.3.2	Excavatability .....	50
4.3.3	Excavation Stability .....	55
4.3.4	Corrosivity .....	55
4.3.5	Erosivity .....	55
4.3.6	On-site Material Utilisation.....	55
5	Good Construction Practices .....	56
5.1	General Material Specifications - Pipelines .....	56
5.1.1	Selected granular material.....	56
5.1.2	Selected fill material .....	56
5.1.3	Fine granular material .....	56
5.1.4	Backfill material .....	56
5.2	Excavations and Earthworks.....	57
5.3	Drainage.....	58
5.3.1	Surface Drainage .....	58
5.3.2	Sub Surface Drainage.....	58
5.4	Earthworks.....	59
5.5	Slope Stability Measures.....	59
5.6	Corrosion Resistance.....	59
5.7	Development within 1 : 100 year-flood lines.....	60
6	Report Provisions .....	60
7	Bibliography .....	61

## LIST OF FIGURES

- Figure 1:** Study Area Location
- Figure 2:** Regional Geology
- Figure 3:** Topocadastral Map
- Figure 4:** Site Segmentation
- Figure 5:** Segment 1 & Segment 2
- Figure 6:** Segment 3
- Figure 7:** Segment 4 & Segment 5
- Figure 8:** Segment 6 & Segment 7
- Figure 9:** GPS Coordinates- TP1 to TP25
- Figure 10:** GPS Coordinates- TP26 to TP50
- Figure 11:** GPS Coordinates- TP51 to TP75
- Figure 12:** GPS Coordinates- TP75 to TP105

## LIST OF GRAPHICS

- Graphic 1:** Summarised Material Succession- Segment 1 (TP1 & TP2)
- Graphic 2:** Summarised Material Succession- Segment 2 (TP3-TP9)
- Graphic 3:** Summarised Material Succession- Segment 2 (TP10-TP16)
- Graphic 4:** Summarised Material Succession- Segment 3 (TP17-TP24)
- Graphic 5:** Summarised Material Succession- Segment 3 (TP25-TP32)
- Graphic 6:** Summarised Material Succession- Segment 3 (TP33-TP40)
- Graphic 7:** Summarised Material Succession- Segment 3 (TP41-TP48)
- Graphic 8:** Summarised Material Succession- Segment 3 (TP49-TP56)
- Graphic 9:** Summarised Material Succession- Segment 3 (TP57-TP61)
- Graphic 10:** Summarised Material Succession- Segment 3 (TP62-TP67)
- Graphic 11:** Summarised Material Succession- Segment 4 (TP68-TP72)
- Graphic 12:** Summarised Material Succession- Segment 4 (TP73-TP78)
- Graphic 13:** Summarised Material Succession- Segment 5 (TP79-TP83)
- Graphic 14:** Summarised Material Succession- Segment 6 (TP84-TP88)
- Graphic 15:** Summarised Material Succession- Segment 6 (TP89-TP94)
- Graphic 16:** Summarised Material Succession- Segment 7 (TP95-TP99)
- Graphic 17:** Summarised Material Succession- Segment 7 (TP100-TP105)

## LIST OF TABLES

**Table 1:** Site Segmentation Breakdown

**Table 2:** Site Segmentation Breakdown Cont.

**Table 3:** Summarised Groundwater Conditions- Segment 1

**Table 4:** Summarised Groundwater Conditions- Segment 2

**Table 5:** Summarised Groundwater Conditions- Segment 3

**Table 6:** Summarised Groundwater Conditions- Segment 3 Cont.

**Table 7:** Summarised Groundwater Conditions- Segment 4

**Table 8:** Summarised Groundwater Conditions- Segment 5

**Table 9:** Summarised Groundwater Conditions- Segment 6

**Table 10:** Summarised Groundwater Conditions- Segment 7

**Table 11:** Summarised Excavation Conditions- Segment 1

**Table 12:** Summarised Excavation Conditions- Segment 2

**Table 13:** Summarised Excavation Conditions- Segment 3

**Table 14:** Summarised Excavation Conditions- Segment 3 Cont.

**Table 15:** Summarised Excavation Conditions- Segment 4

**Table 16:** Summarised Excavation Conditions- Segment 5

**Table 17:** Summarised Excavation Conditions- Segment 6

**Table 18:** Summarised Excavation Conditions- Segment 7

## LIST OF APPENDICES

**Appendix A:** Soil Profiles

**Appendix B:** Laboratory Test Results- **to be included in the final report**

# 1 Project Introduction

## 1.1 General

This report describes the results of the Centerline and Materials Investigation conducted as part of the upgrades to the Olifantspoort Water Supply Scheme, with particular reference to the section of pipeline between the Olifantspoort Water Treatment Works and the Specon Reservoir, Limpopo Province of South Africa.

The investigation was undertaken in order to assess the engineering geological character of the area; focussing on the assessment and modelling of the geotechnical properties which will affect the overall development potential of the site.

## 1.2 Terms of Reference

Mabu Geotechnical Consultancy was appointed by *Sigodi Marah Martin Management Support* to undertake the detailed Engineering Geological and Materials Investigation for the proposed development.

**Document Version:** Draft Report

**Document Number:** M-21-146D

The route of the proposed pipeline was provided by the Client prior to the fieldwork phase of the investigation. Testing locations were adjusted across the proposed site; with the final locations and associated sampling points being chosen on merit to assist with the modelling of the sites' geotechnical nature.

The section of pipeline between chainages of ~19+000 and ~21+400 was completed during a previous assessment.

At the time during which this report was compiled, the final laboratory test results had yet to be received. As such, this report has been compiled into a draft version, with its' contents and findings subject to change on reception of the final results.

## 1.3 Investigative Standard

This report is based on point data collected during the fieldwork phase of the investigation. The generally accepted practices and standards adhered to throughout this investigation were taken from the **Site Investigation Code of Practice** put forward by the **Geotechnical Division of SAICE (2010)**.

The sub-surface evaluation of the site, sampling and testing was representative of the soil/rock conditions observed on-site. The investigation has therefore attempted, through interpolation and extrapolation at known test locations, to identify problem issues of a geotechnical nature on which this report is based. Variances in soil and rock quality and quantity from those predicted may be encountered during construction and these should be recorded.

## 1.4 Available Information

The following sources of information were utilized:

- **Geological Data**
  - Geological Series Map 2428 Nylstroom; scale 1: 250 000 (digital format)
- **Hydrogeological Data:**
  - Hydrogeological Series Map 2326 Polokwane; scale 1: 500 000 (hard copy)
- **Topographic Data:**
  - Topocadastral Series Map 2429 BC Lebowakgomo; scale 1: 50 000 (digital format)
  - Topocadastral Series Map 2429 BC Ga-Mankopane; scale 1: 50 000 (digital format)
  - Elevation Heat Map; Online Resource [*topographic-map.com*]
  - PlanetGIS Explorer 5.2- 5 m elevation contours [*SA-contours\_5m*]
- **Remote Sensing Information:**
  - Google Earth Pro <sup>TM</sup>
- **Documentation Provided by the Client:**
  - Pipeline Alignment- PS1 to Specon (kmz)
- **Previous Investigations**
  - Initial Geotechnical Assessment
  - *M-16-133 A- 160 IGTA- Olifantspoort Bulk Water Scheme*

## 1.5 Scope of the Investigation

The investigation focused on determining and assessing the geotechnical characteristics encountered across the site, with regards to the generalised succession of soil and rock, identification of potential problem soils, excavatability as well as the re-use of the excavated material during construction.

The investigation had the following aims:

- To assess the **geological and geotechnical character** of the site.
- To determine and describe, where possible, the **succession of soil and rock materials** occurring across the site in question.
- To assess the **in-situ mechanical properties** and the **re-usability of the natural material** underlying the site in question.
- To evaluate the **excavation characteristics** across the site in question.
- To **recommend** measures to be implemented during the design and development of the site in question.

The development potential of the study area is assessed based on the following premises:

- Construction of a bulk water pipeline

**It must be noted that this investigation was conducted to assist with the design and construction phases of the development.**

## **1.6 Investigative Methodology**

The detailed engineering geological and materials investigation was undertaken in a number of phases as to allow for an accurate assessment of the study area. Below is a summary of the various investigative phases:

### **1.6.1 Introduction and Regional Assessment of the Site**

The collation and evaluation of all the available topographic, geomorphological, and geological data across the investigated site and its' surroundings. This assessment is done through the use of available regional maps and remote sensing images. This section of the report will include a description and summary of the site's nature, based on existing literature, and is supplemented with the compilation of a series of base maps.

### **1.6.2 Review of Initial Geotechnical Assessment**

During prior phases of the proposed development, an Initial Geotechnical Assessment (IGTA) was conducted in order to to identify potentially adverse geotechnical conditions along the route to facilitate the decision-making process as part of the preliminary designs. The results of this investigation were reviewed and subsequently incorporated into the planning stages of the design phase investigation.

### **1.6.3 Geotechnical Analysis- Centerline and Materials Investigation**

Based on the results of this centerline and materials investigation; the investigated pipeline route is either seen as a single geotechnical entity or is subdivided into a number of geotechnical segments, each displaying their own unique geotechnical nature and characteristics.

Although each segment may display its own unique nature; they were all assessed based on the same methodology.

#### **1. Trenching and Sampling**

The field work phase of the investigation was undertaken by Mabu Geotechnical Consultancy in March 2022. Test pits were excavated through the use of a TLB-type light mechanical excavator (Bell 315 SL & JCB 3DX Super) to a target depth of 2.5 m below the existing ground level, or refusal.

Test pits were conducted at regular intervals (averaging ~4 per km) across the proposed pipeline route, with the final locations adjusted in order to target various geotechnical features identified during the desktop study and site walkover.

The succession of soil and rock layers exposed within the test pits were logged and a series of detailed photographs were taken of the different soil layers.

A number of disturbed samples were extracted from the various on-site exposures, targeting the in-situ materials deemed to be important to the proposed development.

*Continued Overleaf...*

## **2. Laboratory Testing**

Standard **foundation indicator** and **soil compaction tests** were conducted by **Letaba Lab (SANAS Accredited)** on **disturbed soil samples**. These tests were undertaken in order to determine the composition of the underlying soils (i.e.: the relative percentages of gravel, sand, silt, and clay) and to evaluate the suitability of the materials for the re-use in the proposed construction. The following tests were conducted:

- i. Atterberg Limits (liquid limit, plasticity index, linear shrinkage) and Particle-size Distribution.
- ii. Maximum Dry Density versus Optimum Moisture Content.
- iii. Californian Bearing Ratio versus Compaction Effort (Modified AASHTO method).
- iv. pH and EC analysis (chemical analysis).
- v. Double hydrometer tests for dispersivity analysis.
- vi. Compactibility Factor testing

### **1.6.4 Cumulative Data Analysis and Report Compilation**

The investigation concluded with the compilation of a technical report detailing all methodology utilised during the phases of the investigation. This report includes a detailed potential evaluation of the pipeline route and is based on the results of the geotechnical investigation, with recommendations regarding matters such as construction, excavatability and material sourcing.

## 2 Description of the Environment

### 2.1 Project Location and Breakdown

The **study area** for this investigation falls within the central portions of the Limpopo Province of South Africa; approximately 50 km south-east of the City of Polokwane. On a more localised scale, the study area is located between the Lesetsi Rural Settlement and the town of Lebowakgomo (Figure 1).

The **site** in questions is comprised of the **~28.1 km** section of pipeline located between the Olifantspoort Water Treatment Works (WTW) and the Specon Reservoir. The **Olifantspoort WTW** marks the **starting point** of the route (nominally assigned chainage 0+000), whereafter the pipeline extends initially in a general NW direction for ~ 4.0 km (~4+000). Thereafter, the route turns towards a SW direction for a further ~2.2 km (~6+200), before turning into a WNW direction for the remaining ~21.9 km, terminating at the **Specon Reservoir** (~28+100).

Please note, an ~2.4 km length of the route between chainages of ~19+000 and ~21+400 had been assessed as an emergency section during a previous investigation. As such, this section of the route has been excluded from this investigation; and the corresponding report (*M-18-152-Specon Phase 2 Pipeline Replacement*) can be viewed for detailed findings across this section.

Furthermore, the site includes a short section of pipeline (~0.5 km) between the WTW and the facilities abstraction works situated along the Olifants River.

The proposed upgrades are planned to constitute a duplication of the existing bulk water line. The majority of the route runs alongside a network of gravel roads, allowing for suitable accessibility to plant and vehicles. However, isolated sections of the route (~3+640 to 6+400 and ~23+500 to 28+100) were seen to traverse either undeveloped land, farmland, or marsh land, resulting in slightly restrictive accessibility to plant and vehicles.

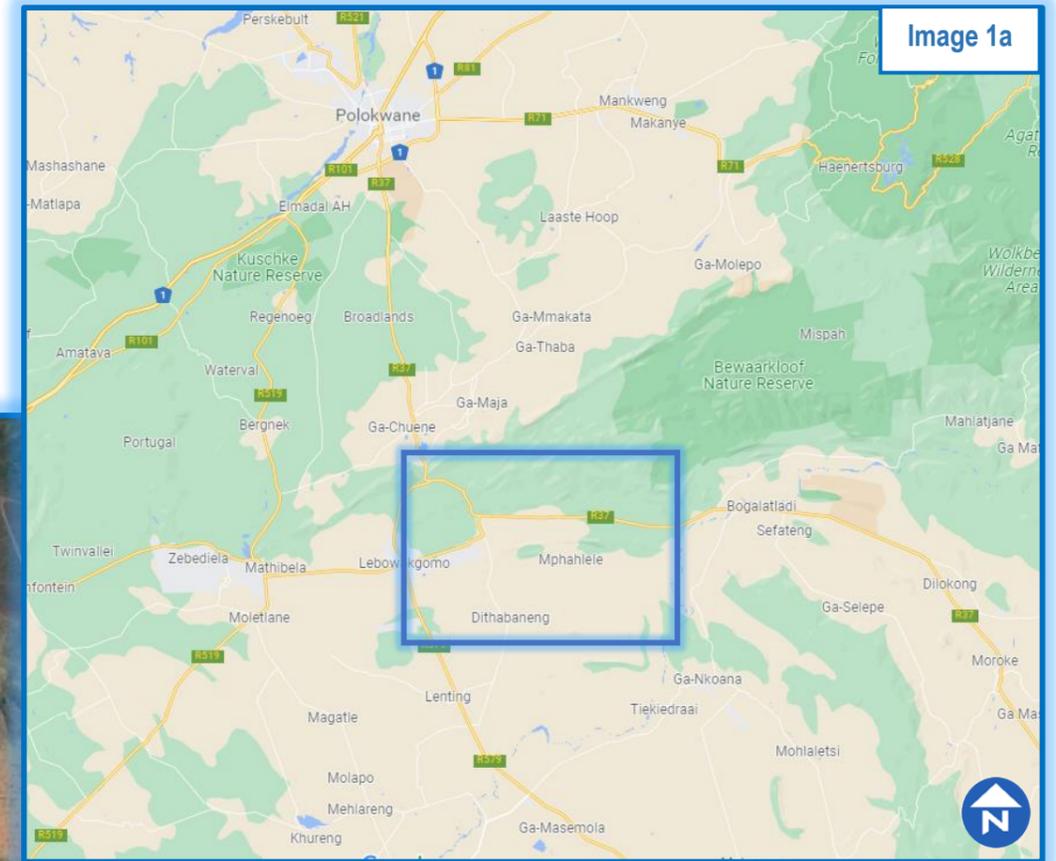
The site is roughly located at the following coordinates:

**Olifantspoort WTW (Route Start):**      **Latitude:** 24.303943° S **Longitude:** 29.511454° E

**Specon Reservoir (Route End):**      **Latitude:** 24.354009° S **Longitude:** 29.756573° E

Refer to Image 1 overleaf graphically delineating the extent of the development:

Image 1: Geographical Location and Breakdown of the Study Area (1a & 1b)



## 2.2 Topography

The regional setting is seen to display an overall uniform continuous landscape with the localised occurrence of prominent/distinct geomorphological features breaking the continuity.

Refer to Image 2 overleaf which graphically depicts the topography of the **site** and its' surroundings.

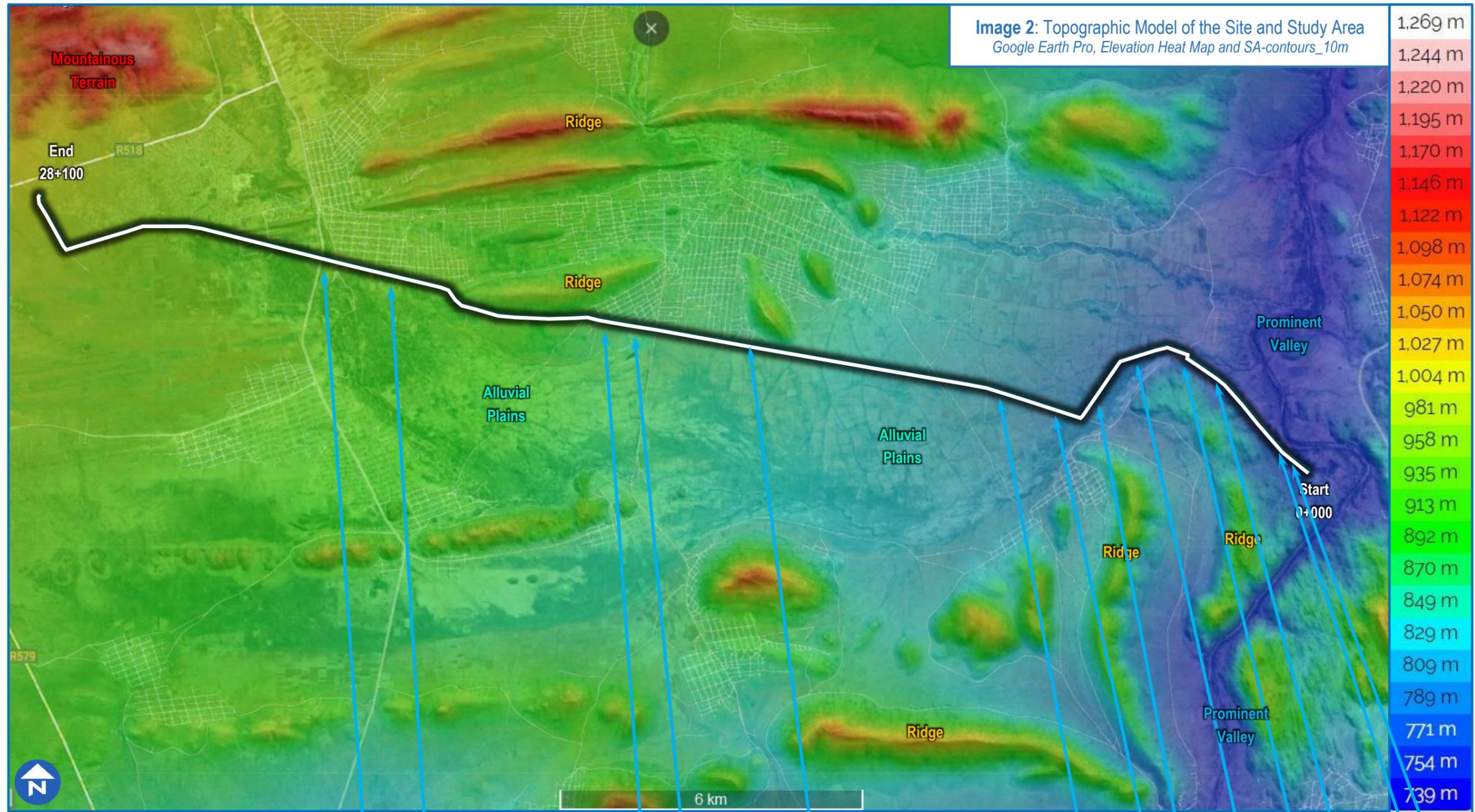
In general, the majority of the study area can be characterised by a **broad** and **near flat terrain** characteristic of an **alluvial plain**. This alluvial plain is seen to slope gradually in an easterly direction towards a **prominent valley landform** (dark blue colours in the image) located along the eastern edge of the study area. The overall uniform terrain is broken by the erratic occurrence of high-lying terrain units in the form of **ridge landforms**, as depicted by the elongated yellow to red colours in the image.

With reference to the image overleaf, the **site** is seen to start along the western flank of the prominent valley landform, extending in a general WNW direction across the alluvial plain. Furthermore, the various directional changes that the route takes are seen divert around the previously mentioned ridge landforms.

According to the available information (Google Earth Pro <sup>TM</sup>, SA-contours\_5m), and confirmed during the fieldwork phase of the investigation, the vast majority of the site traverses **very gentle sloping terrain**, with average measured slopes of **less than 2 degrees**.

The start of the route marks the lowest point, with an elevation of ~750 meters above mean sea level (mamsl); whereafter the road ascends along its length towards the end point of the site, at an elevation of ~1025 mamsl.

See Graphic 1 below depicting the change in elevation along the route of the pipeline.



## 2.3 Drainage

According to the available information, the initial ~1.82 km of the pipeline falls within the **B52E** Quaternary Catchment Area (Olifants River '*main stem*'), with the remaining sections of the pipeline falling within the **B52D** Quaternary Catchment Area; forming part of the greater Olifants Water Management Area.

The drainage character of the site will mirror its' topographic nature as described in the preceding section of this report, whereby the very gentle sloping nature of the sites' surface will result in **low energy surface run-off** (sheet-flow). Furthermore, surface water run-off is interpreted to flow in a general northerly to north westerly direction across the site.

The low energy surface run-off is interpreted to promote surface water **infiltration** into the underlying soils rather than rapid surface water flow. As such, the site may be subject to the periodic fluctuating moisture conditions within the subsoils, coupled with surface water ponding, following prolonged precipitation events.

According to the available information (Topocadastral Map 2329 DC- Figure 3), the site is seen to traverse a number of drainage features. The chainage and nature of these features are summarised as follows:

- D1 (~0+380) - non-perennial river
- D2 (~0+980) - non-perennial river
- D3 (~2+500) - non-perennial river
- D4 (~3+420) - perennial river - '*Tudumo River*'
- D5 (~4+650) - non-perennial river
- D6 (~5+800) - non-perennial river
- D7 (~6+360) - non-perennial river
- D8 (~7+820) - non-perennial river
- D9 (~12+950) - non-perennial river
- D10 (~15+440) - non-perennial river
- D11 (~16+100) - non-perennial river
- D12 (~20+340) - non-perennial river
- D13 (~21+360) - perennial river - '*Chunies River*'

In general, the non-perennial rivers were seen to be poorly defined, typically indistinctive/ undistinguishable from surface level.

## 2.4 Climate

Due to the sites' location, the climate is interpreted to be similar to that of Lebowakgomo, which receives about **548 mm** of rain per year, with most rainfall occurring during the **summer** months. It receives the lowest rainfall (3 mm) in July and the highest (109 mm) in December. The average midday temperatures for Mankweng range from 20.5°C in July to 28.9°C in February. The region is the coldest during July when the mercury drops to 5.8°C on average during the night.

According to Köppen and Geiger climate classification, the climate is classified as **Sub-Tropical Highland Climate (Cwb)** and **Temperate Interior (SANS 204-2)**.

**Climate** determines the mode and rate of **weathering**. The effect of climate on the weathering process (i.e. soil formation) can be assessed through a combination of the climatic N value defined by Weinert (1980), as well as the Peltier Diagram (Peltier, 1950). The **Climatic N-Value** (Weinert, 1980) for the area is deemed to be **between 3 and 4**; indicating that chemical disintegration of the parent rocks in the regional setting is deemed the principal mode of weathering. Furthermore, according average temperature and rainfall stats, the site falls within the "**very slight weathering**" category of the **Peltier diagram**. This mode of weathering favours soil formation, rather than an abundance of rocky fragments occurring within the soil matrix. Physical/mechanical disintegration of parent rock will take place but on a lower scale.

## 2.5 Regional Vegetation

The study area is located within the **Sekhukhune Plains Bushveld** Vegetation Unit (**SVcb 27**) of the Central Bushveld Bio-Region, within the greater *Savannah Biome* (Mucina and Rutherford; 2006). The vegetation within this region is characterised by a grassy ground layer and a distinct upper layer of woody plants.

### 3 Regional Geological and Hydrogeological Setting

#### 3.1 Regional Stratigraphic Setting

According to the available geological information (geological series map: 2428 Nylstroom); the study area is underlain by a range of igneous, metamorphic and sedimentary rocks. The initial sections are mapped to be underlain by large mafic intrusions constituting the Rustenburg Layered Suite of the Bushveld Igneous Complex. The remainder of the route is mapped to be underlain by a sequence of sedimentary and metamorphic rocks of the Pretoria Group, predominantly comprised of Quartzite, Hornfels and Shale (Figure 2).

The sequence of geological bodies mapped to underly the site is as follows:

- ~ 0+000 – 4+020: **Vg**- Gabbro, Norite or Anorthosite (Main Zone- RLS)
- ~ 4+020 – 11+390: **Vu**- Gabbro, Troctolite or Anorthosite (Upper Zone- RLS)
- ~11+390 – 12+530: **Vm**- Quartzite (Magaliesberg Formation)
- ~12+530 – 17+990: **Vc**- Pyroxenite, Anorthosite, Norite (Critical Zone- RLS)
- ~17+990 – 19+100: **Vm**- Quartzite (Magaliesberg Formation)
- ~19+100 – 23+010: **Vsi**- Hornfels, Shale, Limestone or Quartzite (Silverton Formation)
- ~23+010 – 24+110: **Vdq/Vst/Vdw**- Quartzite / Hornfels / sandy Shale (Pretoria Group)
- ~24+110 – 27+160: **Vt**- Shale, Hornfels, subordinate Shist (Timeball Hill Formation)
- ~27+160 – 27+470: **Vt**- Quartzite (Nooitgedacht Member of Timeball Hill Formation)
- ~27+470 – 28+100: **Vt**- Shale, Hornfels, subordinate Shist (Timeball Hill Formation)

With reference to the bedrock of the Bushveld Igneous Complex (BIC), these lithological bodies within the region were seen to be comprised of Gabbro.

Due to the close proximity of the BIC, the surrounding sedimentary and metamorphic bodies are interpreted to display a highly disturbed nature, likely hosting extensive jointing, hydrothermal veins and a higher degree of weathering. As such, it is predicted that highly variable bedrock, ranging from undisturbed competent rock to highly fractured and weathered incompetent rock, could be encountered.

At the contact points with the BIC or where other intrusions are present, it is predicted that the bedrock has undergone various degrees of contact metamorphism induced through the movement of hydrothermal fluids along joint planes or fault planes within the bedrock lithology.

The study area does not reflect any risk for the formation of sinkholes or subsidence's caused by the presence of water-soluble rocks (dolomite or limestone), and as such is not deemed "*dolomitic land*".

### 3.2 Prominent Geological Structures

According to the available information (geological series map: 2428 Nylstroom), the regional setting is seen to host a number of geological structures in the form of two ~NE-SW striking faults, as well as a ~NNW-SSE striking undifferentiated linear structure.

These features are mapped to traverse the site at the following chainages:

- F1: 4+020: concealed Fault
- F2: 11+390: concealed Fault- "*Wonderkop Fault*"
- L1: 21+630: Linear structure identified from aeromagnetic data

It must be noted that the localised presence of igneous intrusions can lead to the formation of micro-structures which could traverse other sections of the site i.e. feeder dykes and hydrothermal veins. These structures can affect the geotechnical properties of the in-situ bedrock.

### 3.3 Hydrogeological Setting

According to the available hydrogeological information (hydrogeological series map: 2326 Polokwane (2003)); the fractured rock mass underlying the study area at depth represents an **Intergranular and Fractured Aquifer** where groundwater rest levels occurs within both the fractures of the bedrock as well as between grains of the intact rock. Seepage through the rock mass is mainly controlled by secondary porosity comprised of the discontinuities such as joints and faults.

For the **initial ~18.0 km** the published borehole yields are **between 0.5 and 2.0 l/s**, with the remaining **~10.1 km** mapped as between **2.0 and 5.0/s**. The groundwater quality is deemed to be between **0 and 300 mS/m** (electrical conductivity range).

According to the available information, large scale groundwater abstraction does not take place within the study area.

### 3.4 Seismic Risk

According to **Kijko et al (2003)** the regional seismic hazard in the project area can be defined as **LOW**, exhibiting a 10% probability of a seismic event with a peak ground acceleration of less than 0.05 for natural events, and between 0.075 and 0.10 for mining related events, within a period of 50 years.

## 4 Geotechnical Setting

Note: this description is based on field observations and does **not** reflect the results of any laboratory tests.

A total of 105 test pits (TP1 to TP105) were conducted along the length of the site at regular intervals (~4 per km). Each of the test pits were excavated by means of a TLB-type light mechanical excavator to a target depth of 2.5 m or refusal/difficult excavations conditions.

Test pit locations can be viewed in Figure 5 to Figure 8 and detailed soil profile logs are presented in **Appendix A**.

### 4.1.1 Generalised Site Character

The site was seen to display highly contrasting geotechnical conditions along the length of the pipeline route; however, these conditions were seen to correlate well with the position relative to the previously mentioned geomorphological features.

The final segmentation was based on the general material successions, geomorphological features and excavatability:

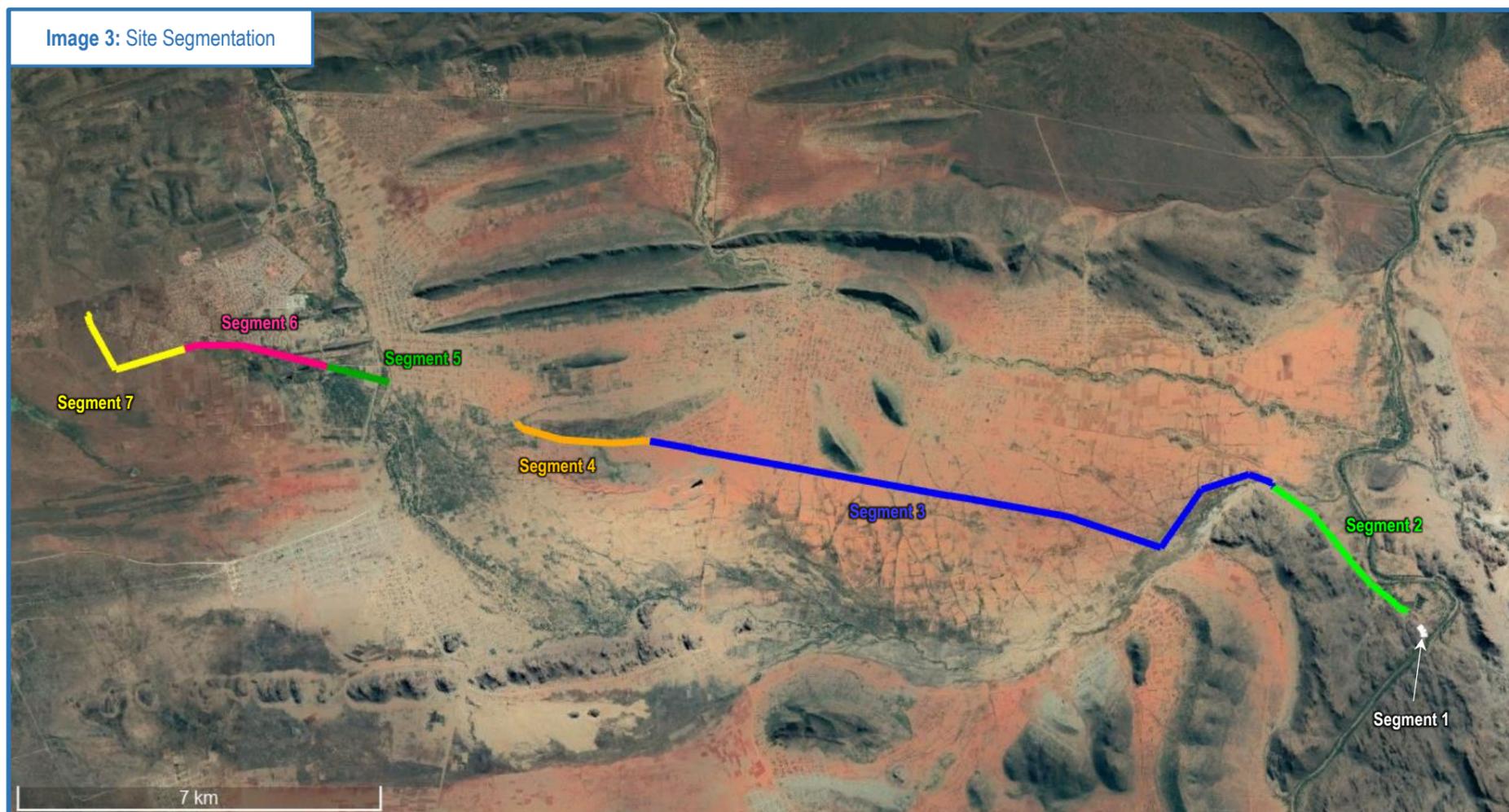
Segment 1	Chainage	WTW to abstraction works (0+000 to 0+500)
Segment 2	Chainage	0+000 to 3+550
Segment 3	Chainage	3+550 to 16+420
Segment 4	Chainage	16+420 to 19+065
Segment 5	Chainage	21+660 to 22+880
Segment 6	Chainage	22+880 to 25+675
Segment 7	Chainage	25+675 to 28+100

The final segmentation is summarised in the tables and images overleaf.

Table 1: Site Segmentation Breakdown



Segment	Chainage	Test Pits	General Geotechnical Character
1	0+000 to 0+500 (WTW to abstraction Works)	TP1 & TP2	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Initial Section: thick alluvial deposit with thin layer of backfill material</li> <li>- Final section: backfill → alluvium → Gabbro bedrock</li> </ul> </li> <li>• <u>Excavatability:</u> <ul style="list-style-type: none"> <li>- <b>Initial</b> Section: <b>good</b> excavatability to 2.5 m</li> <li>- <b>Final</b> section: <b>poor</b> excavatability to 2.5 m (shallow bedrock)</li> </ul> </li> <li>• Groundwater predicted to perch on bedrock along final section</li> <li>• Very gentle sloping surface</li> <li>• Easy accessibility to plant and vehicles</li> </ul>
2	0+000 to 3+550	TP3 to TP16	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Initial Section: alluvium <u>or</u> hillwash → Gabbro bedrock</li> <li>- Middle Section: alluvium (calcified at depth) <u>or</u> Hillwash → residual Gabbro <u>or</u> Calcified Residual Gabbro</li> <li>- Final section: hillwash → Gabbro bedrock</li> </ul> </li> <li>• <b>Overall Poor Excavatability</b> to 2.5 m, due to <b>very dense</b> residual soils and <b>bedrock</b></li> <li>• <b>Localised</b> occurrence of <b>groundwater</b> seepage (TP4) from a depth of <b>~0.90 m</b> below EGL</li> <li>• Perching of infiltrating groundwater on bedrock</li> <li>• Very gentle sloping surface</li> <li>• Easy accessibility to plant and vehicles, with the exception of localised farm boundaries.</li> </ul>
3	3+550 to 16+420	TP17 to TP67	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Thick alluvial deposits</li> <li>- Calcified alluvium, present as nodular and/or concretionary Calcrete</li> <li>- Ferruginised alluvium along final sections</li> <li>- Localised calcified residual Gabbro</li> <li>- Localised occurrence of hardpan Calcrete</li> </ul> </li> <li>• <u>Excavatability:</u> <ul style="list-style-type: none"> <li>- <b>Initial</b> section: <b>moderate</b> to <b>good</b> excavatability to 2.5 m</li> <li>- <b>Middle</b> section: <b>poor</b> to <b>moderate</b> excavatability to 2.5 m- due to very dense soils and/or hardpan Calcrete</li> <li>- <b>Final</b> section: overall <b>good</b> excavatability to 2.5 m</li> </ul> </li> <li>• Groundwater predicted to perch on hardpan Calcrete</li> <li>• Very gentle sloping surface</li> <li>• <b>Slight accessibility issues</b> along initial section- undeveloped land &amp; farm boundaries</li> </ul>

**Table 2: Site Segmentation Breakdown Cont.**

Segment	Chainage	Test Pits	General Geotechnical Character
4	16+420 to 19+065	TP68 to TP78	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Alluvium (initial section) or hillwash (remaining sections)</li> <li>- Residual Quartzite</li> <li>- Calcified and/or ferruginised residual Quartzite</li> </ul> </li> <li>• Localised bedrock (TP70 &amp; TP78) and hardpan Calcrete (TP75)</li> <li>• <b>Poor excavatability</b> to 2.5 m- as a result of very dense soils, bedrock and/or hardpan Calcrete</li> <li>• Groundwater predicted to perch on bedrock and hardpan Calcrete</li> <li>• Very gentle sloping surface</li> <li>• Easy accessibility to plant and vehicles</li> </ul>
5	21+660 to 22+880	TP79 to TP83	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Thick sequence of alluvial deposits</li> <li>- Localised deposits were altered (calcified) at depth</li> </ul> </li> <li>• Localised sidewall instabilities were encountered (TP79)</li> <li>• <b>Good excavatability</b> to 2.5 m</li> <li>• Very gentle sloping surface</li> <li>• Easy accessibility to plant and vehicles</li> </ul>
6	22+880 to 25+675	TP84 to TP94	<ul style="list-style-type: none"> <li>• <u>Two Generalised Material Successions were encountered:</u> <ul style="list-style-type: none"> <li>- Alluvium and/or calcified/ferruginised alluvium, followed by abrupt refusal on hardpan Calcrete/Ferricrete</li> <li>- Hillwash underlain by residual Quartzite (ferruginised within isolated locations)</li> <li>- Isolated occurrence (TP86) of residual Hornfels</li> </ul> </li> <li>• <b>Overall poor excavatability</b> to 2.5 m, due to hardpan Calcrete/Ferricrete and very dense residual soils</li> <li>• Localised <b>groundwater seepage</b> from between <b>0.60 and 2.20 m</b> below EGL</li> <li>• Perching of infiltrating groundwater on hardpan Calcrete/Ferricrete</li> <li>• Very gentle sloping surface</li> <li>• <b>Slight accessibility issues</b>- undeveloped land, marshy areas &amp; farm boundaries</li> </ul>
7	25+675 to 28+100	TP95 to TP105	<ul style="list-style-type: none"> <li>• <u>Generalised Material Succession:</u> <ul style="list-style-type: none"> <li>- Thick scree deposits</li> <li>- Isolated occurrence (TP100) of residual Quartzite underlying the scree deposits</li> </ul> </li> <li>• <b>Localised</b> occurrence of <b>bedrock</b> at depth (TP95 &amp; TP105)</li> <li>• Groundwater predicted to perch on the bedrock</li> <li>• <b>Moderate to good</b> excavatability to 2.5 m</li> <li>• Very gentle sloping surface</li> <li>• <b>Slight accessibility issues</b>- farm and residential boundaries</li> </ul>

#### 4.1.2 Segment 1

##### WTW to abstraction works (TP1 & TP2)

Segment 1 was seen to be underlain by transported material, of variable thickness, deemed to be **alluvium**. Thereafter, these transported soils were further underlain by a jointed **Gabbro rock-mass**. In addition, the surface was blanketed by anthropogenic material deemed to be **backfill**, likely dumped during initial construction of the existing infrastructure present across this segment.

##### Backfill

- Occurrence: entire segment.
- Depth Range: from surface to between ~0.15 and 0.5 m below EGL.
- General Description: *slightly MOIST; light BROWN; LOOSE; structureless; sub-angular silty sandy GRAVEL or silty SAND with minor sub-angular gravel & cobbles.*

##### Alluvium

- Occurrence: entire site.
- Depth Range: from below backfill material to between ~0.80 and 2.50 m below EGL.
- Thickness: variable thickness ranging between ~0.30 and 2.35 m
- General Description: *slightly MOIST; light and dark BROWN; LOOSE or medium DENSE; PINHOLED; silty SAND; traces of roots.*
- Comments: the material was seen to thicken out in a south-easterly direction towards the river.

##### Gabbro Rock-Mass

- Occurrence: final section (TP2).
- Depth Range: from below alluvium to the final excavation depth of ~0.90 m below EGL, at which point refusal was encountered.
- Exposed thickness: ~0.10 m
- General Description: *light GREY speckled black; SLIGHTLY Weathered; COARSE-grained; SLIGHTLY Fractured with no infilling; HARD Rock; Rustenburg Layered Suite GABBRO.*

### 4.1.3 Segment 2

TP3 to TP16 (0+000 to 3+550)

Segment 2 of the proposed new pipeline was seen to be underlain various material horizons and successions.

In general, the segment was underlain by transported soils deemed to be either **alluvium** or colluvial deposits deemed to be **scree**. Some of the alluvial deposits were **reworked** at depth through pedogenic processes, namely **calcification** of the original deposit.

Along the **middle sections**, the transported soils were underlain by material deemed to be **residual Gabbro**. Some of these horizons have also undergone **calcification** to various degrees, with this material being present as a **calcified residual Gabbro**.

Across the majority of the segment, the various material horizons were further underlain by a **Gabbro rock-mass**. Furthermore, along localised sections, the Gabbro rock-mass was seen to be weathered, with the occurrence of a capping of **completely weathered Gabbro**. In addition, bedrock outcrops were encountered along the middle sections of the segment.

It should be noted that a single location within the vicinity of the WTW was blanketed by **anthropogenic soils** (i.e. human origin). Due to their shallow and isolated occurrence, these soils have been excluded from the generalised succession discussed to follow.

Across the entire segment, **refusal** was encountered at depths of between **0.65 and 2.0 m** below EGL, due to the occurrence of **bedrock** and/or **very dense soils**.

#### Scree

- Occurrence: along final sections.
- Depth Range: from surface to between ~0.40 and 1.55 m below EGL.
- Thickness: variable thickness ranging between ~0.40 and 1.55 m
- General Description: *slightly MOIST; light and dark BROWN; LOOSE or medium DENSE; structureless; sub-rounded silty sandy GRAVEL with minor to abundant sub-rounded cobbles and trace to minor amounts of boulders; minor to abundant roots.*

#### Alluvium

- Occurrence: sporadic occurrence.
- Depth Range: from surface to between ~0.20 and 0.90 m below EGL.
- Thickness: variable thickness ranging between ~0.20 and 0.90 m
- General Description: *slightly MOIST to MOIST; light BROWN or orangey BROWN; LOOSE or medium DENSE; structureless; silty SAND or clayey SAND; minor roots.*
- Comments: within a single location (TP4) the material hosted large boulders

### **Calcified Alluvium**

- Occurrence: isolated locations (TP9 & TP13).
- Depth Range: from below alluvium to between ~0.80 and 1.10 m below EGL.
- Thickness: ~0.60 m
- General Description: *slightly MOIST to MOIST; dark orangey BROWN mottled white; light GREY mottled white; medium DENSE; structureless; clayey SAND with traces of sub-angular gravel or sub-rounded silty sandy GRAVEL with minor rounded cobbles & boulders; abundant Calcrete nodules.*

### **Residual Gabbro**

- Occurrence: single location (TP12).
- Depth Range: from below scree to the final excavation depth of ~1.70 m below EGL.
- Thickness: ~1.10 m
- Description: *slightly MOIST; light and dark greenish GREY blotched dark brown; DENSE; RELICT Gneissose & Jointing; sub-angular silty sandy GRAVEL.*

### **Calcified Residual Gabbro**

- Occurrence: middle section.
- Depth Range: from below previous horizons to between ~1.20 and 1.70 m below EGL.
- Exposed thickness: average ~0.64 m
- General Description: *slightly MOIST; dark orangey BROWN mottled black & white, speckled black; light greyish BROWN mottled & blotched white, speckled black; pinkish BROWN mottled & blotched white, speckled black; DENSE to very DENSE with an increase in depth; PINHOLED or structureless; silty SAND with minor sub-angular gravel or angular silty sandy GRAVEL with minor angular cobbles & traces of angular boulders; minor to abundant Calcrete nodules.*
- Comments: the Calcrete nodules provide evidence for fluctuating moisture conditions and/or prolonged periods of saturation.

### **Completely Weathered Gabbro**

- Occurrence: sporadic occurrence.
- Depth Range: from below alluvium and/or scree to the final excavation depths of between ~0.95 and 2.0 m below EGL.
- Exposed thickness: between ~0.30 and 0.70 m
- General Description: *slightly MOIST; light pinkish GREY mottled & blotched white, speckled black; DENSE to very DENSE with an increase in depth; RELICT Jointing; angular silty sandy GRAVEL with minor angular cobbles; localised rock pockets.*

### **Gabbro Rock-Mass**

- Occurrence: majority of the segment (excl. TP10 to TP12 & TP16).
  - Note that the rock-mass could only be partially excavated within a single location (TP5). Across the remaining lengths, the rock-mass was encountered at the base of the excavations.
  - Within a single location (TP8), the bedrock was encountered from the surface.
- Depth Range: encountered from the surface and depths of between ~0.60 and 2.0 m below EGL.
- General Description: *light GREY mottled black & grey, stained red; MODERATELY Weathered with completely weathered pockets; COARSE-grained; SLIGHTLY Fractured & very SLIGHTLY Jointed; HARD Rock with medium hard pockets; Rustenburg Layered Suite GABBRO.*

#### **4.1.4 Segment 3**

TP17 to TP67 (3+550 to 16+420)

The entire segment was underlain by thick transported soils deemed to be **alluvium**. These alluvial deposits were transformed at depth through various **pedogenic processes**, in the form of various degrees of **ferruginisation** and **calcification**. The resulting material horizons were present as either **calcified alluvium**, **nodular Calcrete**, and/or **ferruginised alluvium**. Within isolated locations, material deemed to be **hardpan Calcrete** was encountered at the base of the excavations. Within two isolated locations, the alluvial deposits were underlain by material deemed to be **calcified residual Gabbro**.

Along the **initial to middle sections** (TP17 to TP46), majority of the excavations were terminated at depths of between **0.50 and 2.15 m** below EGL, due to **difficult excavation conditions** in **very dense calcified soils** or **refusal on hardpan Calcrete** and/or very dense calcified soils. Localised excavations reached the target depth of 2.50 m.

Along the **final section** (TP47 to TP67), **majority** of the excavations reached the target depth of **2.50 m** below EGL. **Localised** excavations encountered **refusal on very dense calcified or ferruginised soils**, at depths of between **1.35 and 2.0 m** below EGL.

### **Alluvium**

- Occurrence: entire segment.
- Depth Range: from surface to between ~0.35 and 2.60 m below EGL.
- Thickness: variable thickness ranging between ~0.35 and 2.60 m (average ~1.05 m)
- General Description: DRY to *MOIST*; *light and dark BROWN*; *brownish ORANGE*; *dark brownish RED*; *orangey and reddish BROWN (variable colour profile)*; *LOOSE or medium DENSE*; *structureless or PINHOLED*; *silty SAND or clayey SAND*; *minor to abundant roots*.
- Comments: localised horizons hosted trace to minor amounts of gravel and Calcrete nodules.

### **Calcified Alluvium**

- Occurrence: majority of the segment.
- Depth Range: below alluvium to between ~1.25 and 2.60 m below EGL (variable vertical extent).
- Thickness: variable thickness ranging between ~0.20 and 1.70 m (average ~0.94 m)
- General Description: *slightly MOIST to MOIST; light brownish ORANGE mottled & blotched light grey; LOOSE to DENSE (variable in-situ consistency); structureless or PINHOLED; angular to sub-angular silty sandy GRAVEL or silty SAND with minor sub-angular gravel; abundant Calcrete nodules & minor concretions.*
- Comments: localised deposits were also seen to have undergone minor ferruginisation, with the occurrence of Ferricrete nodules.

### **Nodular Calcrete**

- Occurrence: majority of the segment.
- Depth Range: below alluvium to between ~0.50 and 2.80 m below EGL (variable vertical extent).
- Thickness: variable thickness ranging between ~0.30 and 2.20 m (average ~0.70 m)
- General Description: *DRY to slightly MOIST; light orangey and pinkish BROWN mottled & blotched light grey; LOOSE to DENSE (variable in-situ consistency); structureless; angular to sub-angular silty sandy GRAVEL with trace to minor amounts of sub-angular cobbles; abundant Calcrete nodules & minor concretions.*
- Comments: localised deposits were also seen to have undergone minor ferruginisation, with the occurrence of Ferricrete nodules.

### **Ferruginised Alluvium**

- Occurrence: localised locations across the segment.
- Depth Range: from below alluvium to between ~0.70 and 2.50 m below EGL (variable vertical extent).
- Thickness: variable thickness ranging between ~0.10 and 1.60 m (average ~0.25 m- excl. outliers)
- Description: *DRY to slightly MOIST; orangey BROWN mottled black & red; light brownish ORANGE mottled black & red; LOOSE or very DENSE; PINHOLED or structureless; angular to sub-angular clayey sandy GRAVEL or sub-angular sandy silty GRAVEL or clayey SAND with minor sub-angular to sub-rounded gravel; abundant Ferricrete nodules and minor concretions.*
- Comments: localised deposits were also seen to have undergone minor calcification, with the occurrence of Calcrete nodules.

### **Calcified Residual Gabbro**

- Occurrence: isolated locations (TP25 & TP30).
- Depth Range: from below abovementioned horizons to between ~2.25 and 2.40 m below EGL.
- Exposed thickness: between ~0.90 and 1.40 m
- General Description: *slightly MOIST to MOIST; light orangey BROWN mottled black & white; reddish BROWN mottled white, blotched grey; DENSE; PINHOLED or structureless; sub-angular silty sandy GRAVEL; minor Calcrete nodules.*
- Comments: the material has also undergone minor ferruginisation, with the occurrence of Ferricrete nodules.

#### **4.1.5 Segment 4**

TP68 to TP78 (16+420 to 19+065)

The majority of the segment was underlain by transported soils deemed to be either **alluvium** or various colluvial deposits; comprised of either a fine-grained **Hillwash** and/or a coarse-grained **Talus**.

These transported soils were underlain by material deemed to be **residual Quartzite**. Some of these horizons have also undergone a degree of **calcification** and **ferruginisation**, with these materials being present as a **calcified** and **ferruginised residual Quartzite**.

Along the final sections, the surface was blanketed by **anthropogenic soil** deemed to be **backfill**, likely dumped during initial construction of the existing pipeline.

Across isolated sections, the various material horizons were further underlain by either **Quartzite rock-mass** and/or **hardpan Calcrete**.

Across the majority of the segment, **refusal** was encountered at depths of between **1.10 and 2.20 m** below EGL, due to the occurrence of either **bedrock**, **hardpan Calcrete** and/or **very dense residual soils**.

### **Backfill**

- Occurrence: final section (TP75 to TP78).
- Depth Range: from surface to between ~0.45 and the final excavation depths of between ~1.35 and 2.50 m below EGL.
- Thickness: variable thickness ranging between ~0.45 and 2.50 m
- General Description: *MOIST; dark BROWN; dark reddish BROWN; LOOSE or medium DENSE; structureless; sub-angular to sub-rounded sandy clayey GRAVEL with trace to minor amounts of sub-rounded cobbles & boulders.*
- Comments: localised excavations hosted refuse & building rubble.

### **Alluvium**

- Occurrence: start of segment (TP68 & TP69).
- Depth Range: from surface to between ~0.90 and 1.55 m below EGL.
- Thickness: between ~0.90 and 1.55 m
- General Description: *slightly MOIST to MOIST; dark BROWN or dark brownish RED; LOOSE or medium DENSE; structureless or PINHOLED; clayey SAND; traces of roots.*

### **Hillwash & Talus**

- Occurrence: middle section (TP70 to TP74).
- Depth Range: from surface to between ~0.20 and 1.15 m below EGL.
- Thickness: ranging between ~0.20 and 1.15 m.
- General Description: *MOIST; dark reddish BROWN; LOOSE; structureless or PINHOLED; clayey SAND with minor sub-rounded gravel or sub-rounded clayey sandy GRAVEL with trace to minor amounts of sub-rounded cobbles and boulders; trace to abundant amounts of roots.*

### **Residual Quartzite**

- Occurrence: initial to middle sections.
- Depth Range: from below alluvium or hillwash/Talus to between ~0.80 and 2.20 m below EGL.
- Thickness: variable thickness ranging between ~0.20 and 1.30 m
- Description: *slightly MOIST; orangey BROWN; LOOSE to medium DENSE; structureless; sub-rounded clayey sandy GRAVEL; minor roots.*
- Comments: localised deposits also hosted traces of Calcrete and Ferricrete nodules.

### **Calcified Residual Quartzite**

- Occurrence: isolated locations (TP68 & TP71).
- Depth Range: from below alluvium or residuum to the final excavation depth of ~1.85 m below EGL.
- Exposed thickness: between ~0.20 and 0.30 m
- General Description: *slightly MOIST; light orangey and greyish BROWN; medium DENSE or very DENSE; structureless; sub-angular sandy silty GRAVEL or clayey sandy GRAVEL; abundant Calcrete nodules.*

### **Ferruginised Residual Quartzite**

- Occurrence: middle sections (TP70 & TP72 to TP74).
- Depth Range: from below Talus or residuum to the final excavation depths of between ~1.10 and 1.55 m below EGL.
- Exposed thickness: between ~0.20 and 0.50 m
- General Description: *slightly MOIST; dark reddish BROWN mottled black; very DENSE; PINHOLED & VOIDED; sub-angular clayey sandy GRAVEL; abundant Ferricrete nodules.*

### **Quartzite Rock-Mass**

- Occurrence: end of segment (TP78).
- Depth Range: from below backfill to the final excavation depth of ~1.65 m below EGL.
- Exposed thickness: ~1.20 m
- General Description: *light GREY stained red & orange; SLIGHTLY Weathered with moderately and completely weathered pockets; COARSE-grained; HIGHLY Jointed & MODERATELY Fractured with a clayey sandy gravel infilling (1-10mm); HARD to very HARD; Magaliesberg Formation QUARTZITE; abundant roots along joint & fracture surfaces.*
- Comments: The Quartzite rock-mass was also encountered at the base of test pit TP70.

## **4.1.6 Segment 5**

TP79 to TP83 (21+660 to 22+880)

The entire segment was underlain by thick transported soils deemed to be **alluvium**. Localised deposits were transformed at depth through **pedogenic processes**, in the form of **calcification**. The resulting material horizon was present as a **calcified alluvium**.

Across the entire segment, the excavations reached the target depth of **2.50 m** below EGL.

### **Alluvium**

- Occurrence: entire segment.
- Depth Range: from surface to between ~0.70 and the final excavation depth of ~2.50 m below EGL.
- Thickness: between ~0.70 and 2.50 m
- General Description: *MOIST; light and dark greyish BROWN; very LOOSE to LOOSE; structureless; silty SAND or clayey SAND; trace to minor amounts of roots.*
- Comments: within a single location (TP79) excessive sidewall collapse was encountered due to the occurrence of very loose deposits.

### **Calcified Alluvium**

- Occurrence: single location (TP83).
- Depth Range: below alluvium to final excavation depth of ~2.40 m below EGL.
- Thickness: ~1.80 m
- General Description: *slightly MOIST to MOIST; greyish and orangey BROWN mottled and blotched orange & grey; medium DENSE; structureless or PINHOLED; silty SAND with traces of sub-angular gravel or angular sandy silty GRAVEL; minor to abundant Calcrete nodules & minor concretions.*

#### **4.1.7 Segment 6**

TP84 to TP94 (22+880 to 25+675)

In general, the segment was underlain by transported soils deemed to be **alluvium**. Some of the alluvial deposits were **reworked** at depth through pedogenic processes, namely **calcification** and **ferruginisation** of the original deposit. Within a single location, transported soils deemed to be **scree** and **hillwash** was encountered from the surface

Along localised sections, material deemed to be **residual Quartzite** was encountered from below the alluvium or backfill (discussed below). Some of the residual deposits have undergone **calcification** to various degrees, with this material being present as a **calcified residual Quartzite**.

The scree and hillwash were further underlain by material deemed to be **residual Hornfels**. Localised sections of the segment were also blanketed by a thin layer of **anthropogenic soils** (i.e. human origin). Due to their isolated occurrence and limited vertical extent, the residual Hornfels and anthropogenic soils have been **excluded** from the generalised material succession.

The majority of segment was further underlain by a hard and indurated material deemed to be **hardpan Calcrete/Ferricrete**. In addition, **groundwater** was seen to **perch** on the hardpan material along localised sections.

Across the majority of the segment, **refusal** was encountered at depths of between **0.60 and 2.20 m** below EGL, due to the occurrence of **hardpan Calcrete/Ferricrete** and/or **very dense residual soils**.

### **Scree & Hillwash**

- Occurrence: single location (TP86)
- Depth Range: from surface to ~2.05 m below EGL.
- Thickness: ~2.05 m
- Description: *MOIST; dark reddish BROWN; LOOSE or medium DENSE; structureless; clayey SAND with traces of sub-rounded gravel (Hillwash) or COBBLES & BOULDERS in a clayey sandy gravel matrix (Scree); abundant roots.*

### **Alluvium**

- Occurrence: majority of the segment.
- Depth Range: from surface or below backfill to between ~0.50 and 1.30 m below EGL.
- Thickness: variable thickness ranging between ~0.30 and 1.10 m
- General Description: *very MOIST with wet pockets; dark greyish BROWN; LOOSE; structureless; clayey SAND; trace to abundant amounts of roots.*
- Comments: within a single location (TP88) the material hosted large boulders

### **Calcified & Ferruginised Alluvium**

- Occurrence: localised (TP91 & TP92).
- Depth Range: from below alluviums to the final excavation depths of between ~1.95 and 2.50 m below EGL.
- Thickness: between ~0.95 and 1.20 m
- General description: *MOIST; dark brownish RED mottled black & white; medium DENSE to DENSE with an increase in depth; structureless; angular to sub-rounded sandy clayey GRAVEL; minor to abundant Calcrete and/or Ferricrete nodules.*
- Comments: these material horizons were calcified and ferruginised to varying degrees

### **Residual Quartzite & Ferruginised Residual Quartzite**

- Occurrence: sporadic occurrence.
- Depth Range: from below previous horizons to final excavation depths of between ~0.95 and 2.20 m below EGL.
- Exposed thickness: between ~0.3 and 1.70 m
- General Description: *MOIST; dark reddish BROWN mottled black; DENSE to very DENSE with an increase in depth; structureless; clayey SAND with minor gravel, cobbles & large boulders or sub-angular clayey sandy GRAVEL with abundant cobbles and traces of boulders; abundant roots & Ferricrete nodules.*

#### 4.1.8 Segment 7

TP95 to TP105 (25+675 to 28+100)

The entire segment was underlain by thick transported soils deemed to be of a **colluvial origin**. These materials were present as a finer-grained upper **Hillwash** followed by a lower gravelly and cobbly **Scree**.

Localised sections of the segment were also blanketed by a thin layer of **anthropogenic soils** (i.e. human origin). Due to their isolated occurrence and limited vertical extent, soils have been **excluded** from the generalised material succession.

Across isolated sections (**TP95 & TP103**), **bedrock** was encountered at the base of the excavations, at a depth of **~2.20 m** below EGL.

Across the majority of the segment, **refusal** or **difficult excavation conditions** were encountered at depths of between **~1.95 and 2.20 m** below EGL, due to the occurrence of **bedrock** or **very dense and gravelly soils**.

##### Hillwash

- Occurrence: initial section (TP95 to TP98)
- Depth Range: from surface to between ~0.30 and 0.70 m below EGL.
- Thickness: between ~0.25 and 0.45 m
- Description: *DRY or MOIST; dark reddish BROWN; medium DENSE; structureless or PINHOLED; clayey SAND with traces of sub-rounded gravel (Hillwash); minor to abundant roots.*

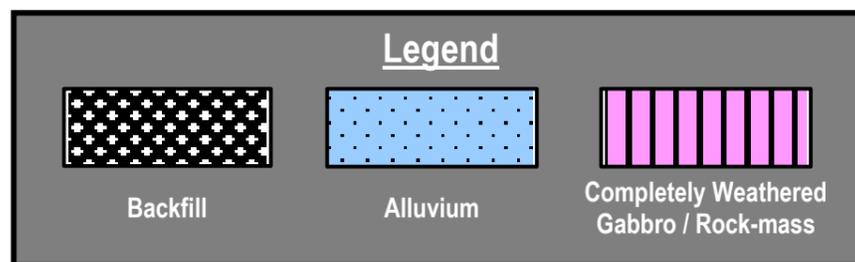
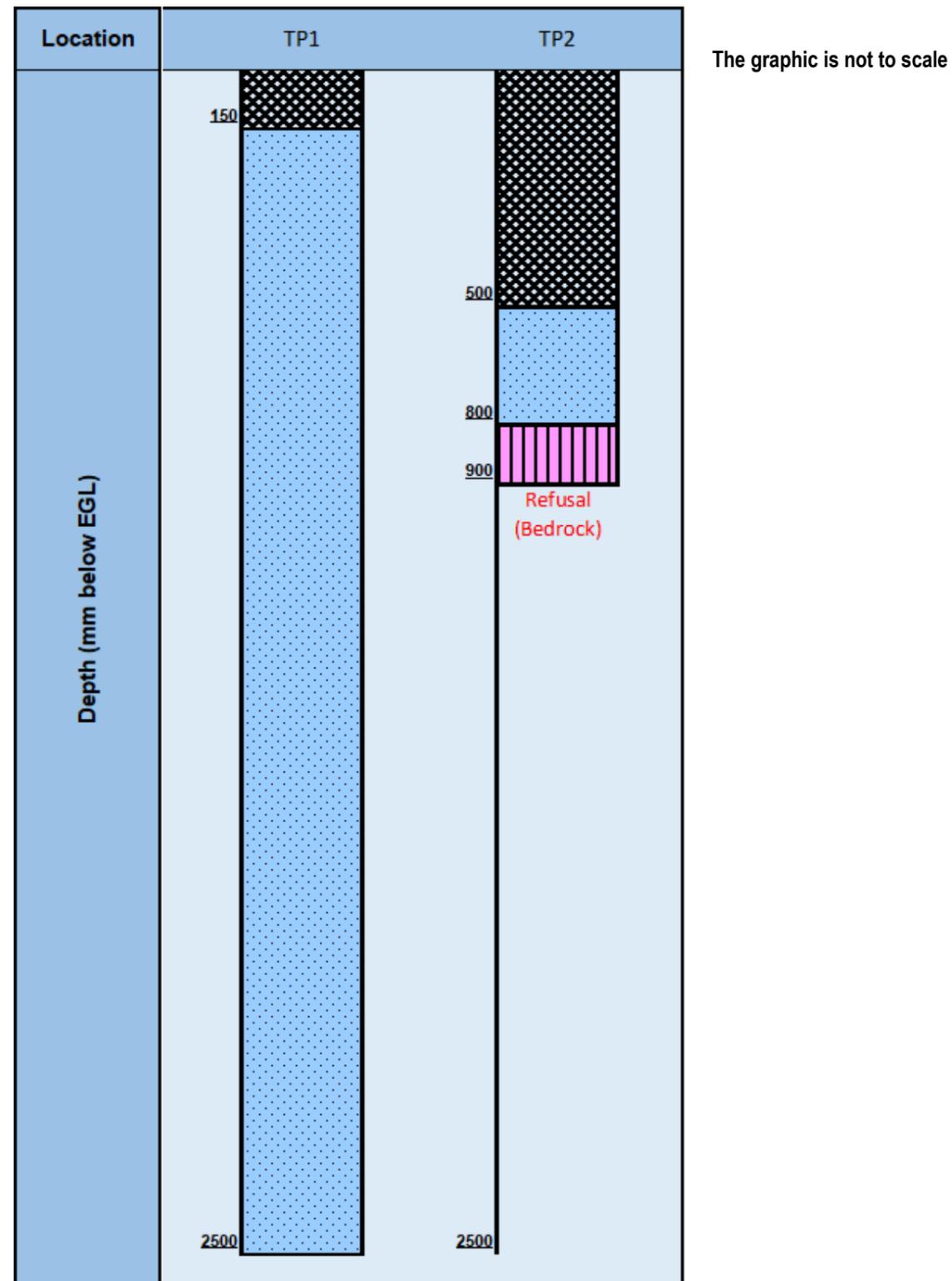
##### Scree

- Occurrence: entire segment.
- Depth Range: from surface or below hillwash to final excavation depths of between ~1.90 and 2.50 m below EGL.
- Thickness: variable thickness ranging between ~1.50 and 2.50 m
- General Description: *DRY; light reddish BROWN; LOOSE or medium DENSE; structureless; sub-angular silty sandy GRAVEL with abundant cobbles and minor boulders; abundant roots.*

#### 4.1.9 Summarised Material Succession

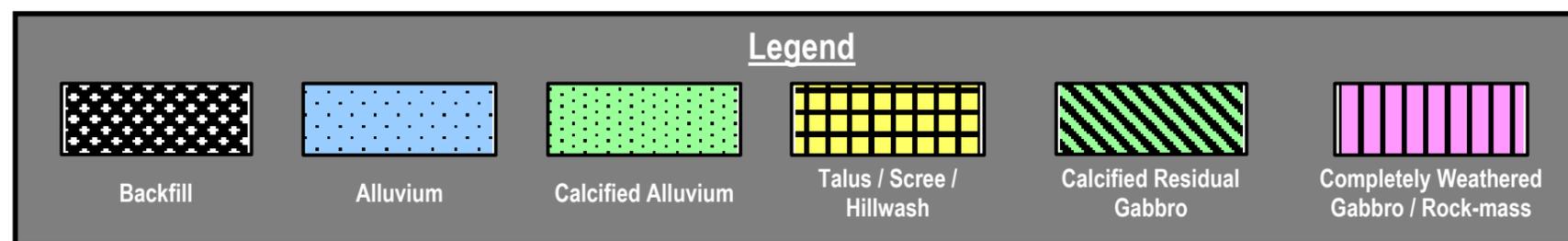
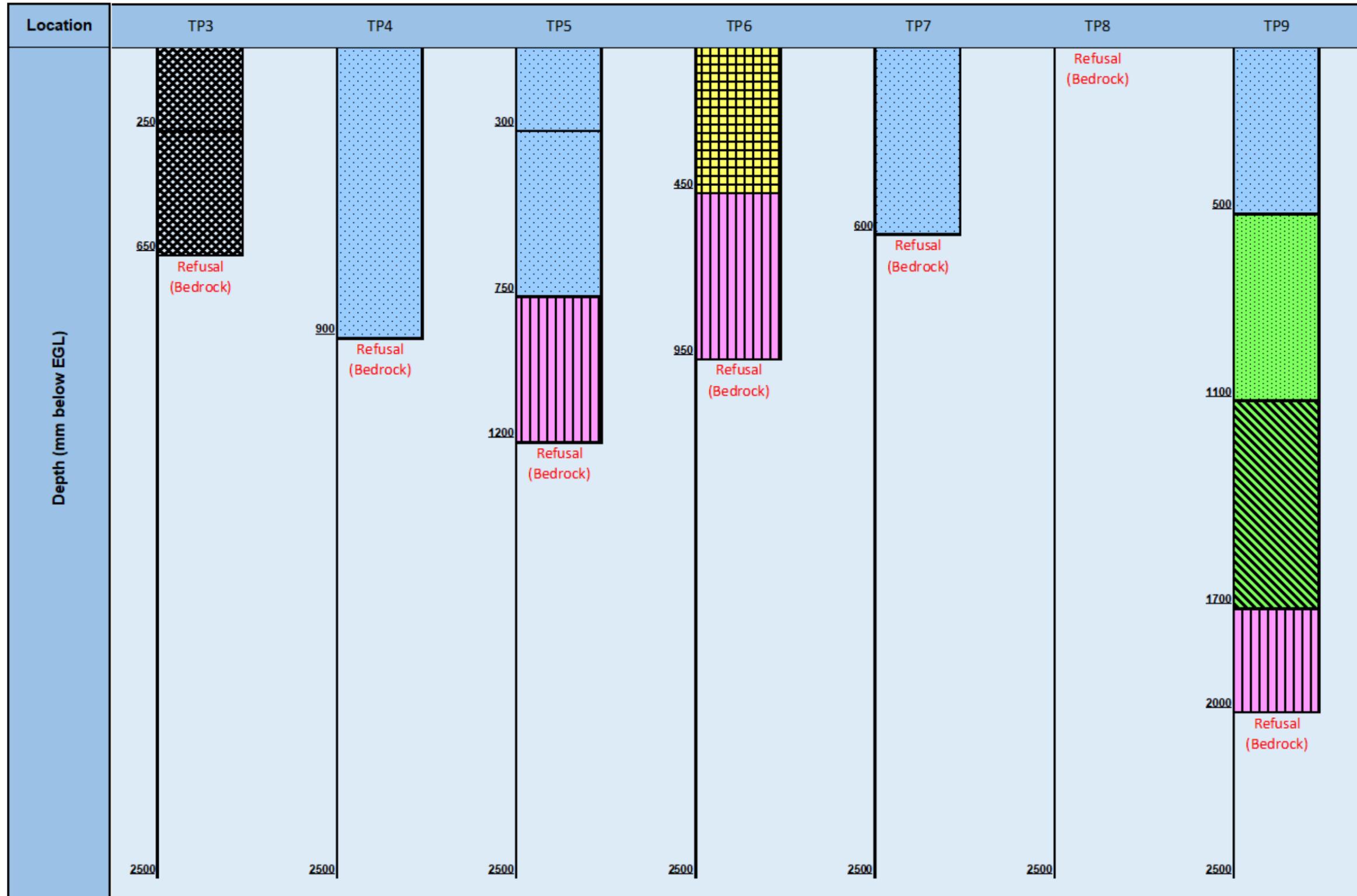
The graphics to follow serve as a visual summary of the occurrence as well as the vertical and lateral extent of the various materials (as per the previous section) encountered across the site in question.

**Graphic 1: Summarised Material Succession- Segment 1 (TP1 & TP2)**



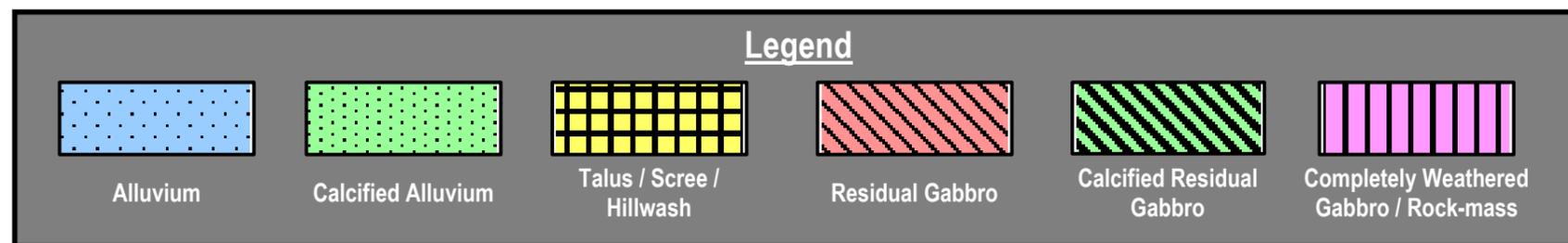
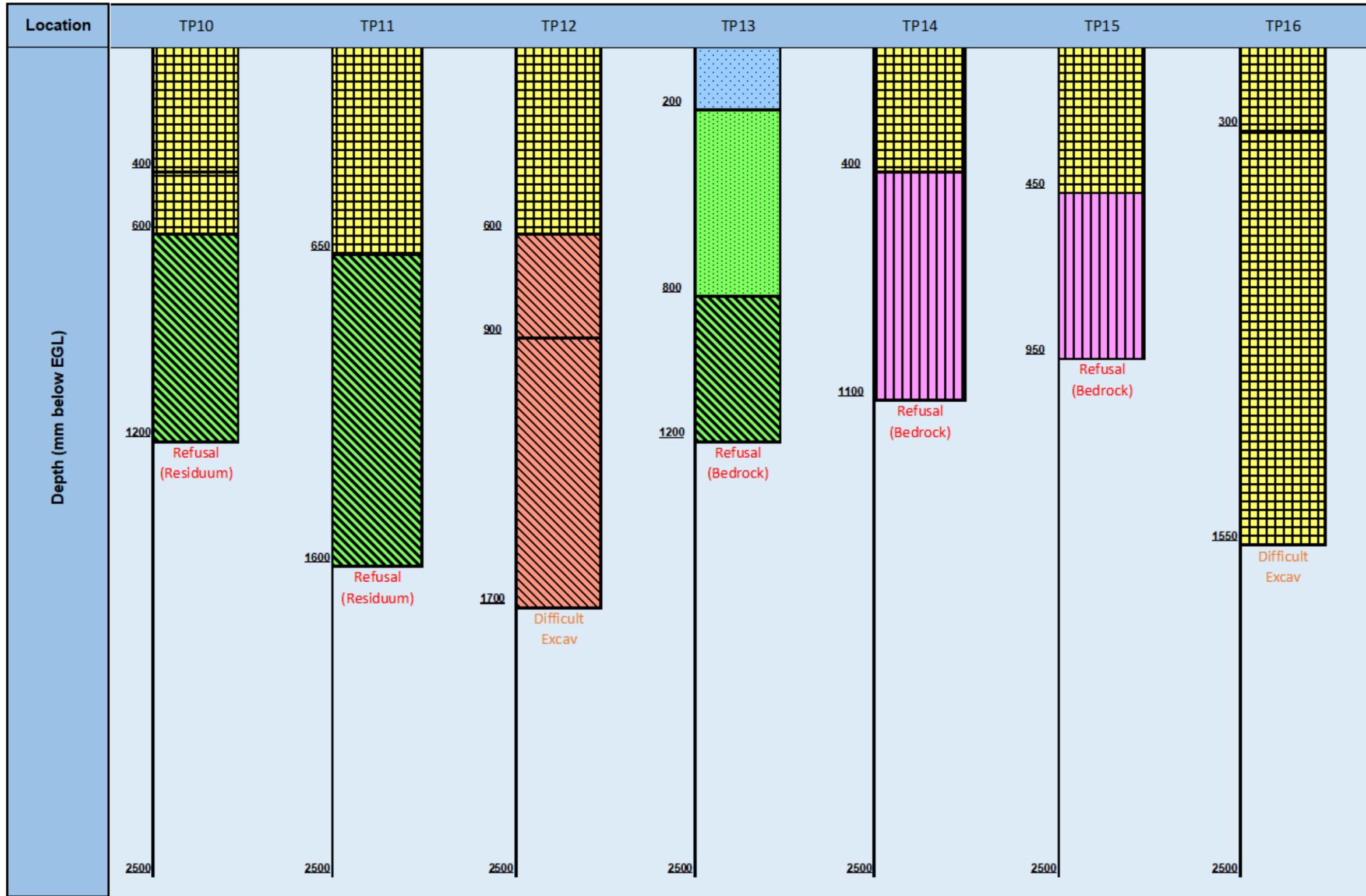
Graphic 2: Summarised Material Succession- Segment 2 (TP3-TP9)

The graphic is not to scale



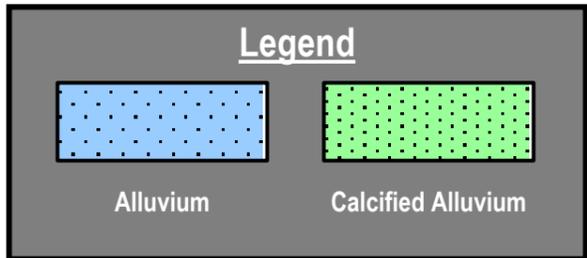
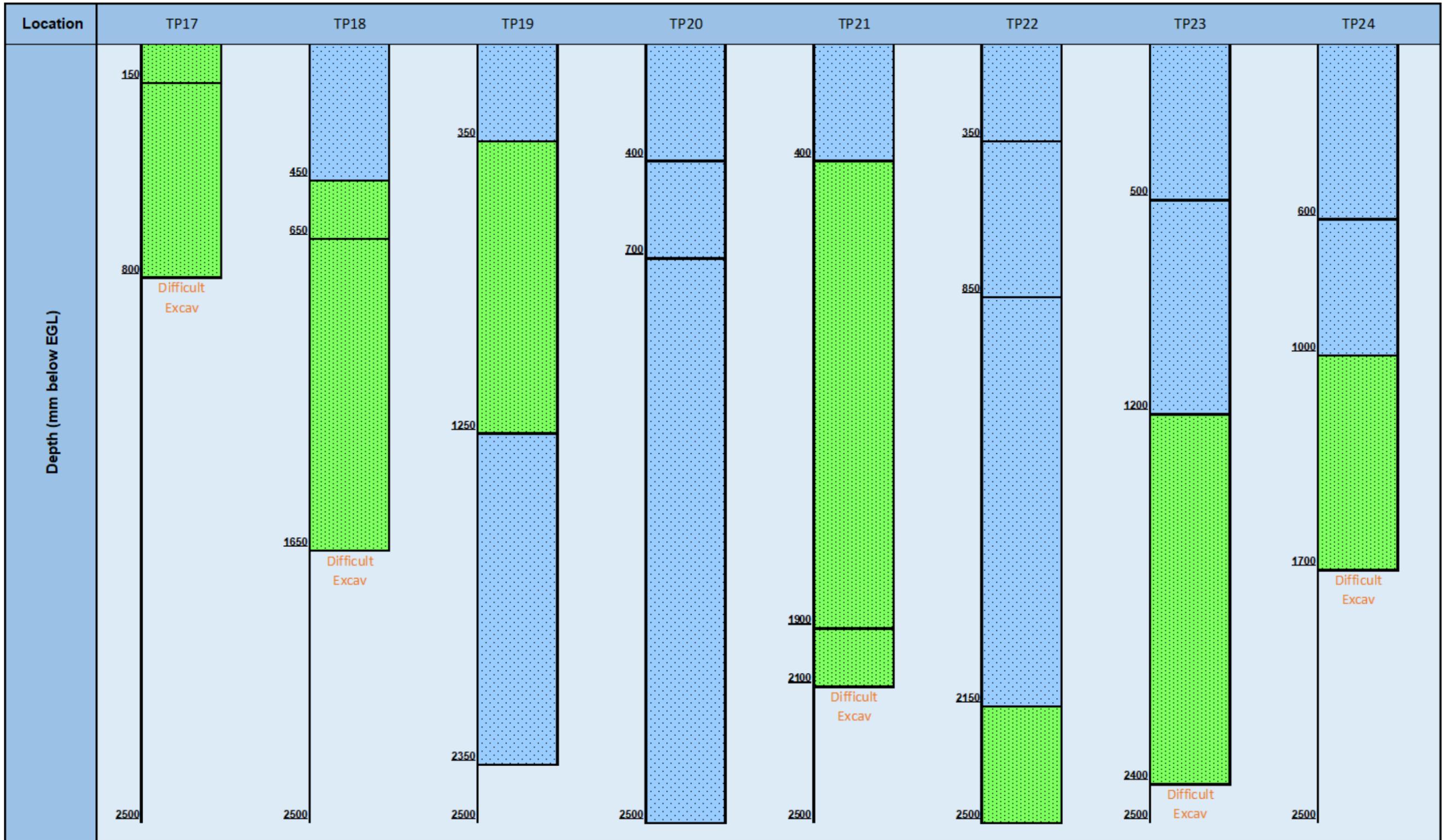
Graphic 3: Summarised Material Succession- Segment 2 (TP10-TP16)

The graphic is not to scale



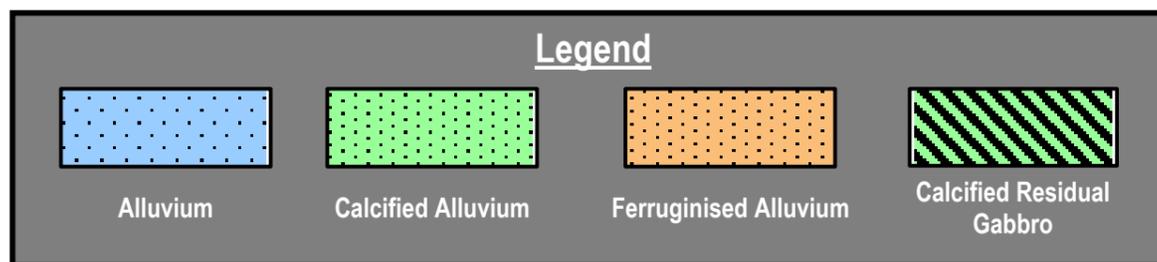
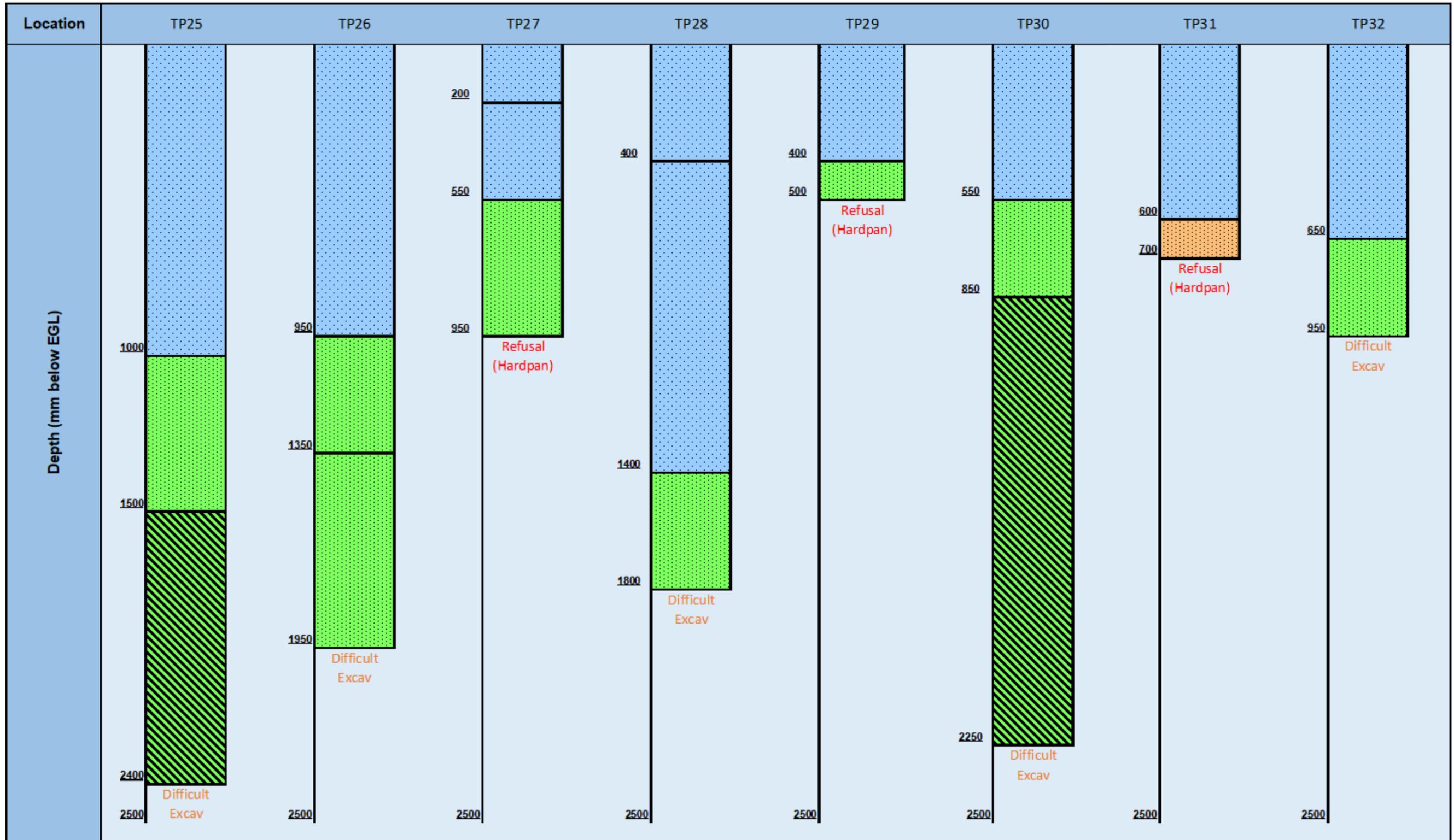
Graphic 4: Summarised Material Succession- Segment 3 (TP17-TP24)

The graphic is not to scale



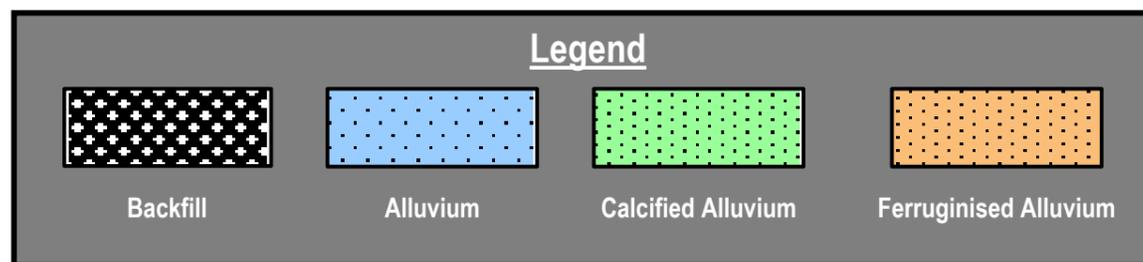
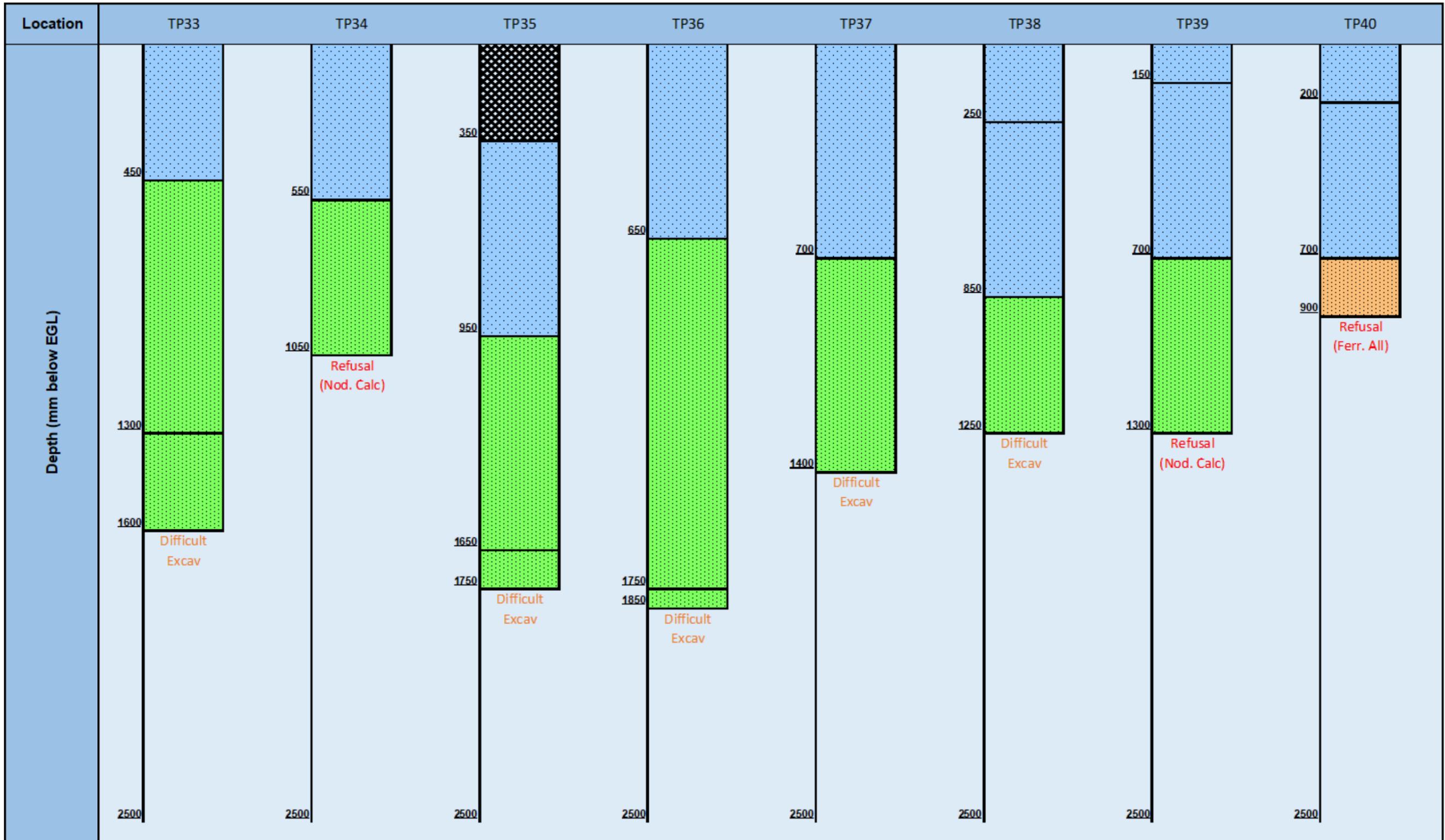
Graphic 5: Summarised Material Succession- Segment 3 (TP25-TP32)

The graphic is not to scale



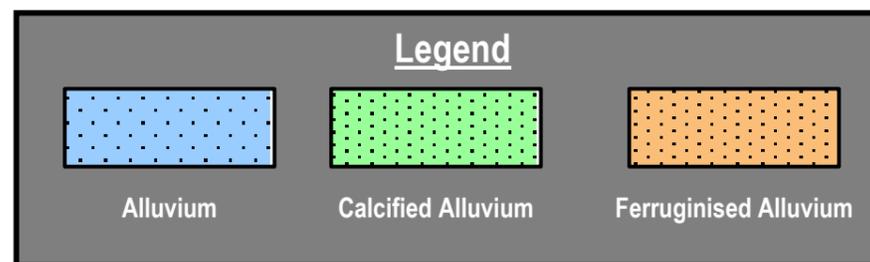
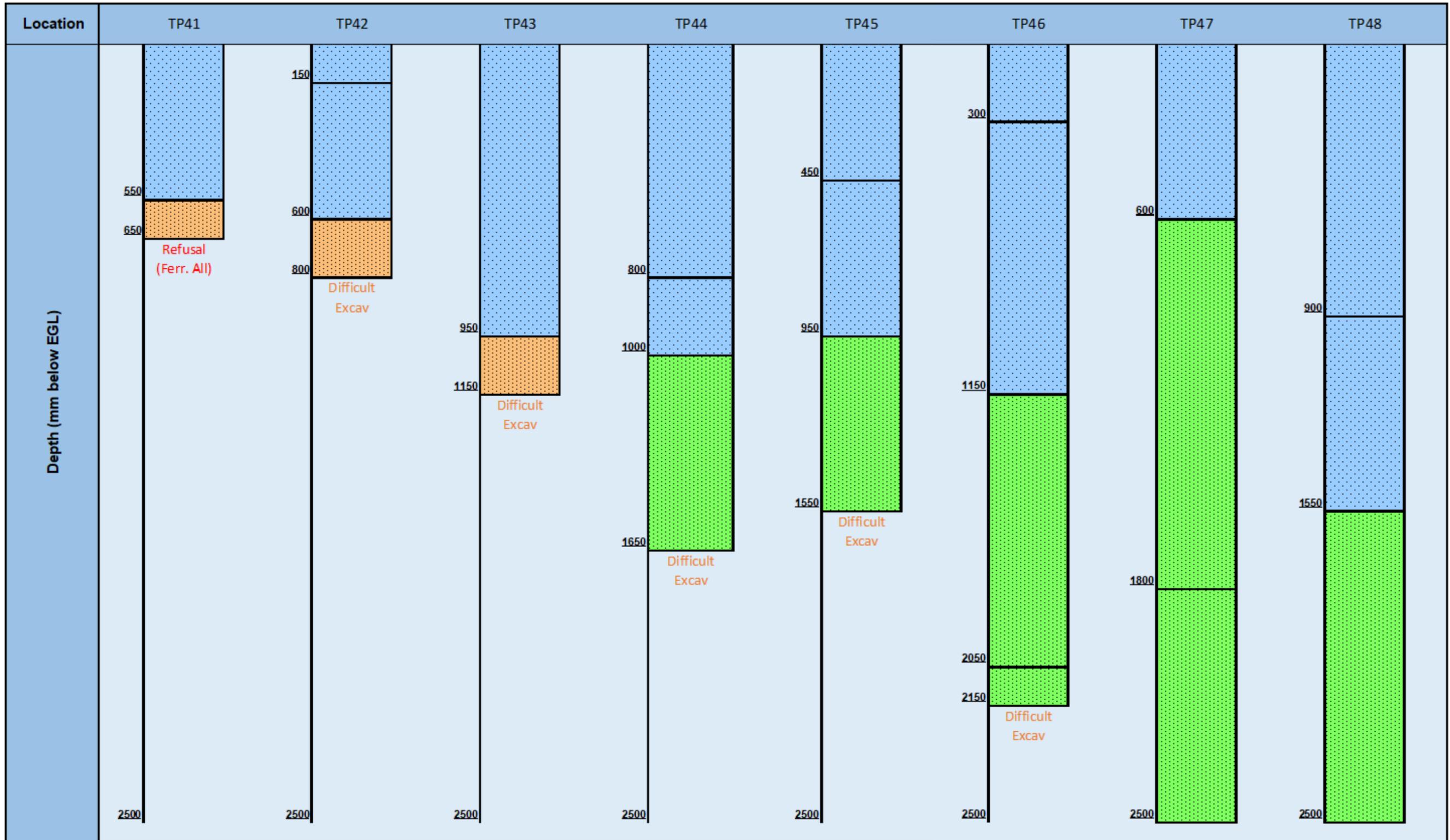
Graphic 6: Summarised Material Succession- Segment 3 (TP33-TP40)

The graphic is not to scale



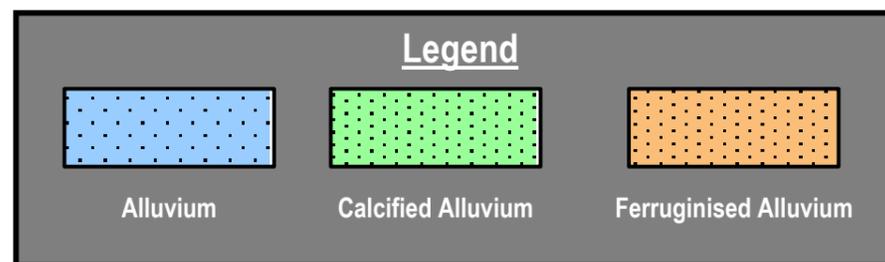
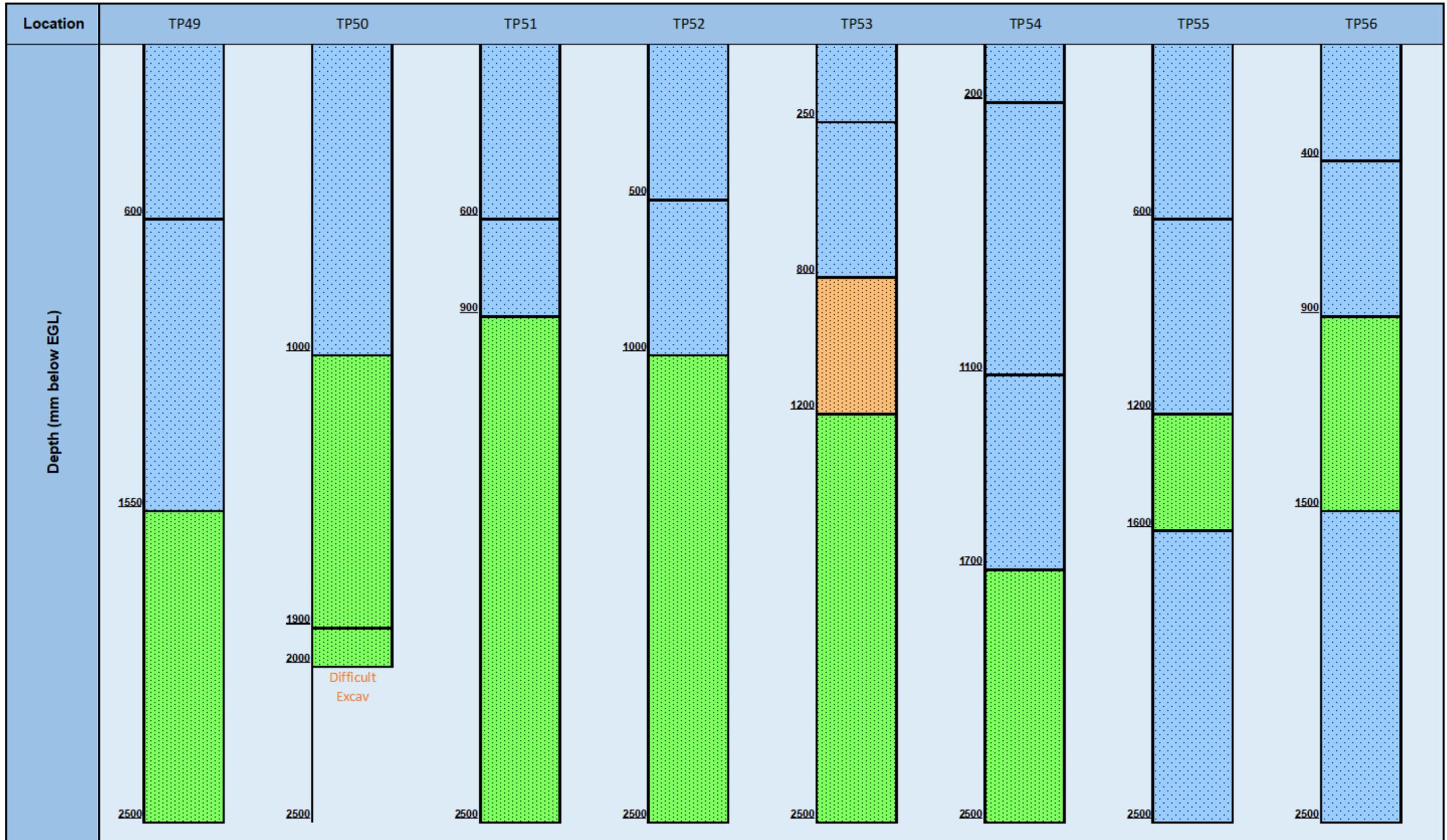
The graphic is not to scale

**Graphic 7: Summarised Material Succession- Segment 3 (TP41-TP48)**



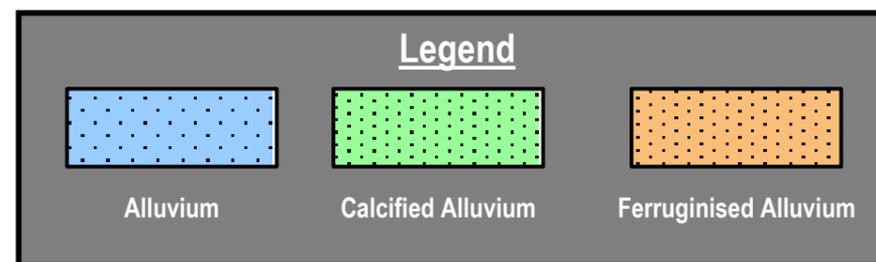
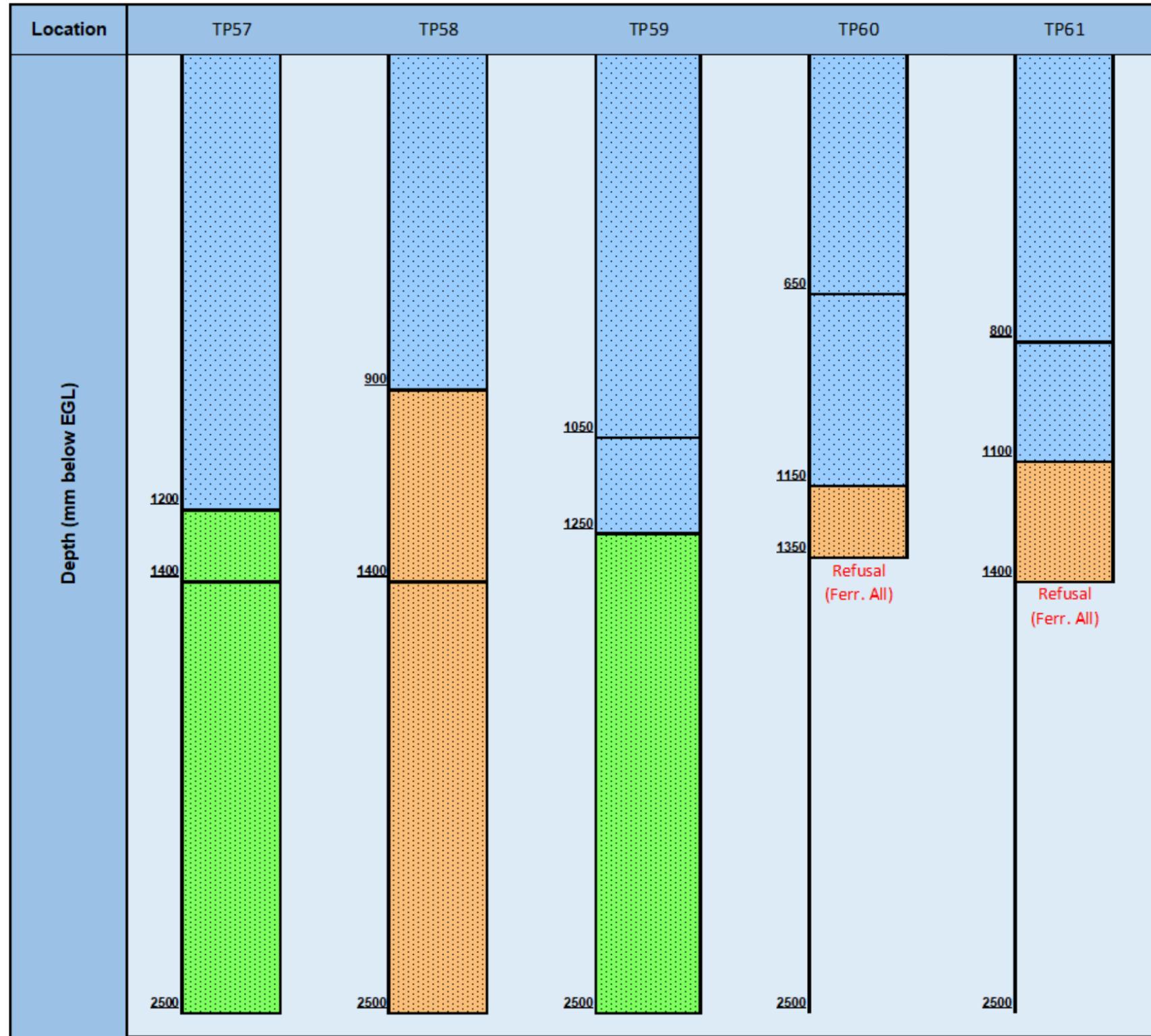
Graphic 8: Summarised Material Succession- Segment 3 (TP49-TP56)

The graphic is not to scale



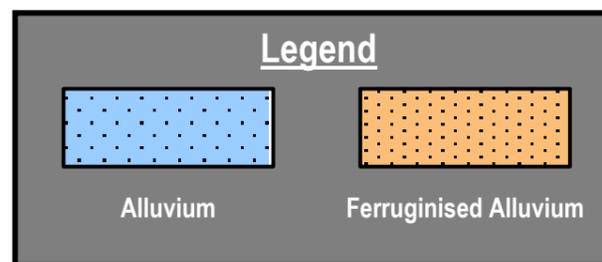
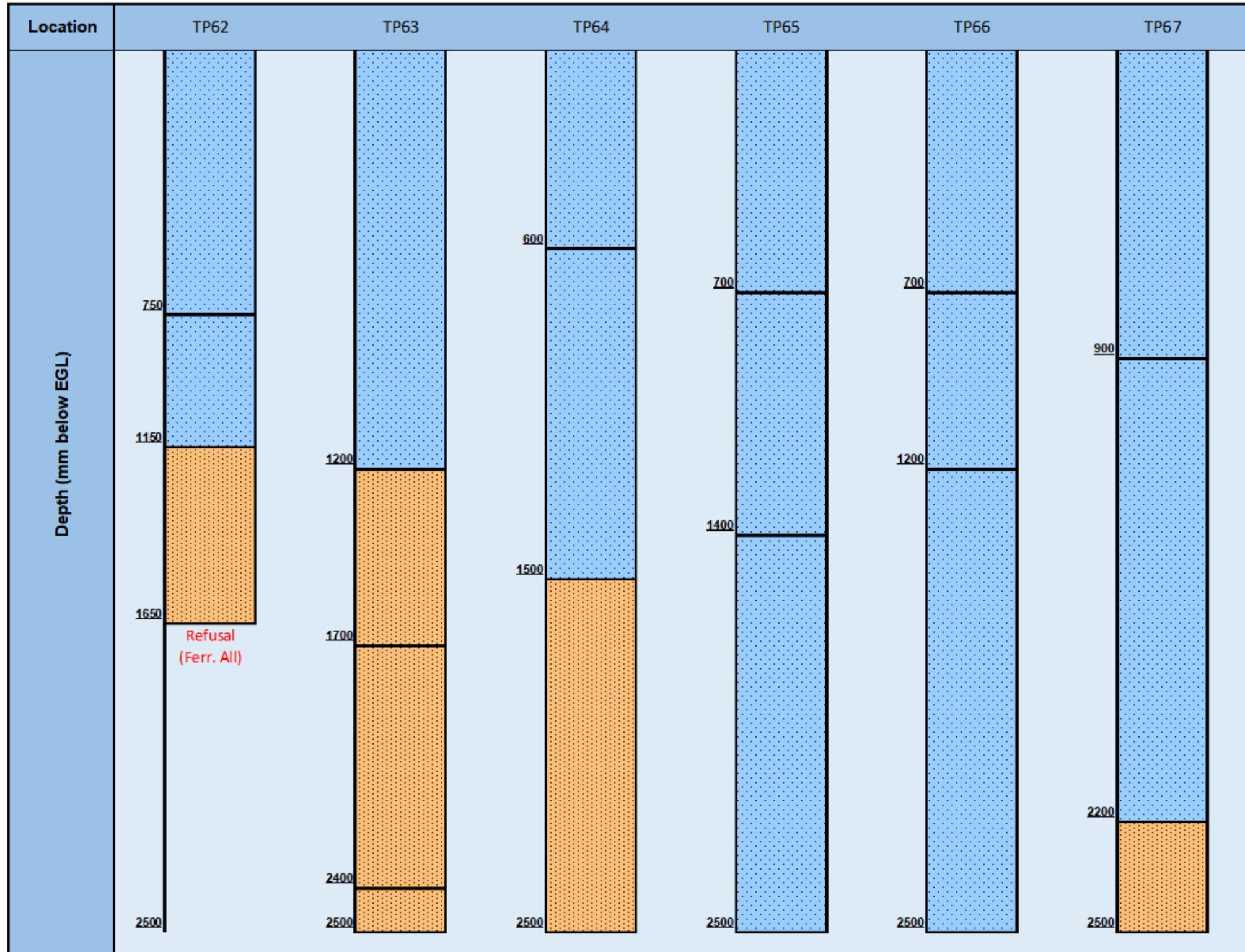
**Graphic 9: Summarised Material Succession- Segment 3 (TP57-TP61)**

The graphic is not to scale



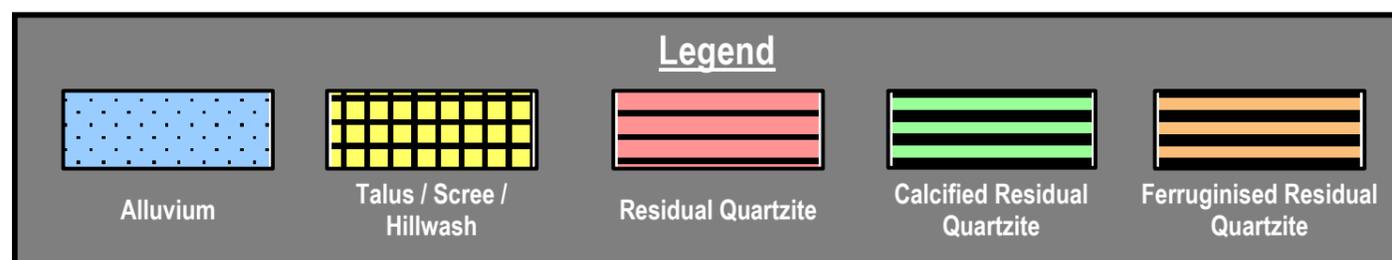
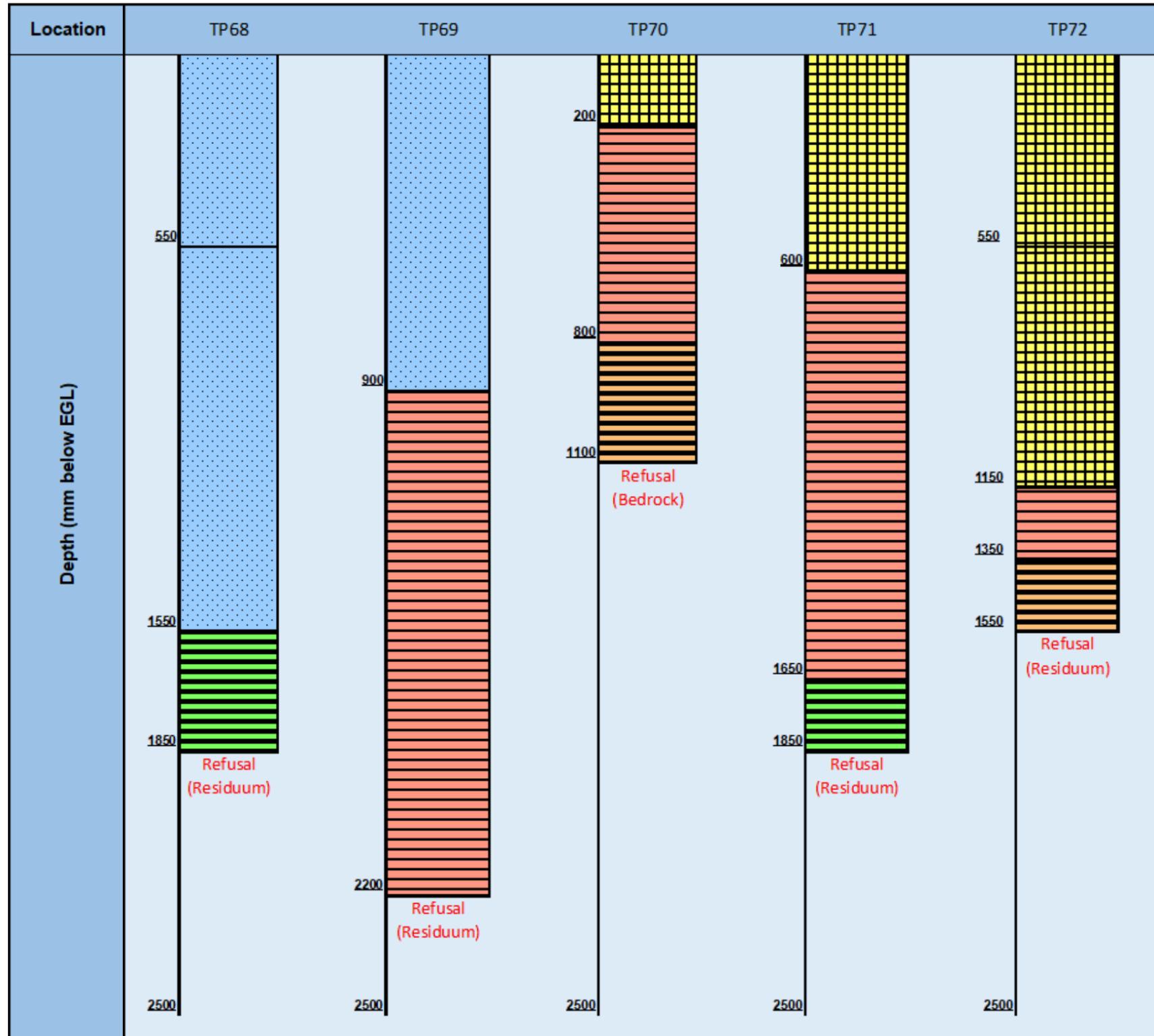
**Graphic 10: Summarised Material Succession- Segment 3 (TP62-TP67)**

The graphic is not to scale



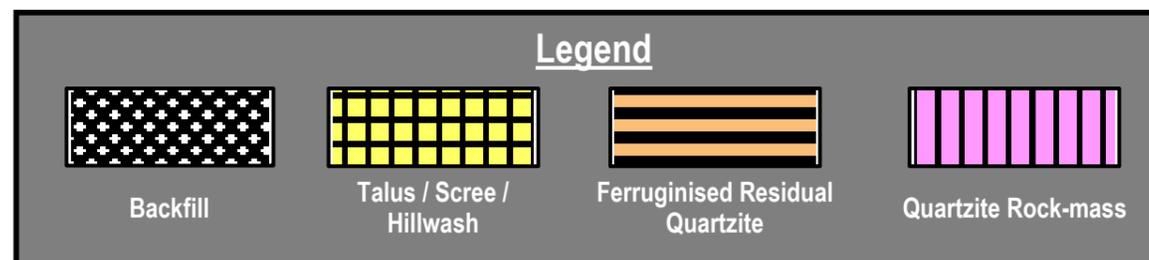
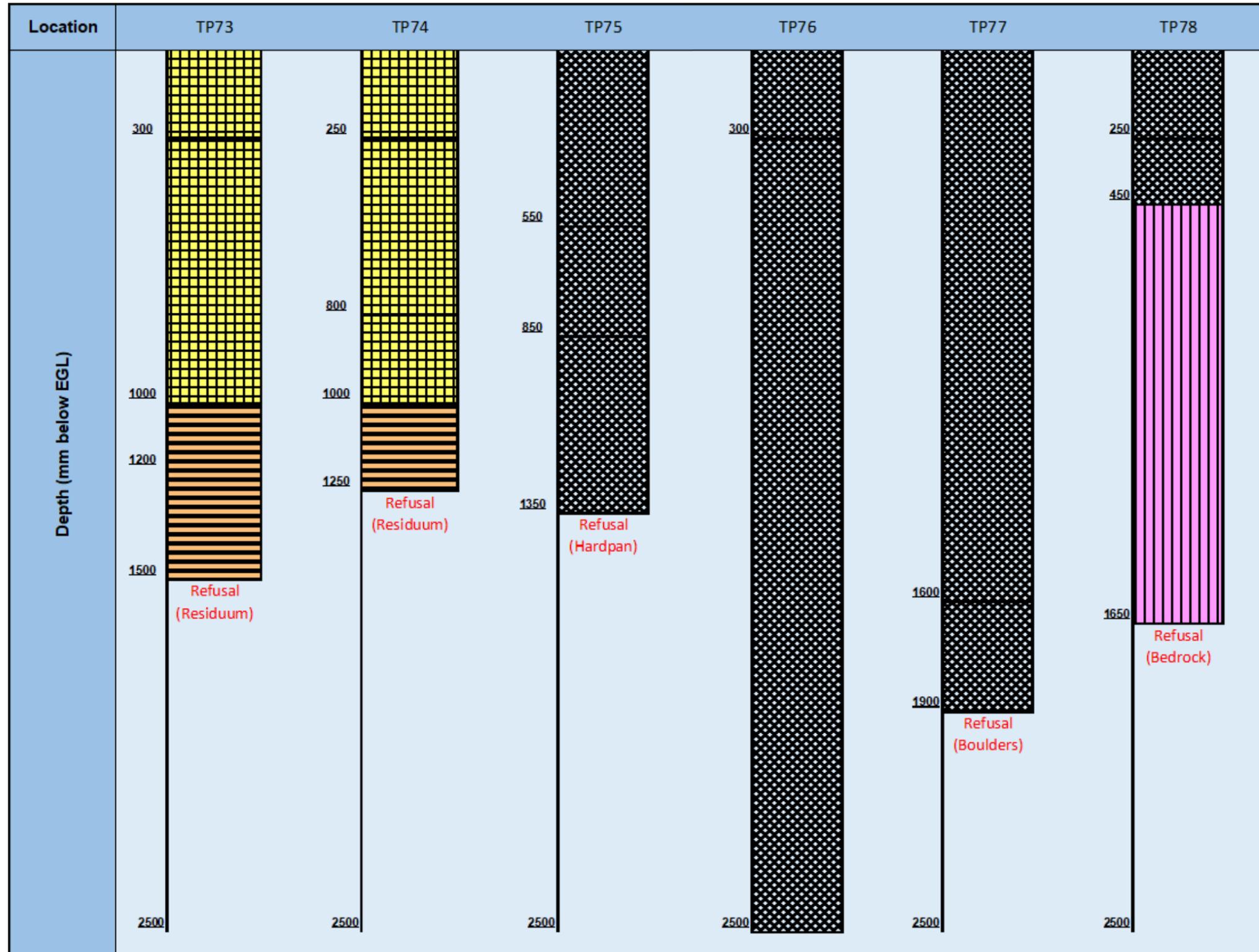
**Graphic 11: Summarised Material Succession- Segment 4 (TP68-TP72)**

The graphic is not to scale



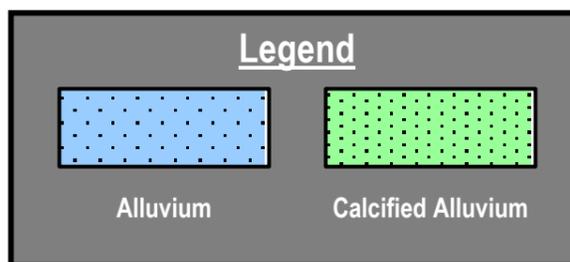
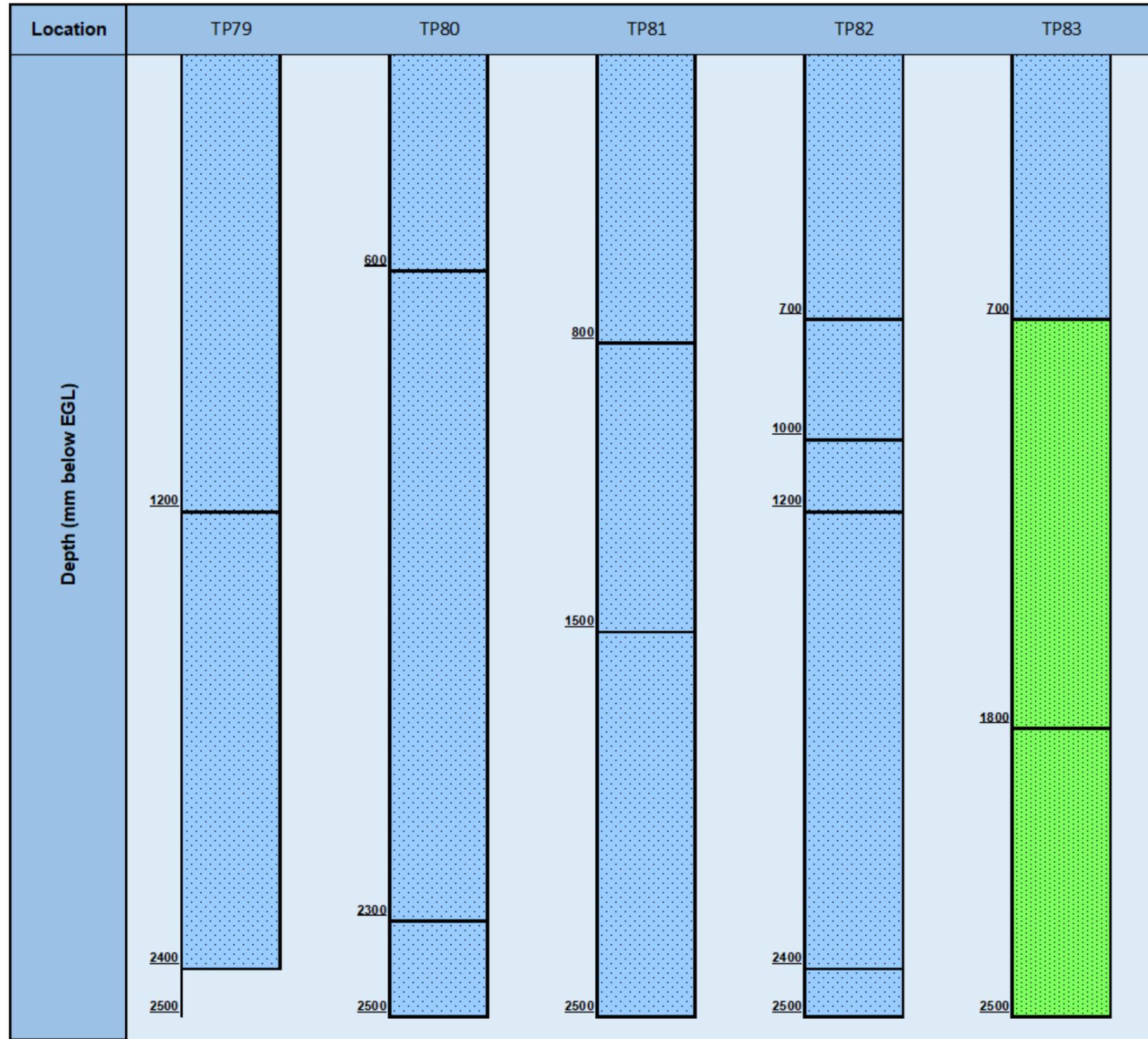
Graphic 12: Summarised Material Succession- Segment 4 (TP73-TP78)

The graphic is not to scale



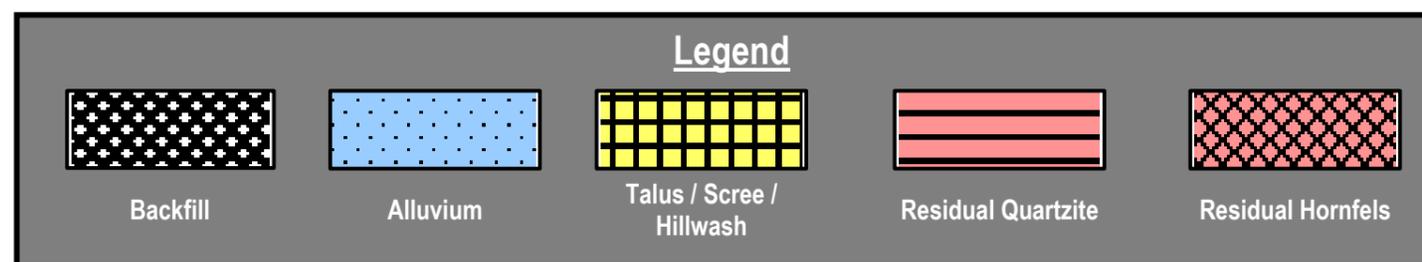
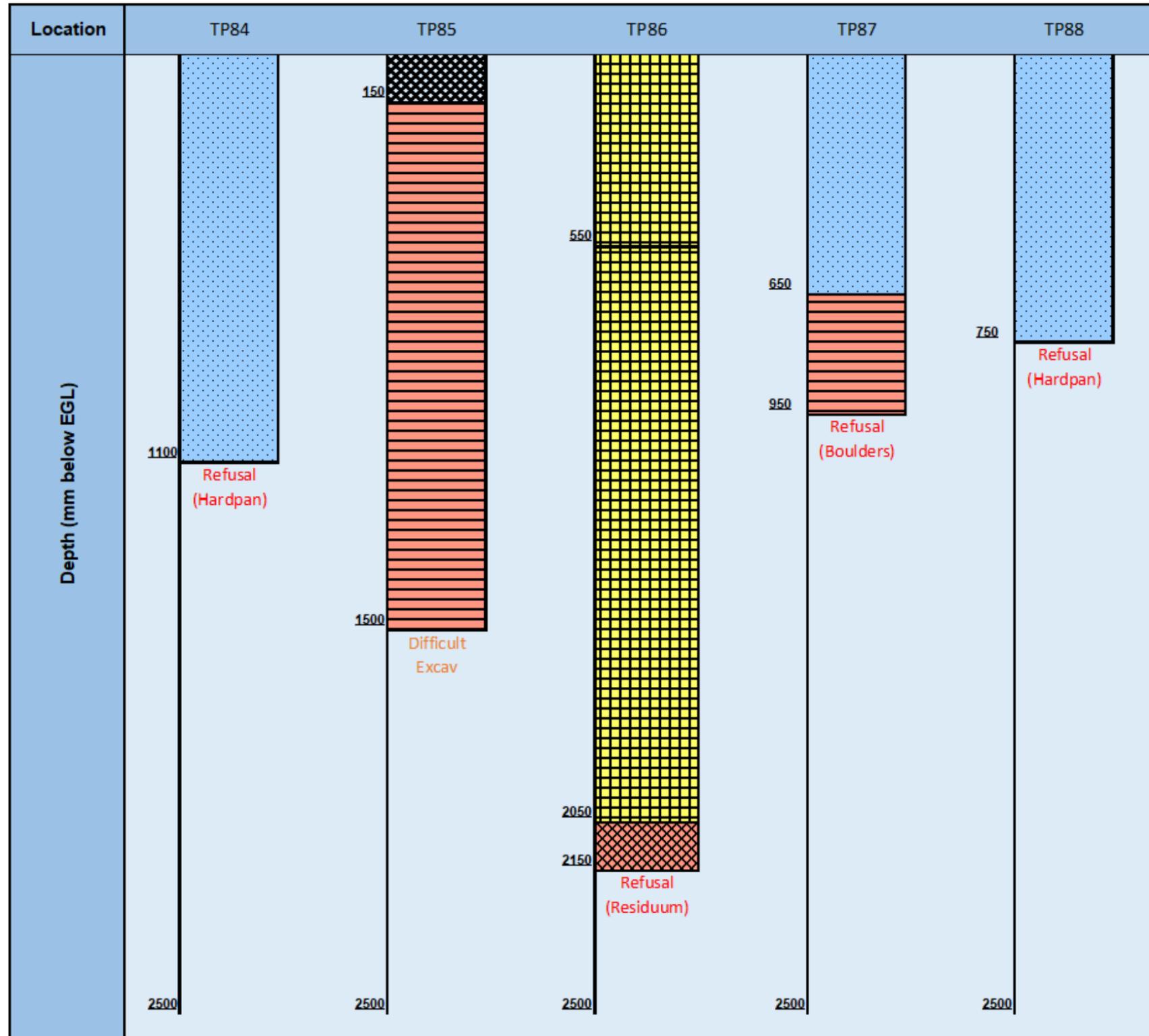
**Graphic 13: Summarised Material Succession- Segment 5 (TP79-TP83)**

The graphic is not to scale

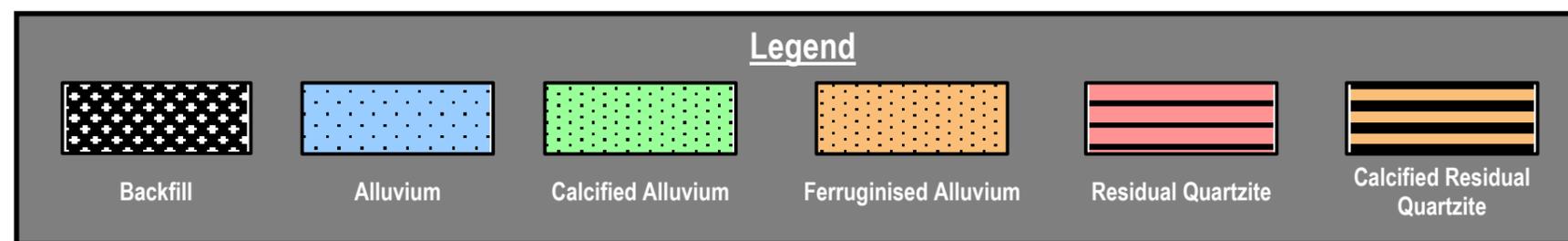
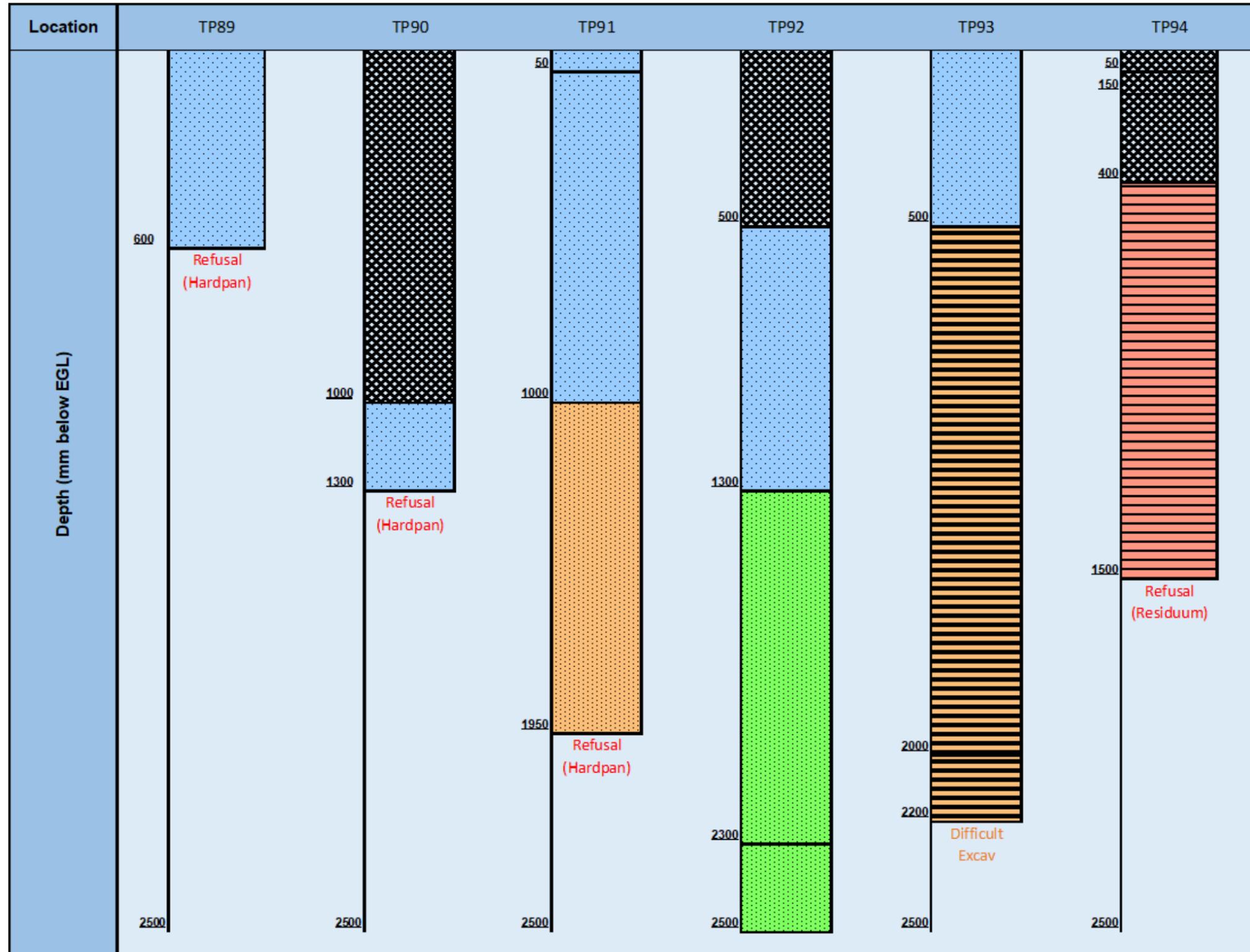


**Graphic 14: Summarised Material Succession- Segment 6 (TP84-TP88)**

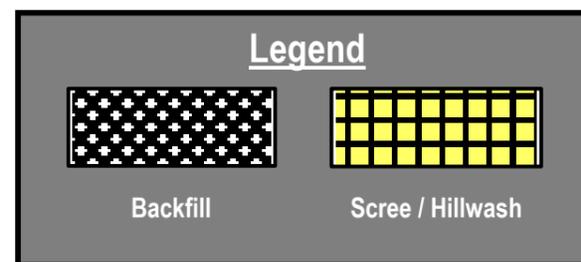
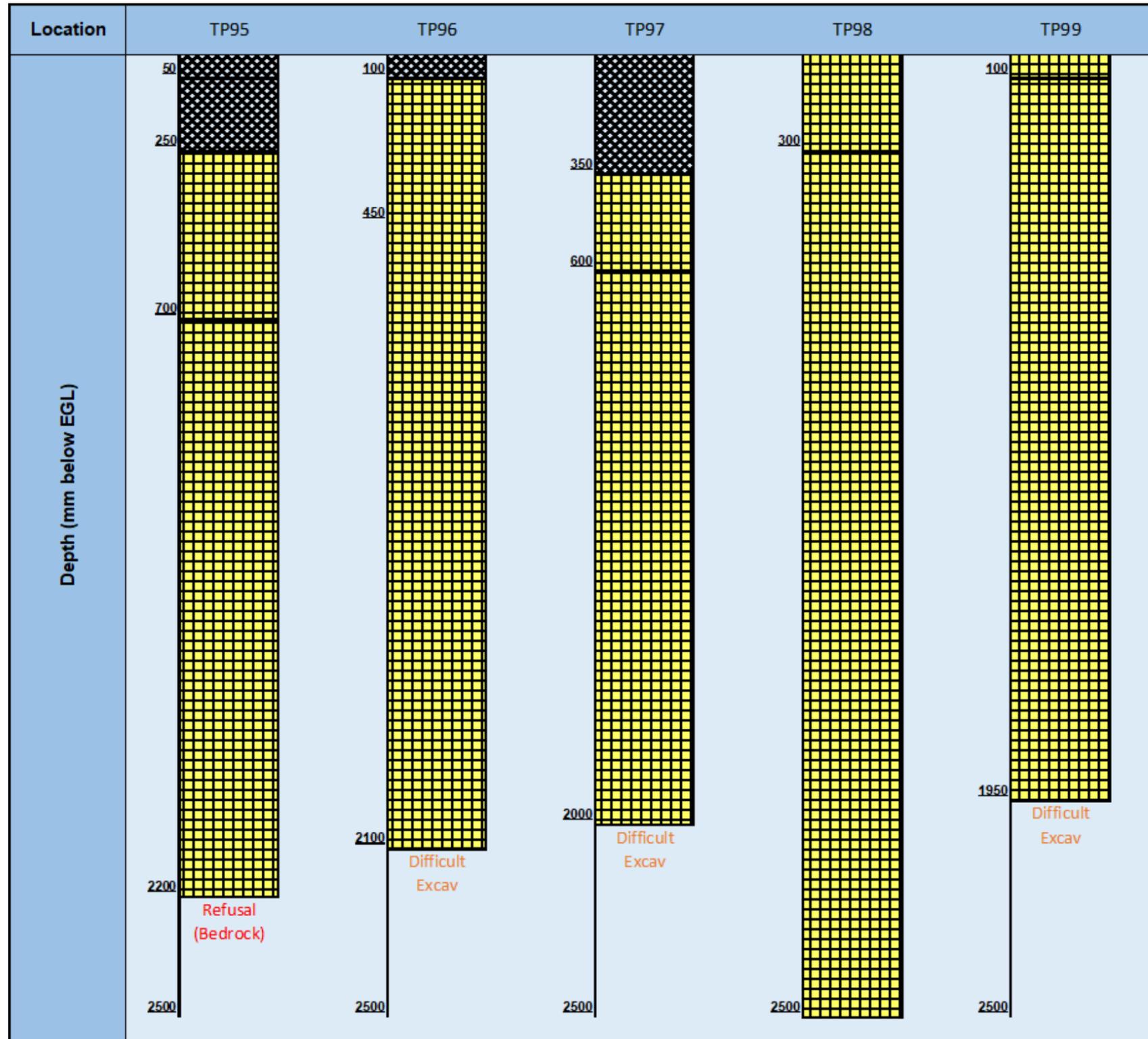
The graphic is not to scale



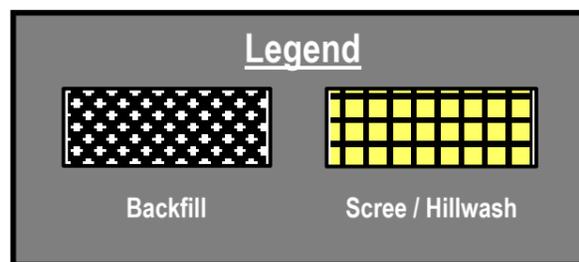
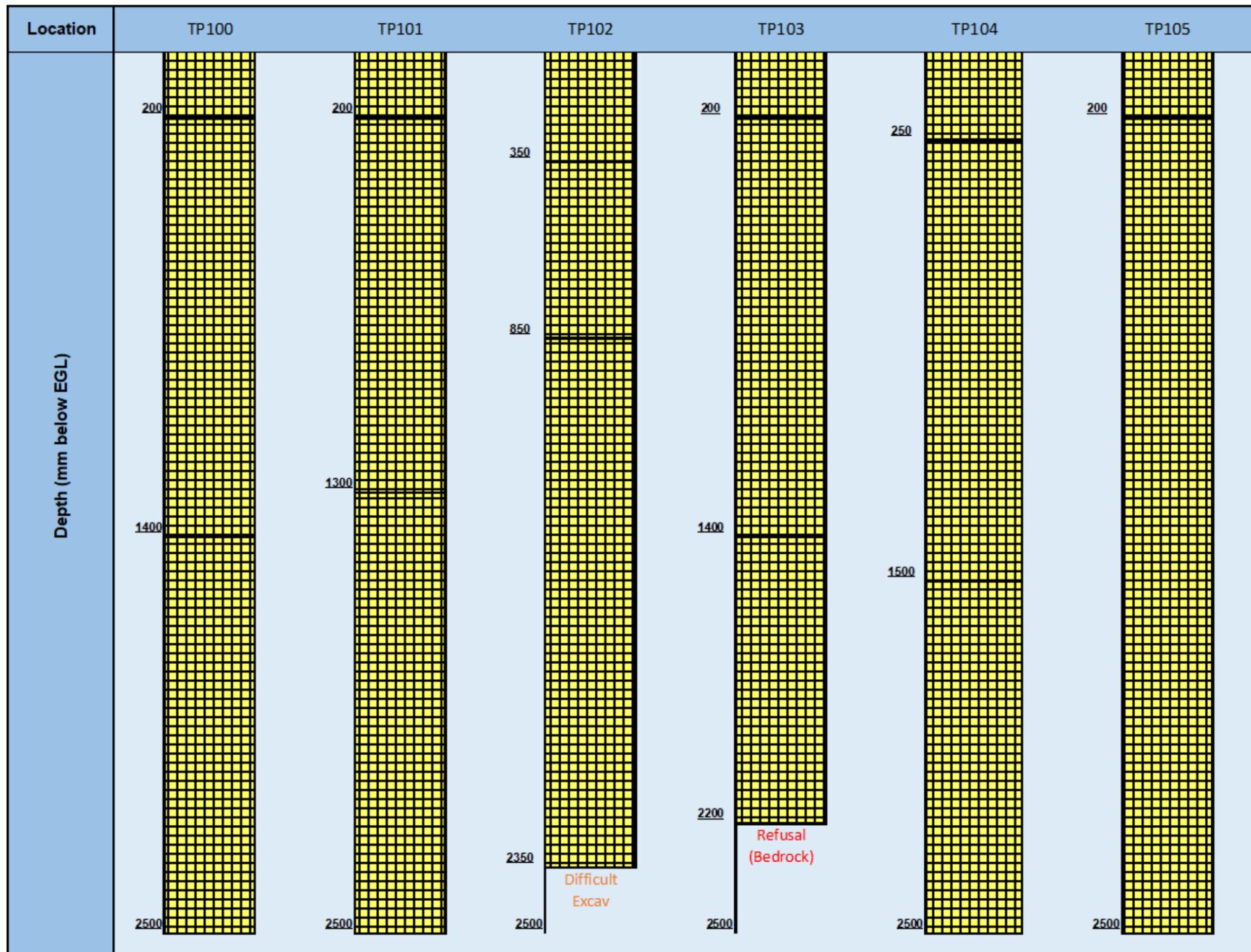
Graphic 15: Summarised Material Succession- Segment 6 (TP89-TP94)



**Graphic 16: Summarised Material Succession- Segment 7 (TP95-TP99)**



**Graphic 17: Summarised Material Succession- Segment 7 (TP100-TP105)**



## 4.2 Laboratory Test Results Analysis

**At the time during which this report was compiled, the laboratory results had yet to be received. These results, and any analysis thereof, will form part of the final report.**

### 4.3 Summarised Geotechnical Character

#### 4.3.1 Groundwater Seepage

During the fieldwork phase of the investigation, **groundwater seepage** was only encountered within **localised** excavations along **Segment 2**, **Segment 6**, and **Segment 7**.

Furthermore, evidence for fluctuating moisture conditions, in the form of **ferruginisation** and **calcification**, was encountered within the **majority** of the excavations within **Segment 2 to**, **Segment 4**, and **localised** excavations within **Segment 5** and **Segment 6**.

These characteristics can be summarised in the tables below:

**Table 3: Summarised Groundwater Conditions- Segment 1**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 1</b>						
TP1	Abstraction Works	-	-	-	-	-
TP2		-	-	-	-	-

**Table 4: Summarised Groundwater Conditions- Segment 2**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 2</b>						
TP3	0+185	-	-	-	-	-
TP4	0+430	very slow seepage	~0.9	perching on bedrock	-	-
TP5	0+730	-	-	-	-	-
TP6	0+945	-	-	-	-	-
TP7	1+205	-	-	-	-	-
TP8	1+435	-	-	-	-	-
TP9	1+685	-	-	-	Calcification and/or ferruginisation	~0.50
TP10	1+945	-	-	-		~0.60
TP11	2+190	-	-	-		~0.65
TP12	2+450	-	-	-	-	-
TP13	2+705	-	-	-	Calcification	~0.20
TP14	2+950	-	-	-	-	-
TP15	3+185	-	-	-	-	-
TP16	3+450	-	-	-	Calcification	~0.30

**Table 5: Summarised Groundwater Conditions- Segment 3**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels		
		Nature	Depth (m)	Notes	Nature	Start Depth (m)	
<b>Segment 3</b>							
TP17	3+690	-	-	-	Calcification	Surface	
TP18	4+000	-	-	-		~-0.45	
TP19	4+230	-	-	-		~-0.35	
TP20	4+465	-	-	-		~-0.40	
TP21	4+715	-	-	-		~-0.40	
TP22	4+975	-	-	-		~-2.15	
TP23	5+225	-	-	-		~-1.20	
TP24	5+475	-	-	-		~-0.60	
TP25	5+735	-	-	-	Calcification and/or ferruginisation	~-1.00	
TP26	5+990	-	-	-	Calcification	~-0.95	
TP27	6+235	-	-	-		~-0.55	
TP28	6+560	-	-	-		~-1.40	
TP29	6+795	-	-	-		~-0.50	
TP30	7+065	-	-	-		~-0.55	
TP31	7+310	-	-	-	Calcification and/or ferruginisation	~-0.60	
TP32	7+550	-	-	-	Calcification	~-0.65	
TP33	7+795	-	-	-		~-0.45	
TP34	8+050	-	-	-		~-0.55	
TP35	8+300	-	-	-		~-0.95	
TP36	8+555	-	-	-		~-0.65	
TP37	8+800	-	-	-		~-0.70	
TP38	9+050	-	-	-		~-0.85	
TP39	9+300	-	-	-		~-0.70	
TP40	9+550	-	-	-		Ferruginisation	~-0.70
TP41	9+800	-	-	-		Calcification and/or ferruginisation	~-0.55
TP42	10+055	-	-	-	Ferruginisation	~-0.60	
TP43	10+295	-	-	-		~-0.95	
TP44	10+550	-	-	-	Calcification	~-1.0	
TP45	10+800	-	-	-		~-0.95	
TP46	11+050	-	-	-		~-1.15	
TP47	11+300	-	-	-		~-0.60	
TP48	11+550	-	-	-		~-0.90	

**Table 6: Summarised Groundwater Conditions- Segment 3 Cont.**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 3</b>						
TP49	11+800	-	-	-	Calcification	~1.55
TP50	12+050	-	-	-		~1.0
TP51	12+300	-	-	-		~0.90
TP52	12+550	-	-	-		~0.50
TP53	12+800	-	-	-		~0.80
TP54	13+055	-	-	-		~1.70
TP55	13+295	-	-	-	~1.20	
TP56	13+560	-	-	-	Calcification and/or ferruginisation	~0.90
TP57	13+800	-	-	-		~1.20
TP58	14+050	-	-	-		~0.90
TP59	14+295	-	-	-		~1.05
TP60	14+550	-	-	-		~1.15
TP61	14+810	-	-	-		~1.10
TP62	15+055	-	-	-	Ferruginisation	~1.15
TP63	15+350	-	-	-		~1.20
TP64	15+550	-	-	-		~1.50
TP65	15+795	-	-	-		~1.4
TP66	16+045	-	-	-		~1.20
TP67	16+295	-	-	-		~2.20

**Table 7: Summarised Groundwater Conditions- Segment 4**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 4</b>						
TP68	16+560	-	-	-	Calcification	~1.55
TP69	16+805	-	-	-		~0.90
TP70	17+055	-	-	-	Ferruginisation	~0.80
TP71	17+300	-	-	-	Calcification	~1.65
TP72	17+550	-	-	-	Ferruginisation	~1.15
TP73	17+805	-	-	-		~1.00
TP74	18+040	-	-	-		~1.00
TP75	18+300	-	-	-		~0.85
TP76	18+550	-	-	-	-	-
TP77	18+805	-	-	-	-	-
TP78	19+040	-	-	-	-	-

**Table 8: Summarised Groundwater Conditions- Segment 5**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 5</b>						
TP79	21+685	-	-	-	-	-
TP80	22+055	-	-	-	-	-
TP81	22+280	-	-	-	-	-
TP82	22+540	-	-	-	Calcification	~1.20
TP83	22+770	-	-	-		~0.70

**Table 9: Summarised Groundwater Conditions- Segment 6**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 6</b>						
TP84	23+030	-	-	-	-	-
TP85	23+280	-	-	-	-	-
TP86	23+525	-	-	-	-	-
TP87	23+785	-	-	-	-	-
TP88	24+060	very slow seepage	~0.75	perching on hardpan calcrete	-	-
TP89	24+270	very slow seepage	~0.60		-	-
TP90	24+520	slow to moderate seepage	~1.00		-	-
TP91	24+800	-	-	-	Ferruginisation	~1.00
TP92	25+050	-	-	-	Calcification	~1.30
TP93	25+305	-	-	-	Ferruginisation	~0.50
TP94	25+540	-	-	-	-	-

**Table 10: Summarised Groundwater Conditions- Segment 7**

Test Pits	Chainage	Groundwater Occurrence			Evidence for Fluctuating Moisture Levels	
		Nature	Depth (m)	Notes	Nature	Start Depth (m)
<b>Segment 7</b>						
TP95	25+785	very slow seepage	~2.20	perching on bedrock	-	-
TP96	26+000	-	-	-	-	-
TP97	26+280	-	-	-	-	-
TP98	26+545	-	-	-	-	-
TP99	26+785	-	-	-	-	-
TP100	27+046	-	-	-	-	-
TP101	27+295	-	-	-	-	-
TP102	27+550	-	-	-	-	-
TP103	27+790	-	-	-	-	-
TP104	28+040	-	-	-	-	-
TP105	28+255	-	-	-	-	-

Along the sections hosting **bedrock** and/or **hardpan calcrete/ferricrete**, it is interpreted that **infiltrating surface water perches** upon these material horizons, restricting free drainage in the blanketing layers.

Furthermore, the **very gentle** sloping terrain is interpreted to **promote infiltration**, while **restricting run-off** and interflow (lateral flow of groundwater). Consequently, it is recommended that the pipeline be designed in such a way so as to prevent/negate the collection and accumulation of groundwater within the vicinity of the proposed new pipeline.

### 4.3.2 Excavatability

The various excavations conducted across the site were conducted by means of a TLB-type light mechanical excavator (Bell 315 SL & JCB 3DX Super). These machines have advertised power outputs of **~72 kW** (Bell 315 SL) and **~69 kW** (JCB 3DX Super).

With a bucket width of 500 mm, the estimated power ranges between **~0.14 kW** (Bell 315 SL) and **~0.13 kW** (JCB 3DX Super) per mm bucket width. As such, it is interpreted that these machines are capable of excavating through material classed as **Soft Excavation conditions** as per SANS 1200D.

It should be noted that the digging strength of the machines decreases at depth due to leverage limitations nearing full reach of the boom. As such, the interpreted extent of the Soft Excavation conditions has been extended slightly beyond the actual depth of excavation.

See the tables overleaf summarising the inferred excavation class for each of the excavated test pits:

**Table 11: Summarised Excavation Conditions- Segment 1**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP1	Abstraction Works	2.50	100%	0%	0%
TP2		0.90	35%	0%	65%
<b>Average:</b>		<b>1.70</b>	<b>68%</b>	<b>0%</b>	<b>33%</b>

**Table 12: Summarised Excavation Conditions- Segment 2**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP3	0+185	0.65	25%	0%	75%
TP4	0+430	0.90	35%	0%	65%
TP5	0+730	1.20	30%	20%	50%
TP6	0+945	0.95	20%	20%	60%
TP7	1+205	0.60	25%	0%	75%
TP8	1+435	bedrock outcrops	0%	0%	100%
TP9	1+685	2.00	65%	35%	0%
TP10	1+945	1.20	25%	70%	5%
TP11	2+190	1.60	25%	70%	5%
TP12	2+450	1.70	25%	75%	0%
TP13	2+705	1.20	30%	10%	60%
TP14	2+950	1.10	15%	30%	55%
TP15	3+185	0.95	15%	20%	65%
TP16	3+450	1.55	10%	90%	0%
<b>Average:</b>		<b>1.20</b>	<b>25%</b>	<b>21%</b>	<b>54%</b>

**Table 13: Summarised Excavation Conditions- Segment 3**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP17	3+690	0.80	30%	70%	0%
TP18	4+000	1.65	65%	35%	0%
TP19	4+230	2.35	95%	5%	0%
TP20	4+465	2.50	100%	0%	0%
TP21	4+715	2.10	75%	25%	0%
TP22	4+975	2.50	100%	0%	0%
TP23	5+225	2.40	95%	5%	0%
TP24	5+475	1.70	40%	60%	0%
TP25	5+735	2.40	95%	5%	0%
TP26	5+990	1.95	80%	20%	0%
TP27	6+235	0.95	40%	55%	5%
TP28	6+560	1.80	70%	30%	0%
TP29	6+795	0.50	20%	75%	5%
TP30	7+065	2.25	80%	20%	0%
TP31	7+310	0.70	30%	60%	10%
TP32	7+550	0.95	40%	60%	0%
TP33	7+795	1.60	65%	35%	0%
TP34	8+050	1.05	40%	60%	0%
TP35	8+300	1.75	70%	30%	0%
TP36	8+555	1.85	70%	30%	0%
TP37	8+800	1.40	55%	45%	0%
TP38	9+050	1.25	50%	50%	0%
TP39	9+300	1.30	50%	50%	0%
TP40	9+550	0.90	35%	60%	5%
TP41	9+800	0.65	25%	70%	5%
TP42	10+055	0.80	30%	70%	0%
TP43	10+295	1.15	45%	55%	0%
TP44	10+550	1.65	65%	35%	0%
TP45	10+800	1.55	62%	38%	0%
TP46	11+050	2.15	85%	15%	0%
TP47	11+300	2.80	100%	0%	0%
TP48	11+550	2.65	100%	0%	0%

**Table 14: Summarised Excavation Conditions- Segment 3 Cont.**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP49	11+800	2.55	100%	0%	0%
TP50	12+050	2.00	80%	20%	0%
TP51	12+300	2.50	100%	0%	0%
TP52	12+550	2.60	100%	0%	0%
TP53	12+800	2.50	100%	0%	0%
TP54	13+055	2.70	100%	0%	0%
TP55	13+295	2.60	100%	0%	0%
TP56	13+560	2.50	100%	0%	0%
TP57	13+800	2.60	100%	0%	0%
TP58	14+050	2.50	100%	0%	0%
TP59	14+295	2.55	100%	0%	0%
TP60	14+550	1.35	55%	45%	0%
TP61	14+810	1.40	45%	55%	0%
TP62	15+055	1.65	65%	35%	0%
TP63	15+350	2.50	100%	0%	0%
TP64	15+550	2.50	100%	0%	0%
TP65	15+795	2.50	100%	0%	0%
TP66	16+045	2.50	100%	0%	0%
TP67	16+295	2.50	100%	0%	0%
<b>Average:</b>		<b>1.89</b>	<b>73%</b>	<b>22%</b>	<b>4%</b>

**Table 15: Summarised Excavation Conditions- Segment 4**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP68	16+560	1.85	75%	20%	5%
TP69	16+805	2.20	85%	15%	0%
TP70	17+055	1.10	45%	0%	55%
TP71	17+300	1.85	75%	25%	0%
TP72	17+550	1.55	60%	40%	0%
TP73	17+805	1.50	60%	40%	0%
TP74	18+040	1.25	50%	50%	0%
TP75	18+300	1.35	55%	40%	5%
TP76	18+550	2.50	100%	0%	0%
TP77	18+805	1.90	75%	25%	0%
TP78	19+040	1.65	15%	30%	55%
<b>Average:</b>		<b>1.70</b>	<b>63%</b>	<b>20%</b>	<b>16%</b>

**Table 16: Summarised Excavation Conditions- Segment 5**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP79	21+685	2.40	100%	0%	0%
TP80	22+055	2.50	100%	0%	0%
TP81	22+280	2.50	100%	0%	0%
TP82	22+540	2.50	100%	0%	0%
TP83	22+770	2.50	100%	0%	0%
<b>Average:</b>		<b>2.48</b>	<b>100%</b>	<b>0%</b>	<b>0%</b>

**Table 17: Summarised Excavation Conditions- Segment 6**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP84	23+030	1.10	45%	50%	5%
TP85	23+280	1.50	60%	40%	0%
TP86	23+525	2.15	85%	15%	0%
TP87	23+785	0.95	40%	55%	5%
TP88	24+060	0.75	30%	60%	10%
TP89	24+270	0.60	25%	65%	10%
TP90	24+520	1.30	50%	40%	10%
TP91	24+800	1.95	80%	15%	5%
TP92	25+050	2.50	100%	0%	0%
TP93	25+305	2.20	88%	12%	0%
TP94	25+540	1.50	60%	30%	10%
<b>Average:</b>		<b>1.50</b>	<b>60%</b>	<b>14%</b>	<b>26%</b>

**Table 18: Summarised Excavation Conditions- Segment 7**

Test Pits	Chainage	Excavation Depth (m below EGL)	Inferred Excavation Class to 2.5 m		
			% Soft	% Intermediate	% Hard
TP95	25+785	2.20	88%	0%	12%
TP96	26+000	2.10	85%	15%	0%
TP97	26+280	2.00	80%	20%	0%
TP98	26+545	2.50	100%	0%	0%
TP99	26+785	1.95	80%	20%	0%
TP100	27+046	2.50	100%	0%	0%
TP101	27+295	2.50	100%	0%	0%
TP102	27+550	2.35	95%	5%	0%
TP103	27+790	2.20	88%	0%	12%
TP104	28+040	2.55	100%	0%	0%
TP105	28+255	2.50	100%	0%	0%
<b>Average:</b>		<b>2.30</b>	<b>92%</b>	<b>5%</b>	<b>2%</b>

**Notes:**

- 1) The classes of excavations presented above are based upon **restricted excavation** to ~2.5 m below EGL (SANS 1200D).
- 2) The percentage volume of soft material is based on the material excavated by the TLB-type light mechanical excavator during the fieldwork phase of the investigation.
- 3) The relationship between the Intermediate and Hard Rock excavation class is not a measured parameter, but rather inferred based on the nature of the material encountered at the refusal point.
- 4) Fluctuations in extent and occurrence of the various material horizons may result in fluctuations in the excavatability classes.

### **4.3.3 Excavation Stability**

During the fieldwork phase of the investigation, the various excavations remained stable for the period of exposure (~30 minutes). Excessive sidewall collapse was only encountered within a single location (TP79- Segment 5), due to the occurrence of non-cohesive alluvial deposits with a very low in-situ consistency.

It should be noted that the long-term stability of the various material horizons is not certain. As such, it is recommended that excavations be adequately sloped and/or braced to ensure their stability.

### **4.3.4 Corrosivity**

**At the time during which this report was compiled, the laboratory results had yet to be received. These results, and any analysis thereof, will form part of the final report.**

### **4.3.5 Erosivity**

**At the time during which this report was compiled, the laboratory results had yet to be received. These results, and any analysis thereof, will form part of the final report.**

### **4.3.6 On-site Material Utilisation**

**At the time during which this report was compiled, the laboratory results had yet to be received. These results, and any analysis thereof, will form part of the final report.**

## 5 Good Construction Practices

### 5.1 General Material Specifications - Pipelines

#### 5.1.1 Selected granular material

According to the SANS 2001-DP1:2008 Earthworks for buried pipelines and prefabricated culverts- specification, ideal **selected granular material** used in pipe bedding, i.e.: the material on which the pipe will rest, should be granular, freely draining, non-cohesive material composed of particles with a diameter not exceeding 20 mm, and a measured Compactivity Factor not exceeding 0.3.

#### 5.1.2 Selected fill material

According to the SANS 2001-DP1:2008 Earthworks for buried pipelines and prefabricated culverts- specification, ideal **selected fill material**, i.e.: the material blanketing the pipe after placement, is defined as material exhibiting a Plasticity Index (PI) not exceeding 6, that is free from vegetation, lumps and granular material with a diameter exceeding 30 mm.

#### 5.1.3 Fine granular material

According to the SANS 2001-DP1:2008 Earthworks for buried pipelines and prefabricated culverts- specification, ideal **fine granular material**, is comprised of material exhibiting a particle diameter ranging between 0.15 and 6.70 mm.

#### 5.1.4 Backfill material

According to the SANS 2001-DP1:2008 Earthworks for buried pipelines and prefabricated culverts- specification:

- a) Except as specified in (b) below, material excavated from trenches may be used as backfill in all areas, provided that it contains little or no organic material, that it excludes stone of average dimension exceeding 150 mm, and that it can be placed without significant voids and so compacted as to avoid significant settlement.

Material containing more than 10% of rock or hard fragments that are retained on a sieve of nominal aperture size 50 mm, and material containing large clay lumps that do not break up under the action of compaction equipment being used, will be regarded as **unsuitable** for use in backfilling.

- b) In areas subject to loads from road traffic and in other areas specified in the project specification, backfill shall have a PI not exceeding 12 and a minimum CBR of 15% at specified density if the backfill is to be placed in the upper 150 mm of the subgrade, and a minimum CBR of 7% if the backfill is to be placed lower in the subgrade.

## 5.2 Excavations and Earthworks

It is recommended that all earthworks be carried out in accordance with standards put forward in **SANS 10400-G** (current version).

With regard to the various excavation classes discussed in this report, according to **SANS 1200 D**, the classifications can be summarised as follows:

### Restricted Excavation

- Hard Rock: Material that cannot be removed without blasting or wedging and splitting
- Intermediate: Material which can be removed by a back-acting excavator having a fly wheel power >0.10 kW for each mm of tined-bucket width, or with the use of pneumatic tools before removal by a machine capable of removing soft material.
- Soft: Material which can be efficiently removed by a back-acting excavator of a fly wheel power >0.10 kW for each mm of tined bucket width

### Non-restricted Excavation

- Hard Rock: Material that cannot be effectively ripped by a bulldozer having an approximate mass of 35 tonne and a fly wheel power of 220 kW
- Intermediate: Material which can be effectively ripped by a bulldozer having an approximate mass of 35 tonne and a fly wheel power of 220 kW
- Soft: Material which can be effectively removed or loaded, without prior ripping, by any of the following plant:
  - A bulldozer or track type front end loader having an approximate mass of 22 tonne and a fly wheel power of 145 kW.
  - A bulldozer or track type front end loader having an approximate mass of 22 tonne and a fly wheel power of 145 kW.
  - A tractor-scraper unit having an approximate mass of 28 tonne and a fly wheel power of 245 kW, pushed during loading by a bulldozer equivalent to that described above.

## 5.3 Drainage

An important factor in the promotion of a stable site is the control and removal of both surface and groundwater from the site. It is important that the design of the storm water management system allow for the drainage of accumulated surface water. Disposal of storm water should in any case conform to the Department of Water Affairs and Forestry and local authority requirements. This includes the obtaining of water use licenses when necessary.

### 5.3.1 Surface Drainage

It is recommended that an efficient surface drainage system be installed around all structures and along all roads throughout the site in order to:

- prevent the ponding of water next to structures directly after heavy precipitation events, this may lead to differential settlement as the saturated material undergoes densification.
- prevent large-scale changes in soil moisture beneath the structures on a seasonal basis.
- prevent the seasonal formation of perched water tables (i.e.: short-term groundwater seepage) within the soil material at shallow depth.
- prevent the possible lateral movement of liquids within the upper soil horizons.

The precautionary measures should ideally include:

- the sealing of open ground surfaces by means of either of the following:
  - a. the cultivation of a natural soil cover (e.g.: grass)
  - b. compaction of the soil surface
  - c. bitumen or concrete paving
- the removal of surface run-off by means of an efficient surface drainage system.
- roads should preferably be constructed parallel to the natural surface elevation contours rather than perpendicular to it, in order to reduce run-off velocities

### 5.3.2 Sub Surface Drainage

Areas requiring subsoil drainage will have to be assessed on site during the construction phase of the development. Should ground water be encountered during construction, these zones will need to be controlled with effective subsoil drains in order to prevent the damming up of groundwater against foundations. The configuration of the sub-surface drains should allow for the interception of groundwater interflow (lateral flow), particularly within areas upslope of the structures. Furthermore, the drains should be designed with adequate capacity and installed at suitable depths in order to allow for sufficient drawdown within the soils surrounding and immediately below the foundations.

## 5.4 Earthworks

It is recommended that all earthworks be carried out in accordance with SANS 10400-G (current version). The imported material should be placed in layers not exceeding 200 mm in thickness and compacted to a minimum of 90% Modified AASHTO maximum dry density.

Cut and fill slopes should be top soiled and planted with grass. This will limit erosion of these slopes and the problems associated with wash-aways of fill embankments.

## 5.5 Slope Stability Measures

Several slope stabilizing measures can be implemented for construction (the nature and design of which to be assessed and determined by responsible engineer).

These methods may include but are not limited to the following:

- Modifying the slope geometry by reducing the slope angle, removing weight from the slope head, increasing weight at the slope toe and/or constructing of benches or berms.
- Constructing walls or other retaining elements (reinforced earth walls, gabion walls).
- Surface protection measures including wire meshes, geotextiles and using plant cover to help reinforce the ground surface of slopes, which were excavated in soils.

Note that water present within the slope, along with destabilising pore pressures, are often the main cause of slope instability. Therefore, adequate drainage measures need to be implemented.

## 5.6 Corrosion Resistance

Considering the potentially corrosive material across the site several methods for corrosion protection can be implemented.

These methods may include but are not limited to the following:

- Sealers and membrane-type coatings (resins, epoxies, emulsions) applied to the concrete surface.
- Concrete reinforcement coatings including nickel, stainless steel and zinc.
- Overlays including Portland cement, latex-modified concrete and polymer concrete.
- Addition of corrosion inhibitors and admixtures to the concrete.
- Adequate site drainage measures to avoid soil saturation.

## 5.7 Development within 1 : 100 year-flood lines

It must be noted that the National Water Act (Act 36 of 1998) states the following regarding development within the 1 : 100 year-flood line of any stream or river (Thompson, 2006):

**Section 21(c):** Impeding or diverting the flow of water in watercourses (including alteration of the hydraulic characteristics of flood events) requires licensing according to the Act

**Section 21(i):** Any action that may alter the bed, banks, courses or characteristics of watercourses (including flood events) requires licensing according to the Act, including:

- ii. widening or straightening of the bed or banks of a river to allow for the construction of a bridge, sports ground or housing development
- iii. altering the course of a river partially or completely (i.e.: river diversion) to be able to use or develop the area where the watercourse originally was.

The National Water Act does not prohibit development within 1 : 100 year-flood lines; however, the Act requires detailed analysis of the effects of the proposed development on the surrounding environment, with special reference to surface and sub-surface water flow. The Act requires that suitable precautionary measures be implemented to limit the effect within and downstream from the proposed development.

## 6 Report Provisions

The presented geotechnical model is based on point data, for this reason, inconsistencies identified during the construction phase of the project should be assessed on site by a qualified individual. Furthermore, the collected data was extrapolated across the site and for this reason, site conditions may vary (for better or worse) from that present in this report. Excavations should therefore be overseen by a competent engineering geologist or geotechnical engineer, in order to identify and assess any variance in the geotechnical character exposed in these trenches.

Test pits were not backfilled in a controlled manner, as such, should these excavations fall within the design footprint of the proposed pipeline, these areas should be over excavated and backfilled in controlled layers.

## 7 Bibliography

**BRINK, A.B.A. AND BRUIN, R.M.H., 2002**

*Site Investigation Code of Practice, 1st Edition, South African Institution of Civil Engineering - Geotechnical Division, January, 2010*

**BYRNE, G, EVERETT, J P and SCHWARTZ, K, 1995.**

*A guide to practical geotechnical engineering in Southern Africa. Third Edition, Franki.*

**LOOK, B G, 2014.**

*Handbook of Geotechnical Investigation and Design Tables, 2nd Edition.*

**COMMITTEE OF LAND TRANSPORT OFFICIALS (COLTO), 1998**

*Standard Specifications for Road and Bridge Works for State Authorities, SAICE, South Africa*

**CONRADIE, D C U, 2012.**

*South Africa's Climatic Zones: Today, Tomorrow*

**DEPARTMENT OF PUBLIC WORKS, 2007.**

*Identification of problematic soils in Southern Africa – Technical notes for Civil and Structural Engineers PW2006/1. July 2007.*

**DEPARTMENT OF WATER AND SANITATION, 2016.**

*New Water Management Areas- Government Gazette, No. 40279, September 2016*

**GEOTECHNICAL DIVISION OF SAICE, 2010.**

*Site Investigation Code of Practice, 1st Edition, South African Institute of Civil Engineers – Geotechnical Division, January 2010.*

**KIJKO, A, GRAHAM, G, BEJAICHUND, M, ROBLIN, D & BRANDT, M B C, 2003.**

*Probabilistic peak ground acceleration and spectral seismic hazard maps for South Africa. Council for Geoscience report 2003/0053.*

**MUCINA, L & RUTHERFORD, M C, 2006.**

*The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria.*

**PARISEAU, R, 2012**

*Design Analysis in Rock Mechanics. 2nd Edition, CRC Press London.*

**RAJAPAKSE, R, 2008**

*Geotechnical Engineering Calculations and Rules of Thumb- Elsevier.*

**SA-EXPLORER, 2000-2017.**

*South Africa Maps*

**SOUTH AFRICAN BUREAU OF STANDARDS (SABS 1200 D)**

*Specifications for Civil Engineering Construction D: Earthworks (1998)*

**SOUTH AFRICAN INSTITUTE OF CIVIL ENGINEERS – Code of Practice.**

*Foundations and Superstructures for Single Storey Residential Buildings of Masonry Construction, Joint Structural Division, 1995, Johannesburg.*

**SOUTH AFRICAN NATIONAL STANDARDS (SANS 2001-DP1)**

*Earthworks for buried pipelines and prefabricated culverts Part DP1, 2008*

**SOUTH AFRICAN NATIONAL STANDARDS (SANS 10400 P)**

*National Building Regulations P: Drainage, 2010*

**SOUTH AFRICAN NATIONAL STANDARDS (SANS 10400 G)**

*National Building Regulations G: Excavations, 2010*

**TERZAGHI, K, 1943.**

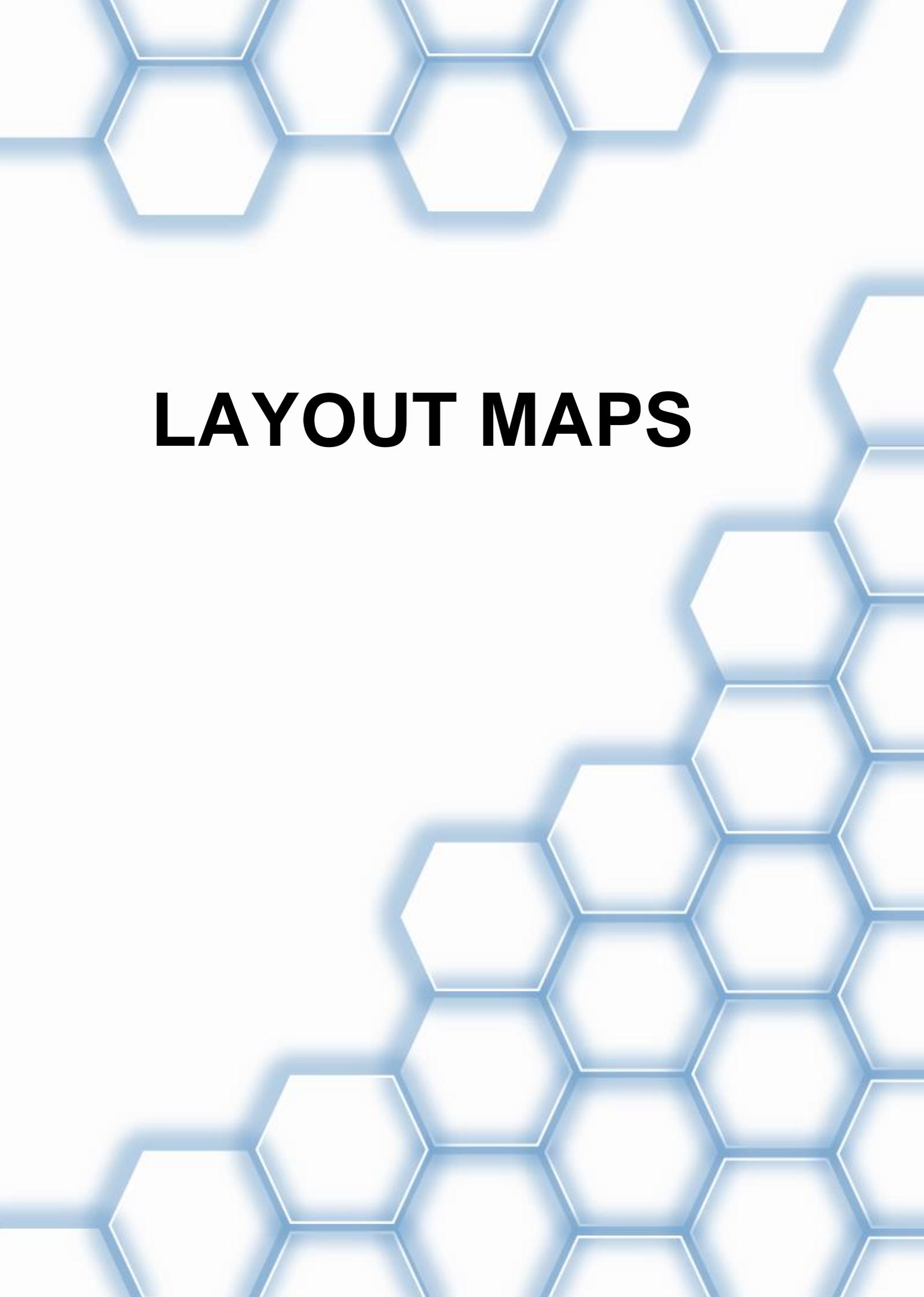
*Theoretical Soil Mechanics, Wiley, New York.*

**WEINERT, H H, 1980.**

*The natural road construction materials of Southern Africa. Academia, Cape Town.*

**WALTHAM, T, 2009.**

*Foundations of Engineering Geology, Taylor & Francis, Abingdon.*



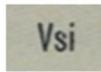
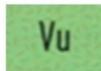
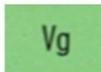
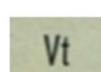
# LAYOUT MAPS



**FIGURE 2**

Regional Geology Map

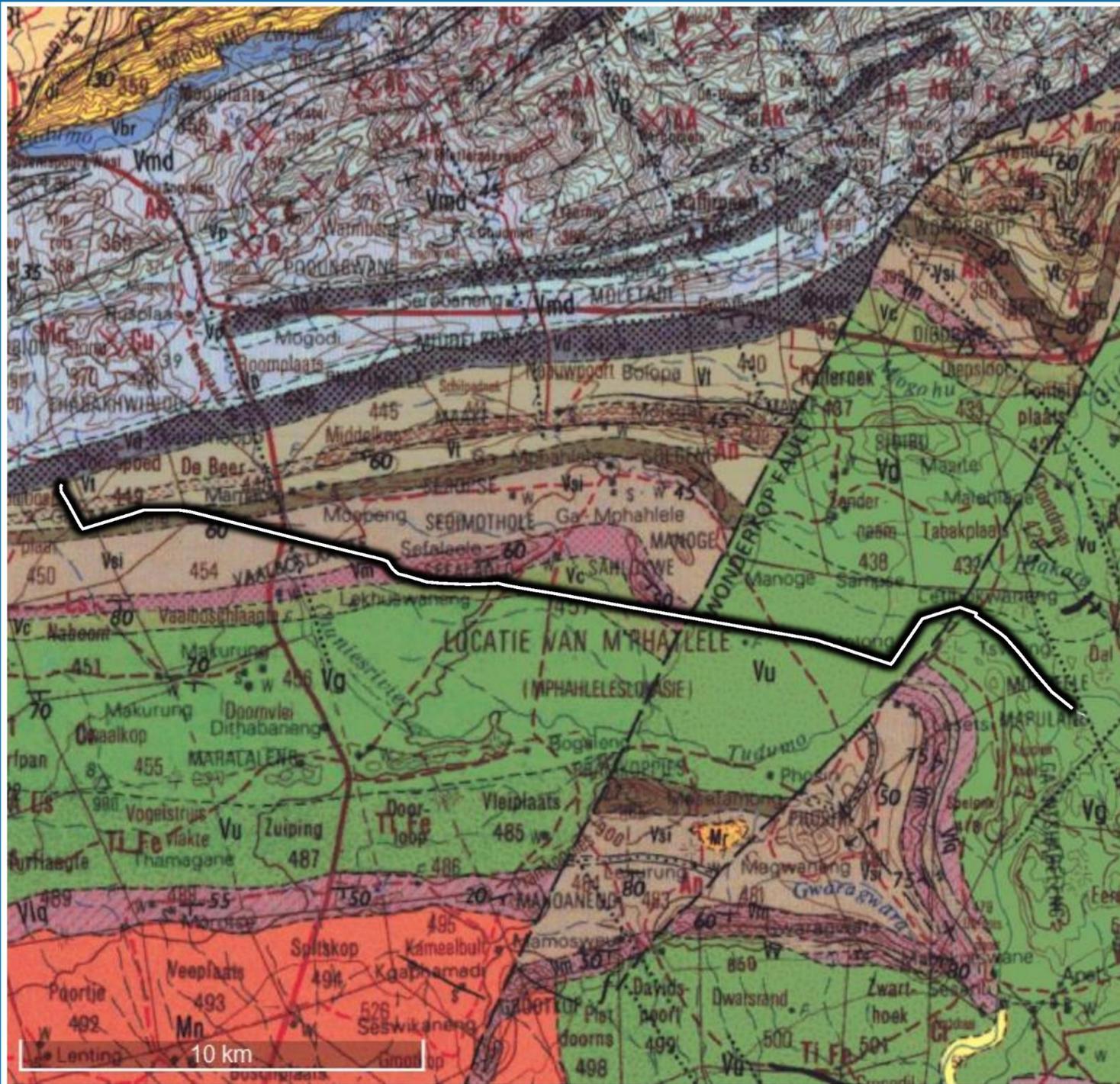
**LEGEND**

-  Wonderkop Fault
-  **Vm** Quartzite  
Magaliesberg Formation
-  **Vsi** Hornfels, Carbonaceous Shale  
Silverton Formation
-  **Vu** Ferrogabbro, Troctolite  
Rustenburg Layered Suite
-  **Vg** Gabbro, Norite  
Rustenburg Layered Suite
-  **Vt** Shale, Hornfels  
Timeball Hill Formation

Geological Series Map:  
2428 Nylstroom; Scale 1 : 250 000



Drawn By: Johannes Heyneke

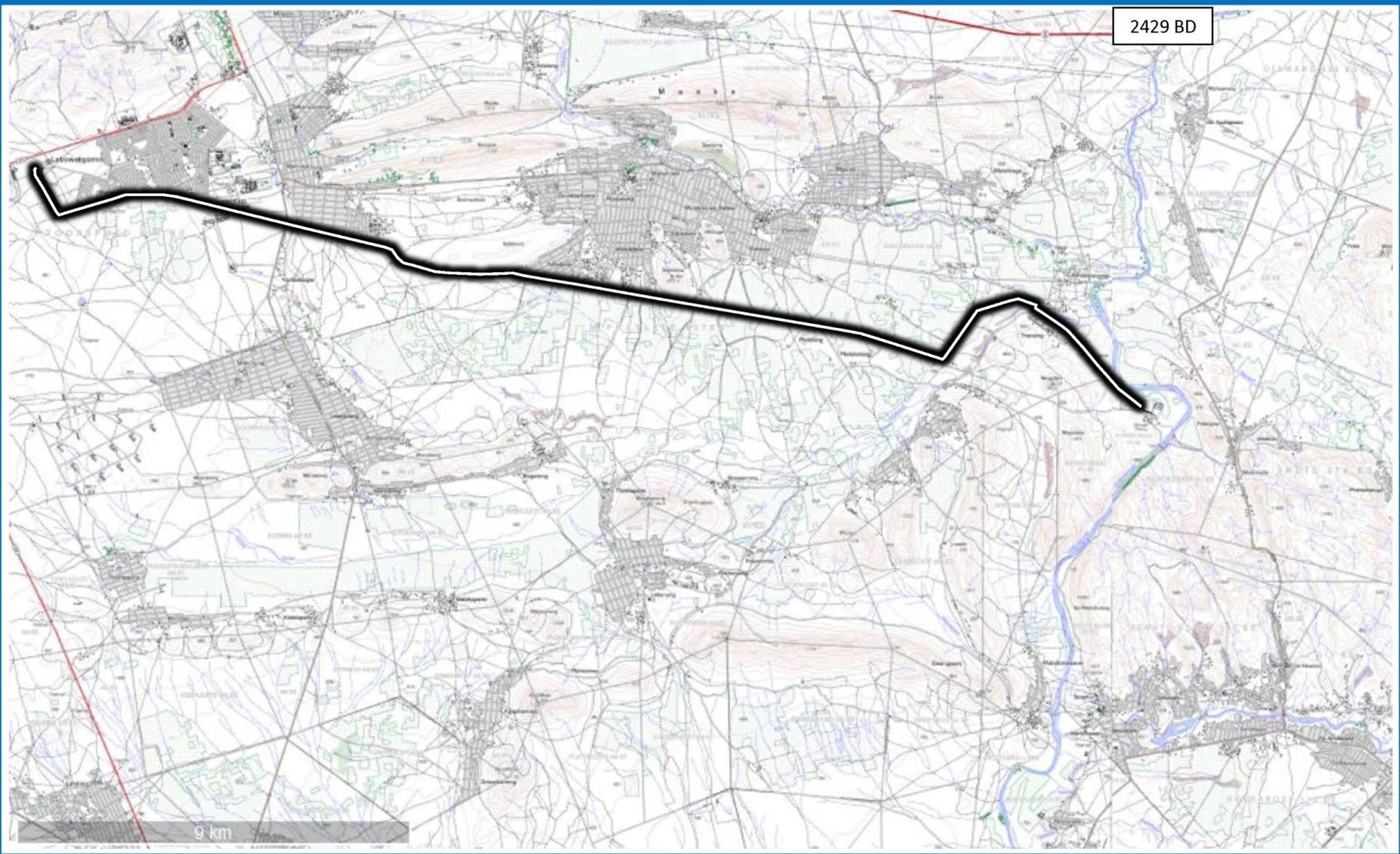


Topocadastral Map:  
2429 BC; Scale 1 : 50 000  
2429 BD; Scale 1 : 50 000

### FIGURE 3

Topocadastral Map

Drawn By: Johannes Heyneke



# FIGURE 4

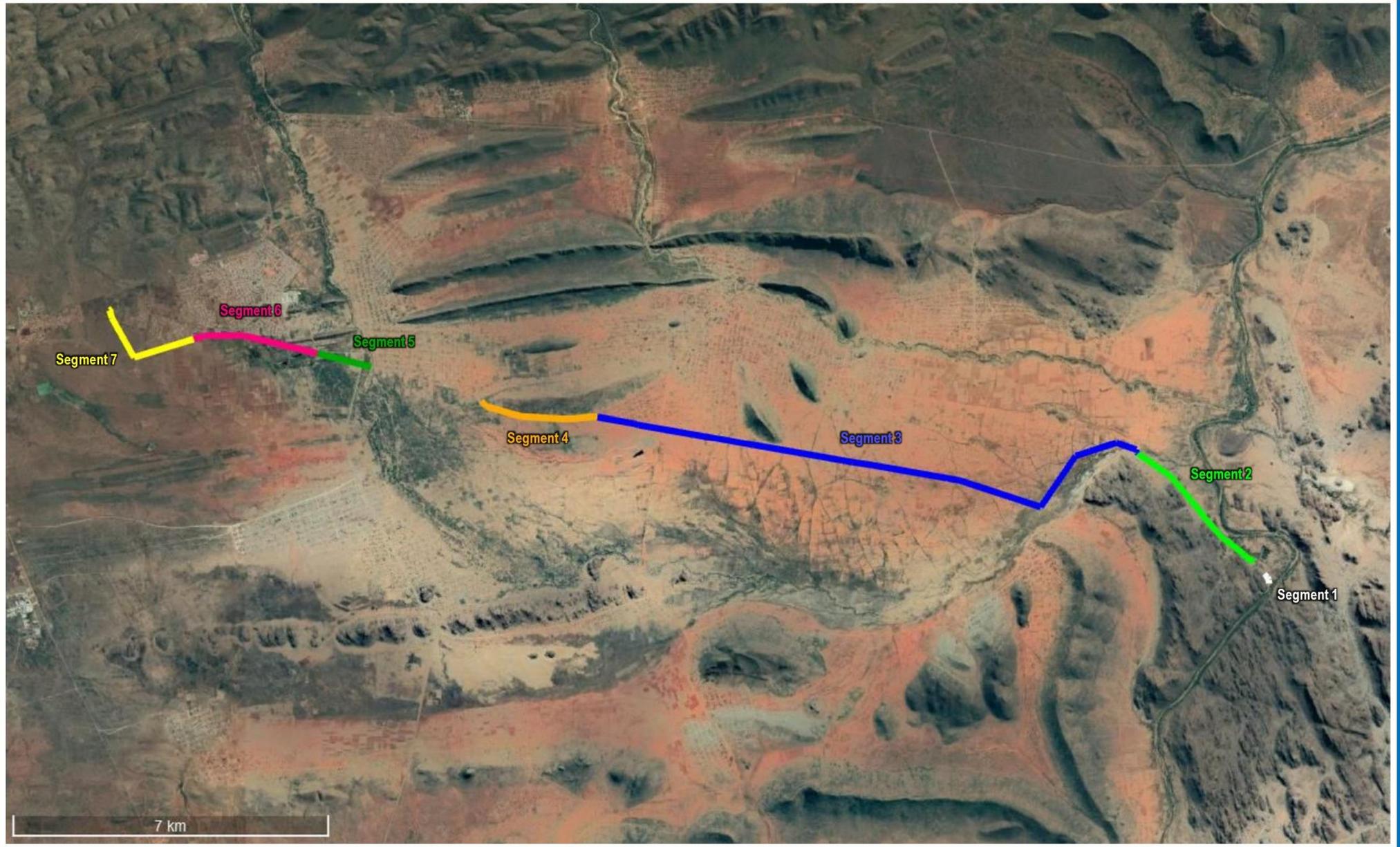
Site Segmentation

Drawn By: Johannes Heyneke



# MABU

GEOTECHNICAL CONSULTANCY



## FIGURE 5

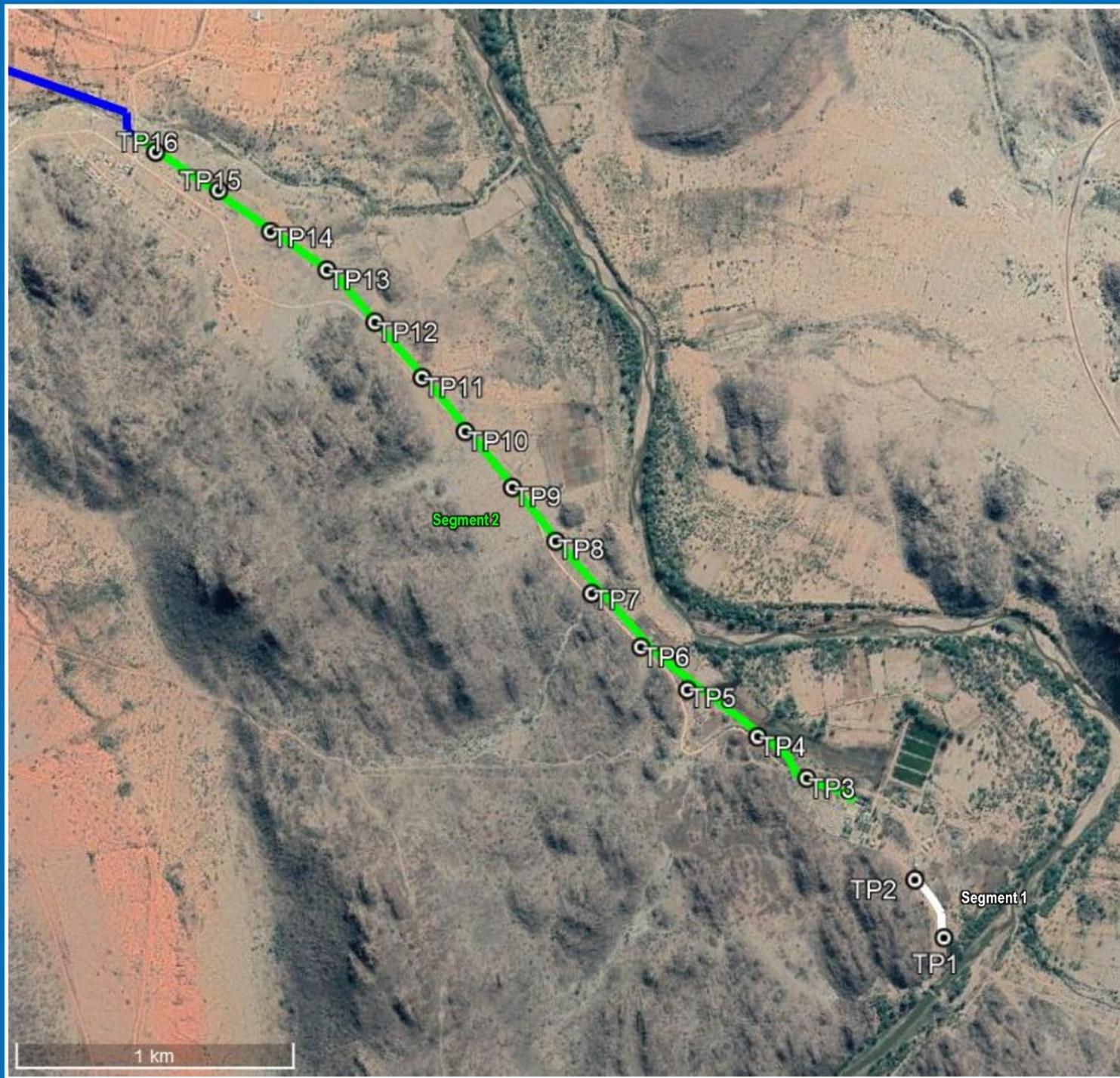
Segment 1 & Segment 2

### LEGEND

○ Test Pits



Drawn By: Johannes Heyneke



# LEGEND

⊙ Test Pits

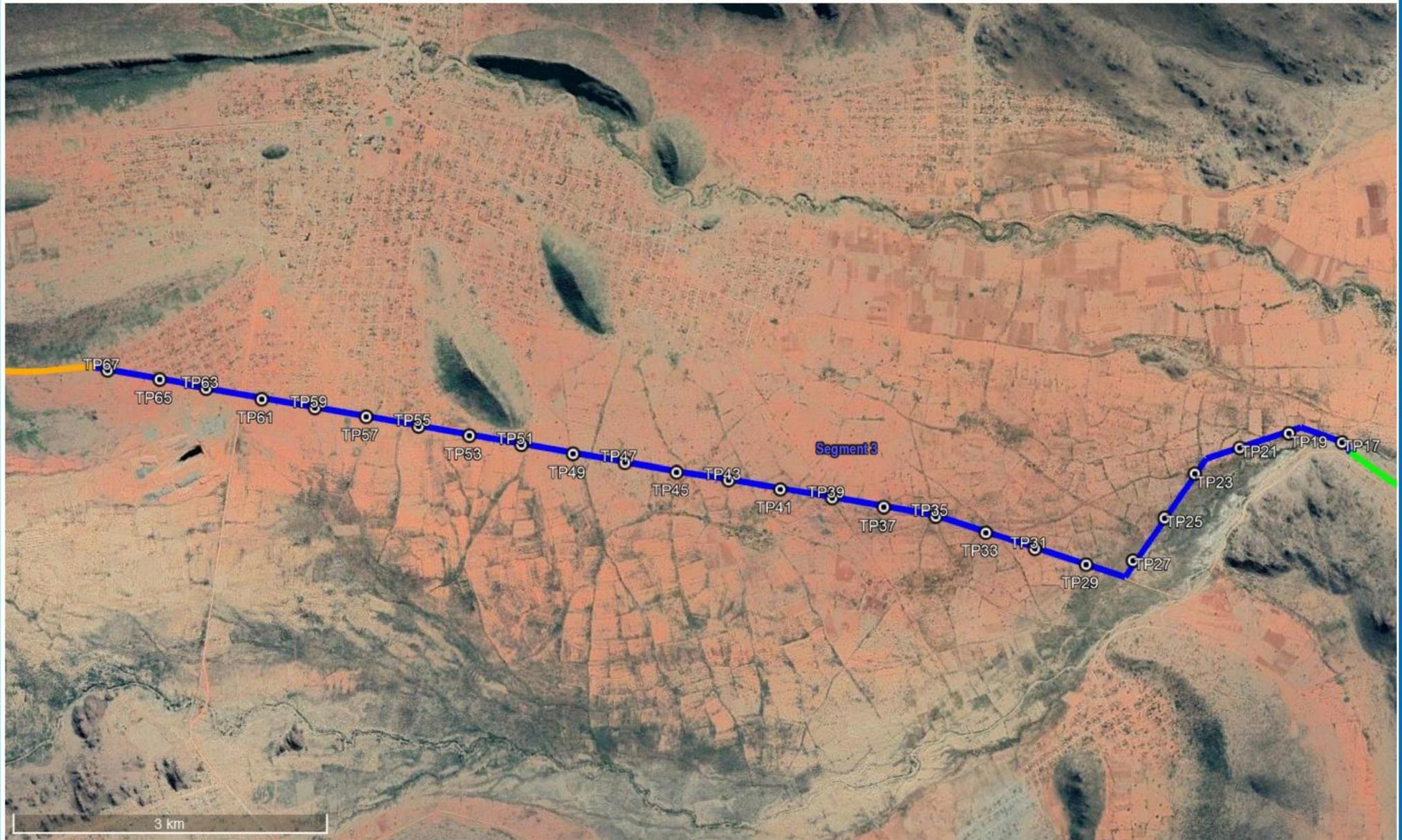
# FIGURE 6

Segment 3



Drawn By: Johannes Heyneke

(Note: odd number TPs excluded for better image quality)



# LEGEND

⊙ Test Pits

# FIGURE 7

Segment 4 & Segment 5

Drawn By: Johannes Heyneke



# LEGEND

⊙ Test Pits

# FIGURE 8

Segment 6 & Segment 7

Drawn By: Johannes Heyneke



## FIGURE 9

GPS Coordinates

TP1 to TP25

Test Pit Locations			
Test Pit Number	Latitude (South)	Longitude (East)	Final Excavation Depth with TLB (m)
TP1	24.35908	29.76173	2.50
TP2	24.35721	29.76070	0.90
TP3	24.35397	29.75687	0.65
TP4	24.35263	29.75513	0.90
TP5	24.35112	29.75264	1.20
TP6	24.34976	29.75099	0.95
TP7	24.34803	29.74925	0.60
TP8	24.34636	29.74798	0.00
TP9	24.34463	29.74644	2.00
TP10	24.34284	29.74477	1.20
TP11	24.34111	29.74324	1.60
TP12	24.33934	29.74157	1.70
TP13	24.33766	29.73987	1.20
TP14	24.33643	29.73787	1.10
TP15	24.33511	29.73603	0.95
TP16	24.33388	29.73380	1.55
TP17	24.33245	29.73230	0.80
TP18	24.33191	29.72930	1.65
TP19	24.33168	29.72732	2.35
TP20	24.33222	29.72509	2.50
TP21	24.33291	29.72270	2.10
TP22	24.33365	29.72027	2.40
TP23	24.33505	29.71849	2.40
TP24	24.33696	29.71718	1.70
TP25	24.33882	29.71565	2.40

Please note that all GPS co-ordinates are extracted from Garmin eTrex 10<sup>tm</sup>.



Drawn By: Johannes Heyneke

## FIGURE 10

GPS Coordinates

TP26 to TP50



Drawn By: Johannes Heyneke

### Test Pit Locations

Test Pit Number	Latitude (South)	Longitude (East)	Final Excavation Depth with TLB (m)
TP26	24.34071	29.71428	1.95
TP27	24.34245	29.71268	0.95
TP28	24.34355	29.71049	1.80
TP29	24.34278	29.70828	0.50
TP30	24.34214	29.70577	2.25
TP31	24.34143	29.70348	0.70
TP32	24.34077	29.70119	0.95
TP33	24.34004	29.69888	1.60
TP34	24.33938	29.69652	1.05
TP35	24.33866	29.69419	1.75
TP36	24.33830	29.69175	1.85
TP37	24.33789	29.68932	1.40
TP38	24.33749	29.68687	1.25
TP39	24.33711	29.68448	1.30
TP40	24.33675	29.68204	0.90
TP41	24.33635	29.67961	0.65
TP42	24.33596	29.67715	0.80
TP43	24.33554	29.67477	1.15
TP44	24.33521	29.67232	1.65
TP45	24.33487	29.66989	1.55
TP46	24.33449	29.66746	2.15
TP47	24.33405	29.66506	2.80
TP48	24.33372	29.66261	2.65
TP49	24.33333	29.66019	2.55
TP50	24.33291	29.65778	2.00

Please note that all GPS co-ordinates are extracted from Garmin eTrex 10<sup>tm</sup>.

## FIGURE II

GPS Coordinates

TP51 to TP75



Drawn By: Johannes Heyneke

### Test Pit Locations

Test Pit Number	Latitude (South)	Longitude (East)	Final Excavation Depth with TLB (m)
TP51	24.33255	29.65535	2.50
TP52	24.33218	29.65291	2.60
TP53	24.33178	29.65047	2.50
TP54	24.33139	29.64806	2.70
TP55	24.33098	29.64571	2.60
TP56	24.33053	29.64312	2.50
TP57	24.33016	29.64080	2.60
TP58	24.32975	29.63836	2.50
TP59	24.32940	29.63599	2.55
TP60	24.32904	29.63347	1.35
TP61	24.32866	29.63100	1.40
TP62	24.32819	29.62864	1.65
TP63	24.32775	29.62579	2.50
TP64	24.32743	29.62382	2.50
TP65	24.32697	29.62144	2.50
TP66	24.32657	29.61903	2.50
TP67	24.32618	29.61655	2.50
TP68	24.32602	29.61407	1.85
TP69	24.32618	29.61158	2.20
TP70	24.32632	29.60917	1.10
TP71	24.32629	29.60676	1.85
TP72	24.32611	29.60426	1.55
TP73	24.32593	29.60185	1.50
TP74	24.32589	29.59950	1.25
TP75	24.32552	29.59695	1.35

Please note that all GPS co-ordinates are extracted from Garmin eTrex 10<sup>tm</sup>.

## FIGURE 12

GPS Coordinates

TP76 to TP105

Test Pit Locations			
Test Pit Number	Latitude (South)	Longitude (East)	Final Excavation Depth with TLB (m)
TP76	24.32494	29.59456	2.50
TP77	24.32439	29.59215	1.90
TP78	24.32310	29.59028	1.65
TP79	24.31614	29.56587	2.40
TP80	24.31514	29.56239	2.50
TP81	24.31470	29.56021	2.50
TP82	24.31417	29.55769	2.50
TP83	24.31364	29.55553	2.50
TP84	24.31312	29.55301	1.10
TP85	24.31259	29.55061	1.50
TP86	24.31204	29.54827	2.15
TP87	24.31147	29.54581	0.95
TP88	24.31088	29.54316	0.75
TP89	24.31027	29.54116	0.60
TP90	24.30984	29.53881	1.30
TP91	24.30961	29.53600	1.95
TP92	24.30977	29.53358	2.50
TP93	24.30979	29.53105	2.20
TP94	24.31067	29.52888	1.50
TP95	24.31130	29.52658	2.20
TP96	24.31188	29.52456	2.10
TP97	24.31261	29.52196	2.00
TP98	24.31286	29.51934	2.50
TP99	24.31342	29.51698	1.95
TP100	24.31409	29.51455	2.50
TP101	24.31230	29.51319	2.50
TP102	24.31028	29.51199	2.35
TP103	24.30838	29.51081	2.20
TP104	24.30639	29.50962	2.55
TP105	24.30461	29.50937	2.50

Please note that all GPS co-ordinates are extracted from Garmin eTrex 10<sup>tm</sup>.



Drawn By: Johannes Heyneke

---

## C5.1-2: REHABILITATION OF MEGORING AND THAKGALANG RIVER CROSSINGS

---

Contractor

Witness 1

Witness 2

Employer

Witness 1

Witness 2

# **ANNEXURE C5.2**

## **BASELINE RISK ASSESSMENT**

<b>GATSHENI SIZWE(PTY) LTD</b> <b>BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER:</b> <b>OLIFANTSPOORT AND EBENEZER</b> <b>WATER SUPPLY SCHEMES:</b> <b>PIPELINE FROM PS1</b> <b>(OLIFANTSPOORT WTW) TO SPECON</b>	<b>BASELINE</b> <b>2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPOORT AND EBENEZER WATER</b> <b>SUPPLY SCHEMES</b>		
		

## TERMS OF REFERENCE

The Health and Safety Baseline Risk Assessment was conducted based on scope of works set out and site visit. The objective of this baseline risk assessment is to identify and evaluate all baseline risks associated with the execution of the **PROJECT NUMBER: OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPOORT WTW) TO SPECON**

## EXECUTIVE SUMMARY

All construction and maintenance activities can subject workers to levels of Occupational stressors and safety factors, e.g., noise, fumes, revolving motor machinery, tools, moving vehicles, electricity, etc., which permanently harm the health and physical wellbeing of persons at work and greatly reduce productivity. The Occupational Health and Safety Act of 1993, and its relevant regulations, require employers to conduct surveys of the actual situation at every site. Measurements must be taken and the identified problems addressed by the employer. Improved conditions ensure better worker morale, loyalty and greater productivity.

## SCOPE OF WORK

### **PROJECT NUMBER: OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPOORT WTW) TO SPECON**

Therefore Gatsheni Sizwe (Pty) Ltd on behalf of Lepelle Northern Water has therefore prepared the following below, must be provided and adhered to by Principal Contractor by means of a Health and Safety File, Plan and Health and Safety Compliance on the following project: Lepelle Northern Water: Refurbishment and Minor Modification of Ebenezer High Lift Pump Station The objective is to ensure that Principal Contractor entering into a contract with Lepelle Northern Water achieves and maintains an acceptable level of occupational health, safety and environmental performance and compliance.

The work to be performed under this contract comprises of the following:

The treatment system involves direct filtration purification works with air stripping pre-treatment and chlorination for disinfection post treatment. The raw water supply is of a very good quality under normal circumstances, however, occasional floods within the catchment of the Ebenezer Dam led to periods of high raw water turbidity. This requires intensive closing and results in short filter runs with the plant struggling to maintain the final water quality targets.

<b>GATSHENI SIZWE(PTY) LTD</b> <b>BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER:</b> <b>OLIFANTSPOORT AND EBENEZER</b> <b>WATER SUPPLY SCHEMES:</b> <b>PIPELINE FROM PS1</b> <b>(OLIFANTSPOORT WTW) TO SPECON</b>	<b>BASELINE</b> <b>2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES</b> <div style="display: flex; justify-content: space-around; align-items: center;">    </div>		

An approximately 26 km long 800 mm dia pumping main from PS1 to the Specon reservoir site in Lebowakgomo was constructed in the mid-1970's with a number of additional offtakes provided along the pipeline route since then. The proposed scope of works for Phase 1 of this project includes the construction of a new 1500 mm dia steel pumping main along the route of existing pipeline, with two major diversions to facilitate better access to the pipeline and to limit impact on the communities along the pipeline route.

The first 7 km long section of the pipeline will start approximately 200 m downstream of pump station PS1 where the new 1500 mm dia pipeline will branch off from the existing 800 mm dia pumping main. The existing pipeline crosses through a hilly and rocky terrain, which is inaccessible to vehicles. Therefore, in order to facilitate pipeline maintenance and repairs this section of the new pipeline will be diverted to enable construction of a service road. Afterwards the new pumping main runs for approximately 15 km parallel to the existing pipeline through a sparsely populated rural area before crossing under R579 provincial road. The last section of the pipeline includes a 3.8 km long diversion to avoid residential development in Lebowakgomo before terminating at the Specon reservoir site.

**1. DEFINITIONS**

- 1.1. **Hazard:** a situation that poses a level of threat to People, production, property, or the environment.
- 1.2. **Risk:** The probability that something unwanted/ unpleasant will happen
- 1.3. **Severity** is the anticipated extent or damage that may occur as a result of an unplanned event.
- 1.4. **Frequency:** how often does activity occur within a predetermined time
- 1.5. **Likelihood:** how likely are the consequences to occur

**2. RISK RATINGS**

- 2.1. Consider what can go wrong that can hurt someone
- 2.2. Determine what the most likely outcome would be - Consequences
- 2.3. Determine worst case scenario how likely those consequences are - Likelihood
- 2.4. Calculate the risk rating
- 2.5. Required action

<b>GATSHENI SIZWE(PTY) LTD BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER: OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPOORT WTW) TO SPECON</b>	<b>BASELINE 2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES</b>		
		

### 3. **CONSEQUENCES:**

- 3.1. Severe - Death or permanent disability to one or more persons
- 3.2. Major - hospital admission required
- 3.3. Moderate - medical treatment required
- 3.4. Minor - first aid required
- 3.5. Insignificant - injuries not requiring first aid

### 4. **LIKELIHOOD**

- 4.1. Almost certain - expected to occur in most circumstances
- 4.2. Likely - will probably occur in most circumstances
- 4.3. Possible - could occur at some time
- 4.4. Unlikely - is not likely to occur in normal circumstances
- 4.5. Rare - may occur only in exceptional circumstances

### 5. **METHOD**

The basic risk assessment principles that will be followed are hazard identification, hazard quantification, risk identification, risk evaluation and ranking and lastly risk management recommendations. (Risk evaluation is described under the heading “Risk evaluation criteria”.) This assessment will be reviewed whenever the Project Scope is altered or after serious / repetitive incidents.

<b>GATSHENI SIZWE(PTY) LTD BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER: OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPOORT WTW) TO SPECON</b>	<b>BASELINE 2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES</b>		
		

## 6. **RESPONIBILITIES**

- 6.1. Site Management - To ensure that Risk Assessments are conducted, assessed, communicated, addressed and signed.
- 6.2. Occupational Health Safety Officer- To ensure and enforce that Risk Assessments are communicated and utilized as a tool during work activities on site, as well as activities in the lay down areas.
- 6.3. Supervision: To ensure that existing Risk Assessments remain applicable and regularly updated upon changes and replacements.
- 6.4. OHS Representative: To discuss risks on a daily basis and to assist employees regarding changes in risk

<b>GATSHENI SIZWE(PTY) LTD BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER: OLIFANTSPORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPORT WTW) TO SPECON</b>	<b>BASELINE 2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPORT AND EBENEZER WATER SUPPLY SCHEMES</b>		
		

## 7. LEGISLATIVE REQUIREMENTS

The following are legislation or guidelines that were identified as most applicable to this project:

- Construction Regulations, 2014
- The Constitution of the Republic of South Africa (particularly Section 24 of the Bill of Rights).
- Occupational Health and Safety Act 1993 (Act 85 of 1993) and its Regulations.
- National Environmental Management Act 1998 (Act 107 of 1998).
- National Road Traffic Act (93 of 1996) National Environmental Management: Waste Act 59 of 2008
- National Environmental Management Act 107 of 1998 and Amendments
- Air Quality Act 39 of 2004
- Hazardous Substances Act 15 of 1973
- National Water Act 36 of 1998
- Conservation of Agricultural Resources Act 1983 (Act 43 of 1983).
- Mine Health and Safety Act 29 of 1996
- Compensation for Occupational Injuries and Diseases Act No 130 of 1993 (COIDA)
- Applicable South African National Standards (SANS).
- ISO 9001:2008 –Quality Management Systems requirements
- ISO 14001:2004–Environment Management Systems requirements
- OHSAS 18001:2007 –Occupational Health and Safety Management Systems Requirement

<b>GATSHENI SIZWE(PTY) LTD BASELINE RISK ASSESSMENT</b>	<b>PROJECT NUMBER: OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES: PIPELINE FROM PS1 (OLIFANTSPOORT WTW) TO SPECON</b>	<b>BASELINE 2202</b>
<b>LEPELLE NORTHERN WATER</b>		
<b>OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES</b>		
		

- Electrical Installations Regulations GNR

#### 7.1. Risk Management (RM)

The RM methodology comprises five key elements, which are:

##### 7.1.1. Identify site hazards

These are conditions on site that could present Health and Safety risks. e.g. dust, noise, work at heights, travelling, trenching, rigging, uneven terrain, construction vehicle, traffic and hazardous chemical substances.

##### 7.1.2. Identify the risks

These are events that could adversely affect the Health and Safety of people as well as the environment. Included in this step is the identification of causal factors. The risk owner is the person accountable for ensuring that controls are in place, implemented and reviewed/ monitored. Highlight unanticipated risks due to abnormal conditions (e.g. sudden unexpected and short-term changes to environmental conditions).

##### 7.1.3. Analyze the Risks

With the hazards and risks identified, start with listing potential consequences and existing control measures. Then assess the effectiveness of the existing controls. Also taking into account existing controls, determine the anticipated consequences and the likelihood of these consequences using the prescribed framework for health, safety and environmental risks.

##### 7.1.4. Evaluate Risks

This step aimed at ensuring that adequate controls have been identified for the risks, adequate resources have been allocated and adequate progress is being made with implementation. The level of managerial oversight and the timeframe within which the treatment strategy must be established is dictated by the priority rating matrix.

LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES



Evaluation includes:

- 7.1.4.1. Agreement by appropriate managerial levels, that appropriate risk and control measures have been identified.
- 7.1.4.2. Review of the appropriateness of the control measures them.
- 7.1.4.3. Review of additional controls/ tasks that have been identified as necessary.
- 7.1.4.4. Assessment of the measures proposed for measuring the progress of implementation.
- 7.1.4.5. Assessment of the measures proposed for monitoring effectiveness of the controls.

The Contractor must ensure through his risk management process the hierarchy of controls stipulated as follows, are implemented:

1. **Eliminate** - The complete elimination of the hazard.
2. **Substitute** - Replacing the material or process with a less hazardous one.
3. **Redesign** - Redesign the equipment or work process.
4. **Separate** - Isolating the hazard by guarding or enclosing it.
5. **Administrate** - Providing control such as training, procedures etc.
6. **Personal Protective Equipment (PPE)** - Use of appropriate and properly fitted PPE where other controls are not practical. (PPE as the last resort)

**GATSHENI SIZWE(PTY) LTD  
BASELINE RISK ASSESSMENT**

**PROJECT NUMBER:  
OLIFANTSPOORT AND EBENEZER  
WATER SUPPLY SCHEMES:  
PIPELINE FROM PS1  
(OLIFANTSPOORT WTW) TO SPECON**

**BASELINE 2201**

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



**APPOINTMENTS AS PER THE CONSTRUCTION REGULATIONS**

Item	Regulation	Appointment	Responsible Person
1.	5(1)(k)	Principal contractor for each phase or project	Client
2.	7.(1)(v)	Contractor	Principal Contractor
3.	7(3)	Sub-Contractors	Contractor
4.	8(1)	Construction Manager	Contractor
5.	8(2)	Assistant Construction Managers	Contractor
6.	8(5)	Construction Safety Officer	Contractor
7.	8(7)	Construction supervisor	Contractor
8.	9(1)	Person to carry out Risk Assessment	Contractor
9.	9(3)	Risk Assessment Trainer/Instructor	Contractor
10.	10(1)(a)	Fall Protection Planner	Contractor
11.	12 (2)	Temporary Works Supervisor	Contractor
12.	11 (2))	Structures Examiner	Contractor
13.	13(1)	Excavation Supervisor	Contractor
14.	13(2)(ii)(bb)	Professional Engineer or Technologist	Contractor
15.	13(2)(k)	Explosives Expert	Contractor
16.	14(1)	Demolition Work Supervisor	Contractor

**GATSHENI SIZWE(PTY) LTD  
BASELINE RISK ASSESSMENT**

**PROJECT NUMBER:  
OLIFANTSPOORT AND EBENEZER  
WATER SUPPLY SCHEMES:  
PIPELINE FROM PS1  
(OLIFANTSPOORT WTW) TO SPECON**

**BASELINE 2201**

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



17.	14(2)	Demolition Expert	Contractor
18.	14(11)	Explosives Expert	Contractor
19.	16(1)	Scaffold Supervisor	Contractor
20.	17(2)(b)	Compliance Plan Developer	Contractor
21.	17(2)(ii)	Rigger	Contractor
22.	18 (1)	Rope Access Work Supervisor	
23.	19(8)(a)	Material Hoist Inspector	Contractor
24.	20(1)	Bulk Mixing Plant Supervisor	Contractor
25.	20(2)	Bulk Mixing Plant Operator	Contractor
26.	21(2)(b)	Explosive Actuated Fastening Device Operator	Contractor
27.	21.2 (g) (i)	Explosive Actuated Fastening Device Controller	Contractor
28.	22(a)	Crane Operator	Contractor
29.	23(d)(i)(ii)	Construction Vehicle and Mobile Plant Operator	Contractor

Item	Regulation	Appointment	Responsible Person
30.	23(1)(k)	Construction Vehicle and Mobile Plant Inspector	Contractor
31.	24(d)	Temporary Electrical Installations Inspector	Contractor
32.	24 (c)	Temporary Electrical Installations Controller	Contractor
33.	28 (a)	Stacking and Storage Supervisor	Contractor



**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



34.	29 (h)	Fire Equipment Inspector	Contractor
35.	29 (i)	Fire Fighter	Contractor

- This list may be used as a reference or tool to determine which components of the Act and Regulations would be applicable to a particular site. This list must not be assumed to be exclusive or exhaustive

**Activities**

A. Administration

B. Site Establishment and Construction Works

1. Clearing and grubbing of camp site
2. Fencing around camp site
3. Erection of barricades
4. Security at camp site
5. Erection of signs/speed limits on site
6. Delivery of materials at camp site
7. Loading and unloading of site materials (cement bags, tools, paving bricks, Steel Pipes, Reinforcement Steel)
8. Use of cranes for Concrete Slabs, Beams, Steel Tanks, Valves and Pumps
9. Stacking and storage of materials
10. Handling of hazardous chemicals
11. Environmental protection, sanitation and waste removal

C. Earthworks



LEPELLE NORTHERN WATER

OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES



1. Excavation and Laying of Bulk Steel Pipes
2. Backfill and compaction
3. Entering a confined space
4. Use of concrete
5. Use of hand tools
6. Use of machinery

D. Emergency preparedness

1. Evacuation during site emergencies
2. Providing first aid
3. Firefighting activities

E. Electrical power supply system, Electrical Sub-Station and energy powered tools

1. Working with electrical power supply system, portable electrical equipment

F. Housekeeping

1. Cleaning
2. Cleaning oil spillages
3. Waste disposal

G. Traffic accommodation

1. Workers crossing the road
2. Working in or next to the road

H. Public safety

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



I. Night work

REF	ACTIVITY, HAZARD & RISK IDENTIFICATION			LOS S TYPE	CONTROLS TO BE IMPLEMENTED	RISK ASSESSMENT			SWP / SOP /MS REF NUMBER
	ACTIVITY	HAZARD	RISK			(C)	(L)	CLASS	
<b>A. Administration</b>									
	Medical examinations	Employees unfamiliar with their medical conditions	Health problems resulting in time loss and project delays	H	<ul style="list-style-type: none"> <li>All employees are to be declared medically fit by a registered occupational health practitioner</li> </ul>	3	3	13(H)	
	Admin documentation	Nonconformance issues	Work stopped due to non-compliance		<ul style="list-style-type: none"> <li>All necessary permits, method statements and plans to be in place prior to commencement of task</li> </ul>	3	3	13(H)	
	Application of wayleaves	No wayleave and supporting permits	Time loss due to work stoppage by authorities		<ul style="list-style-type: none"> <li>Ensure that all documentation and permits are in place</li> </ul>	3	3	13(H)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



	Entering site without being inducted	Employees exposed to unknown hazards	resulting in unnecessary costs						
	Appointments	Appointments not done as per construction regulation	Moderate to severe injuries	S	<ul style="list-style-type: none"> <li>SHE induction must be given to persons before entering site</li> </ul>	4	4	21(CR)	
	Induction training	Persons have not received induction training before starting work	Time loss due to work stoppage by authorities	S	<ul style="list-style-type: none"> <li>Standard appointment letters should be completed as required by the OHSAct. Refer to Appointments in the safety file</li> </ul>	3	2	9(M)	
		Risk assessments not performed before commencement of any new work	Employees are not aware of the risks associated with their activities	S	<ul style="list-style-type: none"> <li>Management is to ensure that all workers have received health &amp; safety induction training pertaining to the hazards associated with the activities performed.</li> <li>Proof of the induction training must be maintained for all persons that perform high risk activities.</li> <li>Complete the Induction Form.</li> </ul>	4	3	18(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



	Performing Risk Assessments	and during hazardous activities	Employees are not aware of the risks they are exposed to during work	S	<ul style="list-style-type: none"> <li>Appoint a competent Supervisor in writing and provide HSE Representative Training. Supervisor to do a risk assessment that includes the following:</li> <li>The identification of risks and hazards to which persons may be exposed.</li> <li>The analysis and evaluation of the risks and hazards identified.</li> <li>A plan to mitigate, reduce or control the risks and hazards that have been identified.</li> </ul>	4	3	18(H)	
<b>B. Site Establishment and Construction Works</b>									
01	Clearing and grubbing of camp site	Incompetent Yellow plant machine operators,	Injury, injuries to third parties & fatalities	S	<ul style="list-style-type: none"> <li>Operator must have knowledge, experience, training, and qualifications specific to the work they have been appointed to do</li> </ul>	4	4	21(CR)	Environmental Management Plan
		Oil leakages from machines	Soil pollution	E	<ul style="list-style-type: none"> <li>Oil spills must be cleaned out</li> <li>Spill kits must be available onsite</li> </ul>	2	4	12(M)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



	Contractor's workers not following Safe Working Procedures (SWP)	Injuries	S	<ul style="list-style-type: none"> <li>Workers to be trained on safe working procedures</li> <li>Toolbox talks on importance of following SWP'S</li> </ul>	5	4	24(CR)	
	Working on uneven surfaces		S	<ul style="list-style-type: none"> <li>Use of proper footwear PPE</li> </ul>	3	3	13(H)	
	Damage to adjacent private property by machine bumping into private property	Leg & ankle injuries property damage	S	<ul style="list-style-type: none"> <li>Prior to the beginning of clearing or grubbing activities, the project engineer or the certified inspector is to inspect the area to determine if these activities are likely to cause damage or require access to adjacent private property.</li> <li>When felling, topping or trimming trees, broken or cut limbs are not to fall on or damage overhead wires.</li> </ul>	3	4	17(H)	
	Non disposal of generated waste		E	<ul style="list-style-type: none"> <li>The disposal of all cleared or grubbed materials is the responsibility of the</li> </ul>	2	4	12(M)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



			Environmental pollution	H	contractor to remove from the right-of-way and disposed at locations off the project outside the limits of view of the traveling public	3	5	20(H)	
		Exposure to venomous reptiles and insect bites	Manifestation of rodents	H	<ul style="list-style-type: none"> <li>All waste must be removed from site through a formal waste management program</li> <li>No littering is allowed on site</li> </ul>	3	4	17(H)	
		Exposure to dust from yellow plant machines	Insect bites and illness from snake bites	H	<ul style="list-style-type: none"> <li>Use of insect repellents</li> <li>Weed control</li> <li>Environmental awareness during toolbox talks</li> </ul>	3	4	17(H)	
			Illnesses associated with lungs, Pollution		<ul style="list-style-type: none"> <li>Spay water on ground to minimize the production of dust</li> <li>Employees working close to the machines and exposed for longer periods to the machine must be provided with dust masks</li> </ul>				

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



02	Fencing around camp site	Substandard fencing	Fence blown down in high winds	S	<ul style="list-style-type: none"> <li>The safety fencing should be strong enough and durable enough to withstand the elements</li> </ul>	3	3	13(H)	
		Exposure to sharp edges	Cuts & lacerations	S	<ul style="list-style-type: none"> <li>Wear proper PPE</li> </ul>	2	3	8(M)	
		Unauthorized persons accessing site via poor fencing and green netting	Theft	S	<ul style="list-style-type: none"> <li>It should be of a design that makes it difficult to climb</li> <li>It should have reinforcement at the bottom so that one cannot climb underneath it</li> </ul>	5	4	24(CR)	
		Persons entering site without PPE	Moderate to severe Injuries	S	<ul style="list-style-type: none"> <li>Gates or joins should not provide a security threat</li> <li>Persons must wear correct PPE before entering site</li> </ul>	4	4	21(CR)	
		Use of hand tools to erect fence		S	<ul style="list-style-type: none"> <li>Use of protective safety eyewear(goggles)</li> </ul>	4	4	21(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



03	Erection of barricades on work site	Work site not barricaded from public	Injuries to eyes  Moderate to severe injuries		<ul style="list-style-type: none"> <li>Erect barricades to control access to the job site from the public and control the worksite as a whole</li> </ul>	4	3	18(H)	
04	Security at camp site	Un-authorized persons entering site	Injuries	S	<ul style="list-style-type: none"> <li>No contractor may allow or permit any employee or person to enter site unless the person has undergone Health and safety induction training</li> </ul>	4	4	21(CR)	
		Unsecured storage facilities	Theft	S	<ul style="list-style-type: none"> <li>Security system and guards should be used</li> <li>Use very secure, lockable storage units</li> <li>Equipment and tools to be locked inside secure area</li> </ul>	1	4	7(M)	
	Substandard fencing	Fence blown away by wind if there is no net	Theft	S	<ul style="list-style-type: none"> <li>Use net to increase security</li> </ul>	1	4	7(M)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



05	Erection of signs/speed limits on site	Speeding vehicles on site	Vehicle accidents	S	<ul style="list-style-type: none"> <li>Ensure erection of site speed signs</li> </ul>	4	4	21(CR)	To be included in Traffic Management Plan
		Poor condition of hand tools used to erect signs	Hand and eye injuries	S	<ul style="list-style-type: none"> <li>Use of proper PPE (protective gloves and goggles)</li> </ul>	4	3	18(H)	
		Manual use of hand tools to dig holes	Back injuries from bending	S	<ul style="list-style-type: none"> <li>Training on proper bending postures</li> </ul>	3	3	13(H)	
		No signage on construction site	Employees parking vehicles anywhere on site	S	<ul style="list-style-type: none"> <li>Allocation of designated parking areas for delivery/plant vehicles and staff/visitors</li> </ul>	2	3	8(M)	
06	Delivery of materials at camp site	Incompetent vehicle and machinery operators	Accidents	S	Employment controls for persons required to drive. Valid driver's license.	4	4	21(CR)	To be included in Traffic Management Plan

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



	Driver not adhering to Safe driving techniques	Injuries	S	Safe driving techniques to be adhered to at all times	3	4	17(H)	
	Machinery operators not competent to perform specific appointed work	Injuries to third parties	S	Operator must have knowledge, experience, training, and qualifications specific to the work they have been appointed to do; follow SWP's	4	4	21(CR)	
	Oil spills from machinery	Environmental pollution	E	Use of spill kits and persons trained on using them; regular maintenance of forklifts; use of drip trays	4	4	21(CR)	
	Inhalation of fumes		H	Air quality monitoring and surveys	3	5	20(H)	
	Dust inhalation	Lung illnesses		Use of masks				

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Dropping of loads	Lung illnesses	H	Regularly spraying water on dry soil to minimize dust	3	5	20(H)	
			Property damage	S	Correct positioning of equipment and low loaders	3	4	17(H)	
07	Loading and off-loading of site materials	Manual lifting	Musculoskeletal injuries	S	<ul style="list-style-type: none"> <li>Practice correct lifting techniques when lifting loads</li> <li>Do not lift heavy loads without assistance</li> </ul>	3	4	17(H)	Procedure for manual handling
		Carrying heavy loads	Back Injuries	S	<ul style="list-style-type: none"> <li>Correct handling techniques, proper posture techniques when handling heavy or big loads of equipment.</li> </ul>	3	4	17(H)	Procedure for manual handling
		Twisting	Spinal injuries	S	<ul style="list-style-type: none"> <li>Avoid twisting the upper body suddenly whilst carrying heavy loads.</li> </ul>	3	4	17(H)	
		Handling exceeding loads	Back and spinal injuries	S	<ul style="list-style-type: none"> <li>Ask for assistance to carry heavy and awkward loads.</li> </ul>	3	4	17(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Workers not following SWP's for manual handling	Back and spinal injuries	S	<ul style="list-style-type: none"> <li>Use correct lifting method and ask for assistance for loads exceeding 25kg.</li> <li>Employees should be properly trained and follow safe work procedures.</li> <li>Only Trained First Aider must perform treatment of injury.</li> </ul>	3	4	17(H)	
		Pregnant women doing strenuous work	Miscarriage in pregnant women	H	<ul style="list-style-type: none"> <li>Woman should avoid strenuous work from early pregnancy onwards to well after the birth.</li> </ul>	3	4	17(H)	
08	Use of cranes to offload Elevated Steel Tank, Concrete slabs, Beams	Operation of crane by incompetent person	Fatalities	S	<ul style="list-style-type: none"> <li>only competent well-trained operators must operate cranes</li> </ul>	5	3	22(CR)	
		Overloading of cranes	Toppling of load	S	<ul style="list-style-type: none"> <li>loads must be properly secured</li> <li>use of competent trained operator</li> </ul>	5	4	24(CR)	
			Swerving	S	<ul style="list-style-type: none"> <li>use of competent out riggers. Loads bigger than 5T- bunksmens. Loads smaller than 5T- Riggers</li> </ul>	3	3	13(H)	
		Fall of loads		S		3	3	13(H)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Incorrect/side loading	Damage to property	S	<ul style="list-style-type: none"> <li>• Proper slinging techniques</li> <li>• Proper lifting and tackling techniques</li> <li>• regular maintenance of cranes</li> </ul>	4	3	18(H)	
		Use of damaged slings and shackles	Pinch or crush points by materials	S	<ul style="list-style-type: none"> <li>• Operation by competent person</li> <li>• Use of adequate full PPE</li> </ul>	4	3	18(H)	
		Poor/unstable ground conditions	Drop of loads	S	<ul style="list-style-type: none"> <li>• All lifting equipment must be inspected before being used</li> </ul>	4	3	18(H)	
		Improper set up of crane pads	Crane tip over	S	<ul style="list-style-type: none"> <li>• Look for impediments, depressions, voids, trenches on ground – check ground stability</li> </ul>	4	3	18(H)	
			Accidents	S	<ul style="list-style-type: none"> <li>• Be aware of potential vehicle traffic that may conflict with your area of operation.</li> <li>• Redirect traffic or adjust your outrigger pad set up as needed</li> </ul>	4	3	18(H)	

**GATSHENI SIZWE(PTY) LTD  
BASELINE RISK ASSESSMENT**

**PROJECT NUMBER:  
OLIFANTSPOORT AND EBENEZER  
WATER SUPPLY SCHEMES:  
PIPELINE FROM PS1  
(OLIFANTSPOORT WTW) TO SPECON**

**BASELINE 2201**

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



					<ul style="list-style-type: none"> <li>All uneven ground should be leveled prior to placement of any crane pad</li> </ul>				
09	Stacking and storage of materials including Concrete Slabs	Improper Stacking of uPVC bulk Pipes resulting in materials falling	Injuries	S	<ul style="list-style-type: none"> <li>Follow proper stacking procedures</li> <li>Proper supervision and inspections</li> </ul>	4	4	21(H)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



10	Handling of hazardous chemicals	No bunding for Storage of fuel and oil resulting in spills	Environmental pollution	E	<ul style="list-style-type: none"> <li>All fuel storage to be in specific bunded fuel storage tanks that holds 110% of the capacity of the container.</li> <li>Spill kits required and persons trained on using them</li> </ul>	4	4	21(CR)	Environmental management plan/ Fire Protection Plan
		Fire extinguishers not accessible	Property damage from fire	S	<ul style="list-style-type: none"> <li>Fire-fighting equipment must be installed in suitable locations around the flammable liquids store with visible symbolic signs.</li> </ul>	4	5	23(CR)	
		Skin contact with chemicals	Skin irritation and skin dermatitis	H	<ul style="list-style-type: none"> <li>Provide 16-section format MSDS and PPE (Gloves)</li> </ul>	1	4	7(M)	
		Inhalation of hazardous chemicals	Illnesses associated with lungs	H	<ul style="list-style-type: none"> <li>Use of dust masks</li> </ul>	3	3	13(H)	
		Incorrect disposal of chemicals	Environmental pollution	E	<ul style="list-style-type: none"> <li>Follow environment plan</li> </ul>	3	4	17(H)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Inventory list of chemicals not kept		S	<ul style="list-style-type: none"> <li>Compile a complete list of the chemicals in your workplace</li> </ul>	3	3	13(H)	
		Ingestion	poisoning	S	<ul style="list-style-type: none"> <li>Making available emergency medical help</li> </ul>	3	3	13(H)	
		Employees not trained on working with hazardous chemicals	risks associated with incorrect use of chemicals	S	<ul style="list-style-type: none"> <li>Trained personnel to handle hazardous chemicals</li> </ul>	3	3	13(H)	
		Unmarked chemicals	risks associated with using unknown chemicals	S	<ul style="list-style-type: none"> <li>All chemicals on site must be correctly marked and labeled</li> </ul>	3	4	17(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



11	Environmental protection and sanitation	Employees smoking anywhere on site	Risk of a fire starting from a lit cigarette	E	<ul style="list-style-type: none"> <li>Smoking must be prohibited outside designated smoking areas</li> </ul>	1	4	7(M)	Environmental Management Plan
		Use of unhygienic toilets according to regulation requirements	Bacterial/viral/fungi and parasite infections	H	<ul style="list-style-type: none"> <li>Ensure that toilets are regularly cleaned and maintained, including temporary units.</li> <li>Employees are required to wash their hands after going to the toilets/ using urinals.</li> </ul>	2	4	12(M)	
		Working in extreme weather i.e. hail, strong winds, Heat	heatstroke	H	<ul style="list-style-type: none"> <li>EHS weather watch via internet</li> <li>Find shelter in a secure building</li> <li>All work must be halted under such conditions</li> <li>Provide employees with water</li> </ul>	2	4	12(M)	Environmental Management Plan
		Run-off lubricants from vehicles	Water and ground water pollution	E	<ul style="list-style-type: none"> <li>Ensure that there is no un-natural flow into storm water channels.</li> </ul>	3	4	17(H)	Environmental Management Plan
		Employees standing near noisy machinery							

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		for prolonged periods	Noise exposure to ears	H	<ul style="list-style-type: none"> <li>Laborers can sustain noise-induced hearing loss when not using correct PPE. I.e. Ear muffs, ear plugs</li> </ul>	2	4	12(M)	
<b>C. Earthworks</b>									
01	Excavations and Laying of Bulk Steel Pipes	Excavations done by incompetent supervisor	Excavations work on unstable ground	S	<ul style="list-style-type: none"> <li>Evaluate the stability of the ground before excavation work begins.</li> <li>Inspection by a qualified engineer</li> <li>A contractor must ensure that all excavation work is carried out under the supervision of a competent person.</li> </ul>	5	3	22(CR)	Appointment of competent person
		Fall or dislodgement of material in an excavation	Being buried/trapped	S	<ul style="list-style-type: none"> <li>The contractor must with instructions from the excavation supervisor take reasonable and sufficient steps in order to prevent any person from being buried or trapped by a fall or dislodgement of material in an excavation</li> <li>Deep excavation signs must be visibly placed near excavation area</li> </ul>	4	4	21(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Workers not following safe working procedures	Injuries	S	<ul style="list-style-type: none"> <li>No load, material, plant or equipment is to be placed or moved near the edge of any excavation where it may cause its collapse and consequently endangers the safety of any person. (1m distance from excavation)</li> </ul>	4	4	21(CR)	
		Excavations not being inspected	Fall of ground	S		Every excavation must be inspected daily and after rain or fall of ground.	4	4	21(CR)
02	Backfill and compaction	Flying debris getting into eyes of workers	Loss of sight – Backfill and Compaction works create flying debris which may pose a significant eye hazard	S	<ul style="list-style-type: none"> <li>Workers must be issued eye protection upon hire. E.g. eye goggles</li> <li>Re-enforcement on the use of eye protection during site tool box talks</li> </ul>	4	4	21(CR)	
03	Entering a confined space	No gas detectors- Air quality is not tested before	Fires and explosion can occur causing	S	<ul style="list-style-type: none"> <li>Before a person enters a confined space, gas detectors must be used to determine the need for breathing apparatus.</li> </ul>	4	4	21(CR)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		entering confined space	multiply injuries to employees						
		Entering a confined space without inspection	Injuries to workers	S	<ul style="list-style-type: none"> <li>All confined spaces must be inspected before any person enters the confined space</li> </ul>	4	3	18(H)	
		Inadequate symbolic safety signs and notices	May result in fatalities to workers	S	<ul style="list-style-type: none"> <li>SWP training must be given to workers.</li> <li>Only competent persons must be appointed in writing</li> </ul>	4	3	18(H)	
		Oxygen content dropping to less than 20% by volume	Insufficient % of oxygen can have a serious impact on the entrant working inside the confined space, suffocate	S	<ul style="list-style-type: none"> <li>When oxygen drops to less than 20% by volume, the area must be cleared of all people and artificial ventilation systems put into place.</li> </ul>	4	4	21(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



04	Use of concrete for Concrete Service Reservoir	Workers not trained on working with concrete	Severe chemical burns to exposed skin and eyes	S	<ul style="list-style-type: none"> <li>Task to be done by competent shutter hands and concrete hands</li> <li>Use of correct PPE, i.e. Waterproof gloves, overalls, eye goggles</li> </ul>	3	3	13(H)	
05	Use of hand tools	Incorrect use of hand tools	Hand loss	S	<ul style="list-style-type: none"> <li>Practice correct use of tools for the correct task</li> </ul>	4	4	21(CR)	
		Not following Safe Working Procedures	Injuries	S	<ul style="list-style-type: none"> <li>Training on safe working procedures</li> <li>Correct use of PPE</li> </ul>	4	4	21(CR)	
		Using sub-standard tools	Injuries to hands	S	<ul style="list-style-type: none"> <li>Regular tool inspections</li> <li>Removal of damaged tools</li> </ul>	4	5	23(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Using homemade tools to perform tasks	Injuries to hands	S	<ul style="list-style-type: none"> <li>Use the correct tools for the correct task</li> <li>Conduct Hand tool Risk Assessment</li> </ul>	4	4	21(CR)	
06	Use of machinery	Use of faulty equipment	Injuries	S	<ul style="list-style-type: none"> <li>Maintenance of equipment as per manufacturer's requirements</li> <li>periodic repairs</li> <li>removal of faulty equipment</li> </ul>	4	5	23(CR)	
		Contact with exposed/damaged wires	Electrocution	S	<ul style="list-style-type: none"> <li>display visible signage that indicates faulty equipment</li> </ul>	3	3	13(H)	
		Work stoppages	Loss of production	E	<ul style="list-style-type: none"> <li>toolbox talks</li> <li>proper supervision</li> </ul>	3	4	17(H)	
		Oil and fuel spills	Environment al pollution	S		3	4	17(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



					<ul style="list-style-type: none"> <li>Any leaks must be contained with drip trays and spill kits must be used to minimize environmental damage</li> </ul>				
<b>D. Emergency Preparedness</b>									
01	Evacuation during site emergencies	Workers uninformed of emergency evacuation routes	Injuries	S	<ul style="list-style-type: none"> <li>Conduct emergency drills</li> <li>SHE Orientation</li> </ul>	3	4	17(H)	Emergency Plan
			Stampede	S	<ul style="list-style-type: none"> <li>Supervision during evacuation</li> </ul>	4	4	21(CR)	
		Emergency evacuation signs not visible to employees	Fatalities	S	<ul style="list-style-type: none"> <li>Emergency evacuation routes and assembly points must be clearly marked</li> </ul>	5	4	24(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



02	Providing first aid	Incompetent first aider	Escalation of injuries	S	<ul style="list-style-type: none"> <li>Trained first aiders</li> </ul>	4	4	21(CR)	Emergency plan
		Untrained persons attending to first aid cases	Fatalities	S	<ul style="list-style-type: none"> <li>Trained first aiders</li> </ul>	5	4	24(CR)	
		First aider not using PPE	Bacterial, viral infections	S	Use gloves and CPR mask	4	4	21(CR)	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



03	Firefighting activities	Incompetent fire fighter	Burns	S	<ul style="list-style-type: none"> <li>Trained fire fighters</li> </ul>	4	4	21(CR)	Fire Protection Plan
		Workers not trained on emergency plan	Injuries	S	<ul style="list-style-type: none"> <li>Conduct fire drills</li> <li>Emergency plan must be in place</li> </ul>	4	4	21(CR)	
		Emergency numbers not displayed on site for everyone to see	Fatalities	S	<ul style="list-style-type: none"> <li>Emergency numbers must be visible to everyone</li> </ul>	5	3	22(CR)	
		Fire extinguishers not working and not inspected	Property damage		<ul style="list-style-type: none"> <li>Fire extinguishers must be easily accessible and available</li> <li>Firefighting equipment must be inspected</li> </ul>	4	5	23(CR)	
		Smoke inhalation	Suffocation	H	<ul style="list-style-type: none"> <li>Use of masks</li> </ul>	4	4	21(CR)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



--	--	--	--	--	--	--	--	--	--

**E. Electrical power supply system, Electrical Sub-Station and energy powered tools**

01	Working with electrical power supply system, portable electrical equipment	Exposure to faulty electrical equipment/tools	Shock	S	<ul style="list-style-type: none"> <li>Regular tool inspections</li> <li>Ensure that the connections (DB Boards, cables to equipment, equipment, etc.) are tight.</li> <li>Risk Assessments</li> </ul>	3	4	17(H)	
		Use of incorrect tools for the wrong job	Fatalities	S		5	4	24(CR)	

LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES



		Incompetent person performing electrical work	Fire	S	<ul style="list-style-type: none"> <li>Equipment must be in good working condition.</li> <li>Correct use of the correct tool for the correct task</li> <li>Access to live equipment is to be controlled.</li> </ul>	4	3	18(H)	
		Contact with live /damaged wires	Electrocution	S	<ul style="list-style-type: none"> <li>Regular maintenance of equipment</li> <li>Only competent persons to perform tasks.</li> <li>Safe work procedure/lock out procedure to be available and followed when working on electrical machinery and/or equipment.</li> <li>Certificate of compliance to be issued before the electrical installation is handed over for use, or if alterations and modifications have been done.</li> <li>Correct usage; do not work on live equipment</li> </ul>	4	4	21(CR)	

LEPELLE NORTHERN WATER

OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES



<b>F. Housekeeping</b>										
01	Sweeping/cleaning	Exposure to cleaning chemicals	Skin irritation	S	<ul style="list-style-type: none"> <li>Use of PPE (gloves)</li> </ul>	1	4	7(M)		
			Skin dermatitis	H		<ul style="list-style-type: none"> <li>Use of PPE (gloves)</li> </ul>	2	4		12(M)
		Inhalation of chemicals	Dizzy spell	H		<ul style="list-style-type: none"> <li>Use of masks where necessary</li> </ul>	1	4		7(M)
		Musculoskeletal from repetitive motion including bending, stretching, reaching etc.	Back injuries	H		<ul style="list-style-type: none"> <li>Practice correct bending postures</li> </ul>	3	4		17(H)
02	Cleaning oil spillages	Spill kits not available	Slips and falls	E	<ul style="list-style-type: none"> <li>Spill kits must be available and accessible on site</li> </ul>	3	4	17(H)	Environmental Management Plan	

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



03	Waste disposal	Untrained persons doing spill cleanups	Improper clean ups	E	<ul style="list-style-type: none"> <li>• Training must be provided to persons responsible for spill cleanups</li> <li>• Conduct spill drills</li> </ul>	2	4	12(M)		
		Incorrect disposal of contaminated waste	Environmental pollution	E		<ul style="list-style-type: none"> <li>• Designated bins for disposal of contaminated waste</li> </ul>	3	4		17(H)
		Mixing of waste	High disposal costs	E		<ul style="list-style-type: none"> <li>• Use of separate coloured bins for the disposal of general, hazardous and recyclable waste</li> <li>• Waste disposal by a registered waste disposal company</li> </ul>	2	4		12(M)

**G. Traffic accommodation**

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



01	Workers crossing the road	Vehicle drivers not adhering to speed limits	Vehicle accidents	S	<ul style="list-style-type: none"> <li>Adherence to Road Traffic Management Plan (RTMP) and NRTA</li> <li>Toolbox talks</li> <li>Use of certified flagmen</li> </ul>	3	4	17(H)	To be included in Traffic Management Plan
		Work area not barricaded	Injuries to 3 <sup>Rd</sup> parties	S	<ul style="list-style-type: none"> <li>Use temporary barriers to close off work site</li> </ul>	4	4	21(CR)	
		Drivers not adhering to stop/go	Property damage	S	<ul style="list-style-type: none"> <li>Safe stopping areas</li> </ul>	3	4	17(H)	
		Working at night	fatalities	S	<ul style="list-style-type: none"> <li>Use of warning lights, hazard lights, directional signs</li> <li>Provide adequately visible PPE</li> </ul>				
02	Working in or next to the road	Employees not aware of their surroundings	Injuries to employees caused by passing traffic	s	<ul style="list-style-type: none"> <li>Use of trained flagmen to conduct and control road traffic</li> </ul>	3	3	13(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



**H. PUBLIC SAFETY**

01	Unauthorized persons entering site	Members of public unknowingly exposed to risks	Moderate to severe injuries	S	<ul style="list-style-type: none"> <li>Site must be clearly fenced and closed off. Warning signage must be placed at entrance to prohibit unauthorized entry.</li> </ul>	4	4	21(CR)	
02	Working near the road	Workers unaware of their surroundings	Damage to public vehicles passing by	S	<ul style="list-style-type: none"> <li>Certified traffic Safety Officer to control traffic</li> </ul>	3	3	13(H)	
			Injuries to third parties	S	<ul style="list-style-type: none"> <li>Safe work procedures must be in place</li> <li>Sufficient signage</li> <li>SARF</li> </ul>	4	3	18(H)	
03	Public passing near construction site	Material falling from elevation	Injuries to third parties	S	<ul style="list-style-type: none"> <li>Construct temporary protective gantries or covered walkways to provide protection when employees are working above areas where the public or other employees need to pass</li> </ul>	4	3	18(H)	

**LEPELLE NORTHERN WATER**

**OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



04	Moving motorized and other equipment around	Workers not following procedures when offloading equipment from low loaders	Moderate to severe injuries to third parties	S	<ul style="list-style-type: none"> <li>Follow procedure for offloading</li> <li>Correct positioning of equipment and low loaders</li> </ul>	4	4	21(CR)	
<b>I. Night Work</b>									
01	Working at night	Reduced visibility for motorists	Accidents	S	<ul style="list-style-type: none"> <li>Temporary lighting set to avoid glare and shadows for motorists, equipment drivers, workers</li> </ul>	4	4	21(CR)	
		Drivers, pedestrians, workers less alert and more likely to be tired	Injuries	S	<ul style="list-style-type: none"> <li>Work schedules set up to allow enough sleep</li> <li>Maintain strict sleep schedule, make sleep a priority</li> </ul>	3	4	17(H)	
		Workers less visible	Accidents and injuries	S		4	3	18(H)	

**GATSHENI SIZWE(PTY) LTD  
BASELINE RISK ASSESSMENT**

**PROJECT NUMBER:  
OLIFANTSPOORT AND EBENEZER  
WATER SUPPLY SCHEMES:  
PIPELINE FROM PS1  
(OLIFANTSPOORT WTW) TO SPECON**

**BASELINE 2201**

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



		Decreased visibility on site	Trips, falls, run overs	S	<ul style="list-style-type: none"> <li>Use of retroflected high visibility apparel meeting ANSI/ISEA 107-2004-Class 3 to improve visibility</li> <li>Temporary lighting to ensure good visibility</li> </ul>	4	4	21(CR)	
--	--	------------------------------	-------------------------	---	--	---	---	--------	--

**RISK ASSESSMENT MATRIX**

LOSS TYPE	CONSEQUENCE ©				
	<i>INSIGNIFICANT (1)</i>	<i>MINOR (2)</i>	<i>MODERATE (3)</i>	<i>MAJOR (4)</i>	<i>CATASTROPHIC (5)</i>
Harm to people (Safety / Health) (S/H)	First aid case / Exposure to minor health risk	Medical Treatment case / Exposure to major health risk	Lost time injury / Reversible impact on health	Disabling Injury / Irreversible impact on health	Fatality / Impact on health ultimately fatal



**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



Environmental impact (EI)		Minimal environmental harm – immediate clean-up	Material environmental harm – incident remediable in short term	Serous environmental harm – incident remediable in medium term	Major environmental harm – incident remedial in long terms	Extreme environmental harm – Incident irreversible
LIKELIHOOD (L)		RISK RATING				
5 (Almost certain)	The unwanted event has occurred frequently; and is likely to re-occur within 1 week	11 (M)	16 (H)	20 (H)	23 (CR)	25 (CR)
4 (Likely)	The unwanted event has occurred infrequently; and is likely to re-occur within 1 month	7 (M)	12 (M)	17 (H)	21 (CR)	24 (CR)
3 (Possible)	The unwanted event has happened in the business at some time; or could happen within the next 3 months	4 (L)	8 (M)	13 (H)	18 (H)	22 (CR)
2 (Unlikely)	The unwanted event has happened in the business at some time; or could happen within the next 6 months	2 (L)	5 (L)	9 (M)	14 (H)	19 (H)
1 (Rare)	The unwanted event has never been known to occur in the business; or it is highly unlikely it will occur the next year	1 (L)	3 (L)	6 (M)	10 (M)	15 (H)
RISK RATING	RISK LEVEL	GUIDELINES FOR RISK MATRIX AND MANAGEMENT PRACTICES				
21 – 25	(CR) – Critical Risk	Eliminate, avoid, implement specific action plans / procedure to manage and monitor				
13 – 20	(H) – High	Pro-actively manage				
6 – 12	(M) – Medium	Actively manage				

**GATSHENI SIZWE(PTY) LTD  
BASELINE RISK ASSESSMENT**

**PROJECT NUMBER:  
OLIFANTSPOORT AND EBENEZER  
WATER SUPPLY SCHEMES:  
PIPELINE FROM PS1  
(OLIFANTSPOORT WTW) TO SPECON**

**BASELINE 2201**

**LEPELLE NORTHERN WATER  
OLIFANTSPOORT AND EBENEZER WATER SUPPLY  
SCHEMES**



1 – 5

(L) - Low

Monitor and manage as appropriate