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Council for Geoscience

Our Reference: F5484.1
Phase 1: Hoerskool Centurion
Your Reference: 17298
Reviewer: NJ Nxumalo
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No. of Pages: 4

11 October 2018

Tshwane Metropolitan Municipality
Department Roads and Stormwater: Geology Section
Centurion Offices
P O Box 14013
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Attention: **Deputy Director: Geological and Geotechnical Engineering Management**
Mrs. Ashika Sudu

By Email: *ashikas@tshwane.gov.za*

The Deputy Manager: Regional Spatial Planning
Mrs. Pat de Vos

By Email: *patdv@tshwane.gov.za*

Dear Madame,

PHASE 1- HOERSKOOL CENTURION.

The firm, Geopractica Pty (Ltd) (GP) submitted their report: "Phase 1 dolomite stability investigation at Hoërskool Centurion", dated August 2018 to this office for comment on behalf of their client, Mr V. Musungaie of PM Plus, on 21 September 2018. This office acts as an agent to state authorities in reviewing dolomite stability investigations on their behalf.

Hoërskool Centurion is bound to the north by Potgieter Road to the west and east by Clifton and Selborne Avenues and to the south by high density residential and commercial properties. The site covers approximately **10 Ha** and is situated immediately west of Unitus private hospital in Lyttelton in Centurion. Hoërskool Centurion is currently in full operation and comprises a range of existing single and double storey structures, sports field, active services and internal roadways.

The existing land use is a School, **C3** type development in terms of SANS 1936:2012.

The following is noted from GP's report:

1) The site is underlain at depth by dolomite of the upper Monte Christo (chert rich) Formation of the Malmani Subgroup within the Transvaal Sequence. There have been a number of krast - related instability events that have occurred within the school property to date. Three reported and rehabilitated sinkholes and two identified subsidence exists on site.

2) A gravity survey was undertaken on a 10 m grid across the site.

3) No ground water was intersected in any of the boreholes, however hydrological data in the area suggest that ground water is level is between 48m and 91m (Hobbs 1988). The site is located in the Fountains West ground water compartment and according to recent work done for the Gautrain Rapid Rail this compartment is relatively undisturbed. The greater Centurion Area is consider as a non de-watering scenario

4) A total of six (6) percussion boreholes exist for the site. These boreholes varied in depth between 15 m and 40 m below surface and they generally intersected:
   - Transported material (fill) from surface to 3 m depths;
   - Residual materials (Chert, dolomite, Karoo & syenite) between 2 m and 40 m depths;
   - Cavities were recorded in BH3 and BH4 between 6 m to 10 & 17 to 20 m, and 17 m to 19 m depths respectively.

5) Based on the available information, GP has divided the site into two zones and classified these as follows:
   - **Zone A: IHC 3/4//1** with a **D3** Dolomite Area Designation.
   - **Zone B: IHC 7/8//1** with a **D4** Dolomite Area Designation.

6) GP has made conclusions in section 3.8 of the report to be implemented during the development of the site.

This office would like to comment as follows:

a) This office is broadly in agreement with the hazard assessment and zonation of the site. GP has divided the site into two zones and classified these as follows:
   - **Zone A: IHC 3/4//1** with a **D3** Dolomite Area Designation and this is supported.
   - **Zone B: IHC 7/8//1** with a **D4** Dolomite Area Designation and this is supported.

b) GP has indicated that the existing development comprises school facility which according to SANS; classifies as **C3** type development. It is further indicated that a new double storey classroom block is planned on site. According to Table 2 of SANS 1936-1:2012, **C3** type developments are permissible up to **IHC 6** land, subject to footprint investigations and **D3** precautionary measures:
   - This office confirms that the drilling of six boreholes is considered adequate and meets the feasibility-stage drilling as per SANS 1936:2012 minimum drilling requirements
   - This office confirms that the geological conditions as revealed by drilling results in Zone A are considered suitable for the proposed development.

c) The conclusions in Section 3.8 of the report are generally supported.

Therefore this office has no objection to the feasibility-level investigation conducted for the existing school **(C3)** type development and confirms provisional support of the proposed new double storey classroom block adjacent to the Gymnasium within **Zone A**, at Hoerskool Centurion, subject to the points above and the following:

d) No further development is supported in **Zone B**. Also wet services audit survey must be conducted across this site and the results should be reported to the Local Authority. Any shortcomings identified shall be rectified to the satisfaction of the Local Authority and in accordance with SANS 1936-4:2012 requirements.

e) A certified site development plan should be submitted to this office for co-signing.

f) All foundations for any new structures should be suitably designed to span at least **5 m** loss of support due to sinkhole or subsidence formation and these must be according to SANS 10400-H requirements.

g) A site specific Dolomite Risk Management Plan in accordance with SANS 1936-4:2012 must be compiled and implemented for the site. The owners/responsible persons must be made aware of the risks involved in building on dolomite, and be informed about how to be vigilant and act pro-actively by applying sound water management principles.

h) General precautionary measures as set out in SANS 1936 Part 3: Design and construction of buildings, structures and infrastructure, must be studied and implemented for a **D3** site. Some precautions are listed below:
   - All stormwater from downpipes and gutters from buildings and structures shall discharge onto concrete-lined channels which, in turn, shall discharge the water at least 1,5 m away from structures onto areas permitting surface drainage away from buildings and structures. Joints between any open channel drains and buildings shall be suitably sealed.
   - Where guttering is not provided, impervious paved areas or apron slabs shall be provided within 3 m (or greater if deemed appropriate by the competent person (engineer)) of buildings or structures, runoff from which shall drain into lined channels feeding into a designed stormwater system or shall be spread as sheet flow. The paved areas or apron slabs shall include areas located below the drip line or the periphery of the building or structure that is subject to draining rainwater.
   - Wet engineering services should, wherever possible, not be placed parallel to buildings unless they are at least 5 m away (if stand size allows) from the structure. Should this be unavoidable, a rational design shall be performed by the competent person (engineer).
   - Liquid-retaining structures shall be watertight (zero leakage), constructed without any joints, and shall not be placed closer than 5 m from a building. Alternatively, the design of such pools shall be integrated into the rational design of the foundation of the residential structure.
   - The preferred pipe type for all wet engineering services, and the sleeve systems for such services, on dolomite area designation D3 sites are polyethylene (PE) pipes and fittings that comply with the material manufacturing requirements of the relevant of parts 1, 2, 3 and 5 of SANS 4427.
   - The water supply to a building shall be via a single water supply connection unless otherwise approved by the competent person (engineer). This also applies to other pressurized liquid bearing services.
   - Wet engineering services, excluding stormwater systems, shall be capable of spanning the projected notional sinkhole diameter (5 m), which has a high likelihood

of formation in accordance with the requirements of SANS 1936-2, without the service rupturing or any joint leaking or separating from the pipeline.

- Gardens within 15 m of buildings and structures shall not include (a) water features, such as fish ponds, except where an impermeable lining is provided in accordance with a design prepared by a competent person (engineer); or (b) water features with automatic replenishment systems. No automated irrigation systems shall be installed within a distance of 5 m from any structure or building designated as D3.

i) The builder must inform the professional team when the service/foundation trenches are open for inspection to takes place. The results of these inspections and quality control must be recorded in a construction report (copy to the Local Authority, and this Office).

j) The professional team involved, including GP, shall carefully consider the appropriate water precautionary measures and then ensure and finally certify that these have been implemented.

k) Wet services should be laid exactly where indicated on the drawings presented to the Local Authority, and to this Office. Wet service may not be laid below structures. The Builder or his appointed professional team should certify that they have been placed as indicated. The Home Owner must also have a copy of the exact plan presented to this Office.

l) The Local Authority must implement a risk management system. Commenting on the suitability of sites within its jurisdiction is based on the premise that this system will be implemented.

This letter reflects the Council for Geoscience's view and approach to development on dolomite at this time, as reflected by the above date. These comments may not be viewed as open-ended. If a property changes ownership or land-use changes are made, the comment may in part or wholly no longer apply. This Office should be informed of such changes and the Competent Person responsible for the dolomite stability investigation should be given the opportunity to indicate the influence such changes could have on the overall stability.

If you have any further queries, please do not hesitate to contact this office.

Yours faithfully,

S NGUBELANGA
Engineering Geologist

Double storey classroom at Hoerskool Centurion (F5484.1)

CC: **Geopractica**

ATTENTION: **Thando Sodawe**

By email: *thando.sodawe@geopractica.co.za*

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PHASE 1 DOLOMITE STABILITY INVESTIGATION
at
Hoërskool Centurion

Client: PM Plus **Date: August 2018** **Job No: 17298**

C O N T E N T S

APPENDICES

1 INTRODUCTION

1.1 Preamble

On the 17th of May 2017, a proposal, reference *Y:\Proposal 2017\PM Plus\ Centurion High School \Phase 1 Dolomite Stability Investigation. wpd* was submitted to Mr. V. Musungaie of PM Plus (Pty) Ltd, for a phase 1 Dolomite Stability Investigation across the existing Hoërskool Centurion campus.

On the 4th September 2017, Mr. V. Musungaie instructed Geopractica to proceed with the investigation and issued a letter to Geopractica, confirming the appointment.

1.2 Database

Prior to the investigation, the following data was provided by the client:-

A ORSCO drawing, entitled CENTURION Hoërskool SERVICES DETECTION, at scale of 1:1000.

An A0, coloured site layout showing all structures and sports fields within the school.

Following a geotechnical literary review at the Council of Geoscience (CGS) in Pretoria, the following data was obtained:-

An A4, coloured map showing all previous dolomite reports and percussion boreholes drilled in the vicinity of the site.

1.3 Objectives

The objectives of the investigation were as follows:-

1.3.1 Conduct a Phase 1 Feasibility Level Dolomitic Stability Investigation in terms of SANS 1936-2:2012 (Development of Dolomitic Land Part 2: Geotechnical Investigations and Determinations.

1.3.2 Classify the site according to the “SANS 2012 Guidelines for Development on Dolomitic Land”.

1.3.3 Categorise the site into dolomite risk zones.

1.3.4 Provide suitable foundation recommendations for the double storey classroom block, adjacent to the gymnasium, which was demolished after the last sinkhole event.

2 FACTUAL REPORT

2.1 Programme of Work

2.1.1 *Literary Review*

Prior to the commencement of any field work, a literary review was conducted on data obtained from previous investigations by both Geopractica, other consultants and the data base library at the Council for Geoscience (CSG).

The 1:250 000 geological map, “No 2628 East Rand” was consulted in order to determine the regional geology in the vicinity of the site.

2.1.2 *Field Work*

Between the 10th and 12th October 2017, Geofocus, conducted a geophysical gravity survey across the site with gravimetric stations set out on a 10m grid.

This information was used to produce a Relative Bouguer Map, which assisted in determining suitable positioning for the six percussion boreholes that were to be drilled.

At the end of October 2017, the investigation was temporarily discontinued, due to financial issues encountered by the Department of Education.

Between the 27th and 28th June 2018, six rotary percussion boreholes were advanced from ground level using a rotary DTH percussion drilling rig with a 165mm down the hole hammer operated with an 18 bar 950 cfm compressor. The boreholes were drilled to depths of between 15m and 40m.

Upon completion of the drilling, the holes were left to stand for 24 hours, then dipped to determine the depth to the water table, if present and immediately backfilled using a mixture of in-situ material and cement.

The chip samples recovered from each percussion hole, together with the drilling contractors “drillers log”, were used by an engineering geologist to profile the holes according to the methods described in the “Guidelines for soil and rock logging in South Africa, 2nd Impression 2002".

The detailed borehole profiles appear as appendix 3 to this report, while their locations are shown on the “Google Earth Site Plan” attached as appendix 1.

A Residual Gravity Map was produced based on the results of the percussion drilling and this together with the Relative Bouguer Map and the report by the specialist geophysical consultants is presented in Appendix 5.

2.1.3 *Office and Laboratory Work*

Due to the nature of the investigation, no laboratory testing was undertaken.

The report was finally prepared using the data obtained from all the sources mentioned above.

2.2 Site Description

Hoërskool Centurion is bound to the north by Potgieter Road to the west and east by Clifton and Selborne Avenues and to the south by high density residential and commercial properties. The site covers approximately 10Ha and is situated immediately west of Unitus private hospital in Lyttelton in Centurion.

Hoërskool Centurion is currently in full operation and comprises a range of existing single and double storey structures, sports field, active services and internal roadways.

The site is at an elevation of between 1492m and 1484m above mean sea level and has a gentle gradient of approximately 1.4% down towards the north and east.

2.3 Site Geology

From available literature as well as the observations during the investigation, it is evident that the site is underlain at depth by dolomite of the Malmani Subgroup within the Transvaal Sequence. Typically the upper dolomite surface usually weathers insitu to form a dark reddish brown to black, clayey silty with scattered hard and ferruginised dolomite cobbles and leached dolomite (dolomite residuum).

Dolomite bedrock, being a carbonaceous rock, is slightly soluble in mildly acidic conditions (rainwater) and this can result in the formation of cavities and fissures within the rock mass. Typically these can be filled with wad (a very soft, “silt and clay” derived from the insitu decomposition of dolomite) and other alluvial debris (dolomite and chert residuum). The collapse of these cavities can result in the formation of sinkholes or doline depressions at the surface.

The Malmani Subgroup is subdivided into the Oaktree (lower), Monte Christo (lower middle), Lyttelton (upper middle) and Eccles (upper) formations. The Oaktree and Lytleton are chert poor while the Monte Christo and Eccles are generally chert rich.

Typically the chert rich formations tend to be less problematic as the insoluble chert lenses provides stability to the surrounding soluble dolomite.

It is our opinion that the site is located within the upper Monte Christo (chert rich) Formation.

Within the south western portion of the site, sedimentary deposits, belonging to the Vryheid Formation of the Karoo Supergroup were encountered, below the transported soils. Typically these Karoo sediments were found to be variable in thickness, ranging from nothing to 20m.

A regional geological map has been attached as appendix 2 of this report.

2.4 Hydrology

The region receives between 565mm and 640mm of rainfall per year, most of which occurs in heavy isolated falls between November and March.

Whilst the site is relatively flat, it is likely that stormwater, during periods of heavy or prolonged rainfall, will drain towards the north and east as sheetwash.

No ground water was intersected in any of the boreholes, however hydrological data in the area suggest that ground water is level is between 48m and 91m (Hobbs 1988).

The site is located in the Fountains West ground water compartment and according to recent work done for the Gautrain Rapid Rail this compartment is relatively undisturbed. The greater Centurion Area is consider as a non de-watering scenario, which is beneficial from a dolomite stability point of view

Whilst two water extraction boreholes are utilised for irrigation purposes only, the water extraction from these boreholes is regarded as insignificant in terms of de-watering.

2.5 Observations

2.5.1 *General*

From a general inspection of the site, and based on reports from the site personnel and information received from Council for Geoscience, there have been a number of krast - related instability events that have occurred within the school property to date.

Two subsidence's were identified during site inspection and evidence of cracking was also observed in the existing pavilion, just imminently north of BH3.

Geopractica are aware of two rehabilitated sinkholes in the area of the gym, whilst the Council for Geoscience data suggests a third rehabilitated sinkhole. located adjacent to classroom block T26

The location of the above mentioned krast- instability features are shown on a Site Plan attached as appendix 1.

2.5.2 *Boreholes*

Possible cavities where observed in BH3 and BH4 with significant air loss and sample loss experienced in these two boreholes. Difficulties drilling through the chert residuum was experienced in some boreholes, namely BH2 and BH4.

A summary of the soil and rock conditions obtained from all the boreholes

(new and existing) is given below:-

2.5.2.1 Transported / Fill

The upper portion of the site comprises approximately 1m to 5m of transported and Fill material (ie chert fragments in a silty sand matrix or sandy silt). This material has low (Fill) to moderate (Transported) risk of mobilisation.

2.5.2.2 Chert Residuum (Malmani - Monte Christo Formation)

Predominantly the chert residuum was intersected below the fill or Transported Formation at depths between 3m and m below current ground level. Material thicknesses of between 4m and 40m were encountered.

In boreholes BH2, BH3, and BH4, the significant thickness of the chert with lenses of wad made drilling through it extremely difficult, due to the jamming of the percussion hammer and collapse of the hole. Some of these boreholes were prematurely terminated at depths of 40m, while still within the chert horizon. This material has a moderate to high mobilisation potential.
It is evident that the chert residuum encountered in the boreholes is typically “chert rich” again substantiating our view that the site is underlain by the Monte Christo Formation of the Malmani Sub Group.

2.5.2.3 Dolomite Bedrock

Slightly leached dolomite bed rock was only intersected in three boreholes drilled across the site, at depths ranging between 5m in BH5 to 25m in BH3, below current ground level.

This rock comprised a blue grey, moderately weathered becoming slightly weathered with depth, highly fractured hard rock with a corresponding low mobilisation potential.

2.5.2.4 Karoo Sediments

Assessment of the chip samples recovered from the percussion drilling of the dolomite stability boreholes suggests that the chert residuum horizon is overlain by a material which has been described as a orange, pink, red and greyish brown, clayey silty, possibly highly weathered, very soft rock to soft rock, shale, sandstone or conglomerate with zones containing abundant chert and quartz gravels.

These sediments were intersected in most boreholes from surface to depths of more than 20m around BH1.

It is our opinion that these deposits form a overwhelming blanketing

material over the site which will act as an aquitard that should prevent mobilisation.

3 INTERPRETIVE REPORT

3.1 Discussion of Results

Dolomite instability can occur as either a sinkhole collapse or doline subsidence and the primary triggering mechanisms includes the following:-

The ingress of water from leaking water-bearing services
Poorly managed surface stormwater drainage
Groundwater level draw down (see 2.4 above)
Significant ground vibration and resonance

A graphical representation and explanation of sinkhole and subsidence formation is given in appendix 6 of this report.

From a Dolomitic Stability perspective, it should be noted that:-

3.1.1 there are three reported and rehabilitated sinkholes within the site.
3.1.2 there are two areas where subsidence has occurred
3.1.3 there is a substantial thickness of mobile overburden comprising chert residuum and wad.
3.1.4 a blanketing horizon of sedimentary soil/rock was encountered in the extreme south west corner of the site.
3.1.5 the depth to ground water is between 48m and 91m (Hobbs 1988).
3.1.6 the site is not subject to de-watering.

3.2 Foundation Recommendations - New Class Room Block

The client has requested Geopractica make foundation recommendations for a new double storey classroom block, adjacent to the Gymnasium, that was demolished during the rehabilitation of a sinkhole, which occurred below this structure in 2016/2017.

The sinkhole rehabilitation was conducted by Stefanutti Stock Geotechnical, during the period May 2017 to July 2017. The details of the rehabilitation are included in appendix 9. It should be noted that Geopractica were not involved during this rehabilitation project.

Assessment of the report suggests that rotary percussion drilling and pressure grouting of 18 boreholes was undertaken within the footprint of the demolished building. The drill hole spacing appears to be in the order of approximately 5m.

Assuming that the work was conducted in terms of SANS 2001-BE3:2012, and supervised by a Level 4 Geo-Professional, we must assume that this work has improved the Dolomite Area Designation from D4 to at least D3 and an Inherent Risk Classification of IHC 7 to IHC 3/4.

Thus, it is our opinion that the new structure should be founded on a suitable designed reinforced concrete raft, constructed at ground level. As a minimum the raft must be able to span at least 5m (loss of support). It is imperative that the raft be designed by a proficient structural engineer.

It is recommended that the current, brick paved parking area to the north of the new classroom block be removed down to a depth of at least 650mm below paving level. The road bed should be inspected by a geo-professional, for any signs of dolomite instability.

If approved, the road bed should be ripped and re-compacted to at least 90% Mod AASHTO and a layer of RockGrid 200 (or similar) installed. The bulk excavation should then be backfilled in 150mm layers using a G7 quality material compacted to 93% Mod AASHTO, up to the underside of the pavement layer works.

3.3 Dolomitic Stability Assessment

The dolomite stability evaluation has been undertaken using the “SANS 1936: 2012 parts 1 to 4 Development on Dolomitic Land ”.

The application of this process is described below:-

3.3.1 *Geophysical Survey*

A gravity survey was carried out over the entire site, at a gravimetric station grid spacing of 10m. A report was produced by the specialist geophysical consultant and is attached as appendix 5 of this report.

3.3.2 *Locate and Drill Percussion Boreholes.*

The Relative Bouguer Gravity map produced, was use to optimally position the proposed percussion boreholes on the gravity features revealed, typically being:-

Gravity High
Gravity Low
Steep Gravity Gradient.

The depth to dolomite bedrock, determined from the percussion holes was used to produce a final Residual Gravity map, which models the approximate dolomite bedrock topography.

3.3.3 *Characterize the Boreholes Using Methods of Scenario Supposition*

By reviewing a generalised set of evaluation factors that relate to the potential for sinkhole and doline formation, the risk of development and potential size at surface of such phenomena, can be obtained. A brief summary of the various factors are given below, and are subsequently presented in table 2:-

Receptacle - For the purpose of the stability investigation, it **must** be assumed that voids and cavities exist within the dolomite bedrock, representing potential receptacles.

In this respect, possible cavities and existing sinkholes were identified on or near the site. However occasional boreholes encountered varying degrees of air and sample recovery with irregular hammer strike. These are summarised in Table 2 below.

Mobilising Agent - The major mobilising agents are generally considered to be ingress of water, ground vibration caused by blasting or seismic activities and ground water draw-down. Leaking water supply pipes, stormwater pipes and sewage pipes acts as mobilizing agents.

The site is assumed to be in a ground water compartment that has not been affected by mining related, de-watering processes. For the purpose of the dolomite stability investigation the site will be considered as a non de-watering scenario.

Blanketing Layer - Determining the nature and thickness of the blanketing layer overlying the dolomite bedrock. The blanketing layer on this site comprise the transported materials, sedimentary material belonging to the Karoo formation and chert with wad belonging to the chert rich Monte Christo Formation within the Malmani Subgroup.

Table 1 below gives the thicknesses of the blanketing layer at each borehole position.

Table 1: Thickness of layers

Percussion BH No	Total thickness of the blanketing layer	Approximate thickness of Syenite Sill layers and Karoo soils within the geological profile
BH1	20m	20m
BH2	40m	None
BH3	25m	None
BH4	40m	None
BH5	4m	None
BH6	10m	None

Maximum Potential Sinkhole Development Space - A calculation on each borehole has been undertaken to determine the "*maximum diameter of surface feature"* in the event that the feature does occur.

This is based on the estimated depth below the ground surface to the potential throat of either the receptacle or disseminated receptacle,

the thickness of each layer that make up the blanketing material above a possible receptacle and the estimated angle of draw in the various horizons of the blanketing layer. This is calculated from the horizontal to the assumed sinkhole sidewalls.

Mobilisation Potential - The mobilisation potential of the blanketing material is seen to be low for transported soils and, Karoo and moderate to high for chert and wad respectively as discussed in section 2.5 above.

Bedrock Morphology - In a site or an area underlain by shallow dolomite, the variation in bedrock plays an important role as this reflects the degree of gryke and pinnacle development. Depths to bedrock dolomite are summarised in table 2 below.

Table 2: Evaluation of Drill Hole Data

BH no.	Overburden materials			Chert / Dolomite with Wad (m)	Weathered Dolomite Bedrock (m)	Air Loss (m)	Potential Cavities (m)	Depth to Hard rock Dolomite Bedrock (m)	Inherent Risk Of Sinkhole & Doline Development With Regards to Ingress of Water		
	Transported Soils/ Fill (m)	Karoo Formation (m)	Chert/Dolomite Residuum						Sinkhole	Doline	Inherent Hazard Class (IHC)
BH1	0.0 - 2.00	2.00 - 18.00	-	-	-	-	-	-	Medium for Small and Medium	Medium	2
BH2	0.0 - 1.0	-	1.0 - 5.0 8.0 - 2.0	20.0 - 40.0	5.0 - 8.0	35.0 -36.0	-	-	Medium for Large	Medium	7
BH3	-	-	0.0 - 2.0 10.0 - 17.0 22.0 - 25.0	-	2.0 - 5.0	6.0 - 10.0 17.0 - 25.0	6.0 - 10.0 17.0 - 20.0	25	High for large	High	8
BH4	0.0 - 5.0	-	-	5.0 - 40.0	-	17.0 - 19.0	17.0 - 19.0	-	High for large	High	8
BH5	0.0 - 3.0	-	3.0 - 4.0	4.0 - 5.0	5.0 - 9.0	3.0 - 4.0	-	5.0	Medium for Small and Medium	Medium	3
BH6	0.0 - 2.0	-	2.0 - 5.0	5.0 - 9.0	9.0 - 10.0	-	-	10	Medium for Small and Medium	Medium	3

3.4 Land Usage Designation

According to the recently introduced SANS 1936 - 1: 2012 Document " Development of Dolomitic Land ", all Developments can be constructed on Dolomitic Land, however, the worse the Inherent Risk Class, the greater the precautions required.

Table 3 below summarises the different land usage designation for the proposed development:-

Table 3 - Land Usage Designation
C3 - School

3.5 Dolomite Risk Classification

The overall Dolomite Risk Classification of the site, based on the six boreholes drilled, is summarized in Table 4 below.

Table 4 - Dolomite Risk Classification

Borehole No	Land Usage Designation	Land Usage Description	Area	Dolomite Area Designation	Inherent Hazard Class
BH1	C3	School	Zone A	D3+FPI	IHC 2
BH2	C3		Zone B	D4	IHC 7
BH3	C3		Zone B	D4	IHC 8
BH4	C3		Zone B	D4	IHC 8
BH5	C3		Zone A	D3+FPI	IHC 3
BH6	C3		Zone A	D3+FPI	IHC 3

Tables 5, and 6 below explains how the following IHC and D values were obtained for the site.

Inherent Hazard Class (IHC)
Land Usage (C)
Dolomite Designation (D)
Design Level Investigation (DLI)

3.5.1 *Determination of Inherent Hazard Class (IHC)*

Table 5 below indicate IHC classes which indicate the chance of a sinkhole occurring as well as its likely size. The larger the inherent hazard class number, the greater the chance of a sinkhole occurring and the larger its potential size, should it occur.

Table 5 - Statistical occurrence of sinkholes and Doline subsidence					
Inherent Hazard Class (IHC)	**Small Sinkhole**	**Medium Sinkhole**	**Large Sinkhole**	**Very Large Sinkhole**	**Doline Subsidence Formation**
	< 2m	**2 - 5m**	**5 - 15m**	**> 15m**	
1	Low	Low	Low	Low	Low
2	Medium	Low	Low	Low	Medium
3	Medium	Medium	Low	Low	Medium
4	Medium	Medium	Medium	Lo w	Medium
5	High	Low	Low	Low	High
6	High	High	Low	Low	High
7	High	High	High	Low	High
8	High	High	High	High	High

3.5.2 *Determination of Dolomite Area Designation (D Value)*

Table 6 - Dolomite Area Designation	
Dolomite area designation	**Description**
D1	No precautionary measures are required
D2	General precautionary measures in accordance with the requirements of SANS 1936 Part 3, that are intended to prevent the concentrated ingress of water into the ground, are required
D3	Precautionary measures in addition to those relating to the prevention of concentrated ingress of water into the ground as contained in SANS 1963 - 3, are required.
D4	Precautionary measures required in SANS 1936 - 3 will not be adequate to reduce the hazard sufficiently. Site - specific, structural design and extra special precautionary measures will be required.

3.5.3 *Guidelines for assessing the potential for mobilization of the blanketing layer*

Inherent Hazard	**Table 7: Typical Site Conditions**
Low	The profile displays no voids. No air loss or sample loss is recorded during drilling operations. Either a very shallow water table or a substantial horizon of materials with a low potential susceptibility to mobilisation may be present within the blanketing layer (e.g. continuous intrusive features or shale material). Depth to potential receptacle is typically great and the nature of the blanketing layer is not conductive to mobilisation.
Medium	This type of profile is characterised by an absence of substantial ‘protective’ horizon and has a blanketing layer of materials potentially susceptible to mobilisation by extraneous mobilisation agents. The water table is below the blanketing layer. Typically chert rich profiles of intermediate to very great thicknesses without voids.

Inherent Hazard	Table 7: Typical Site Conditions
High	The blanketing layer of the high risk profile reflects a great susceptibility to mobilisation. A void may be present and is interpreted to be very likely, within the potential development space, indicating that the process of sinkhole formation has already started. Boreholes may register large cavities, sample loss, air loss, etc. Convincing evidence exists of cavernous subsurface conditions which will act as receptacles. The water table is below the blanketing layer. In a dewatering situation, the lowering of a shallow groundwater level would obviously increase the risk of mobilisation.

3.6 Discussions of Classification

It should be noted that the investigation undertaken on the site comprises a Feasibility Level Dolomite Stability Investigation only.

Should the land owner decide to erect new structures within the school premises a phase 2 Dolomite Stability Investigation must be undertaken. This will comprise a design level investigation as set out in section 4.3 of SANS 1936-2: 2012, followed by a detailed near surface geotechnical investigation.

On completion of these investigation, the classification of the site will have to be reassessed on the basis of the additional information obtained.

Based on this Feasibility Investigation, the site has been divided into 2 Preliminary Dolomite Stability Zones as indicated on the plan which appears in appendix 6 and as described below:-

3.6.1 Zone *Area A - (D3) IHC 3(4) // 1*

This is the better of the two areas, with regards to the risk of the development of sinkholes. This zone has an IHC 3/4 classification which implies that the statistical occurrence of a large sized sinkholes is low to medium.

The D3 designation requires more stringent measures to prevent concentrated ingress of water into the ground, than those measures acceptable at a lower risk site.

These include and not limited to :-

3.6.1.1 The building must be designed in such a manner, that the most likely sinkhole size predicted from Table 3 above, shall not result in the toppling or sliding failure of the building into the sinkhole.

3.6.1.2 There is sufficient period of structural stability to allow occupants to escape from a building, should a sinkhole occur below the structure.

3.6.1.3 Where guttering is not provided, impervious paved areas or apron slabs shall be provided, with runoff into lined channels feeding into a designed storm water system.

3.6.1.4 Storm water upstream of the buildings and structures shall be diverted away

3.6.1.5 Storm water shall be controlled and disposed of using suitable means i.e. contouring and shaping, open storm water channels.

3.6.1.6 Majority of this area is currently being used as irrigated sports grounds, a more stringent irrigation program must be developed

Design level percussion drilling and a detailed geotechnical investigation will be required for all the new structures within this zone in the future

3.6.1.7 Gravity

The area is characterised by a gravity low in the south western and north section, grading into a high in the north eastern portion.

3.6.1.8 Blanketing Layer

The blanketing layer in this zone comprised moderately to highly weathered Karoo with an average thickness of 20 meters in the south western section of the site. No voids, air loss or sample loss were recorded in BH1 drilled in this area. The nature of the blanketing layer will act as an aquitard that prevents mobilisation and the ingress water. Thus this area has generally been classifies as IHC 2

In BH 6 and BH7 this area is covered by a thin layer of moderately weathered chert and dolomite, with minor residuum (wad).These areas have been classifies as IHC 3/4.

Reference should be made to table 3 above for thicknesses and depths to top of each horizon.

3.6.1.9 Bedrock Morphology

BH5 and BH6 were drilled at least 6 meter into competent dolomite bedrock, whilst the BH1 was drilled to prove 20m of Karoo cover. The depth to competent dolomite bedrock increases to the north west of the zone.

3.6.1.10 Geohydrology

No ground water was intersected in any of the boreholes in this zone.

3.6.2 Zone *Area B - (D4) IHC 7/8 // 1*

This area has been identified as potentially problematic with regards to the risk of the development of sinkholes with a high inherent susceptibility for the formation of large size sinkholes and doline subsidence with respect to ingress of water and a low susceptibility for the formation of small size

sinkholes and subsidence with respect to water level draw-down.

It is considered that the site is located in a non de-watering scenario

This area has been identified as potentially problematic area with regards to the risk of the development of sinkholes with a IHC 7/8 classification. It comprise the areas around BH 2, BH 3 and BH 4.

Using the method of scenario supposition on this area, suggests potentially very large sinkholes (>15m in diameter) could possibly occur within this area. The occurrence of doline subsidence is also high.

The D4 designation indicates that all the usual precautionary measures given in SANS 1963-3: 2012, will not be adequately reduce the hazard sufficiently, for it to be developed. In this instance, site specific precautionary measures are required, such as:-

dynamic compaction
“footprint” drilling and grouting

These intervention will need to be conducted to improve the engineering parameters of the underlying materials such that they can be re-designated a D3 or better.

In our opinion, given that the majority of the structures in the school lie with the areas designated D4, the following precautionary measures must be considered to reduce the possible ingress of water into the underlying geology:-

Ensure that all structures are surrounded by a perimeter apron with moisture barrier. (See appendix 8)

Pressure check all water borne services for leaks and repair/replace as necessary.

Ensure that the area surrounding the structure is landscaped to allow rapid drainage the stormwater away from the structure and that no ponding occurs.

All surface stormwater to be channelled into suitable “water tight” channels and drains

All large trees, shrubs and irrigation closer than 5m to the structure should be removed, particularly in the western portion of the property .

3.6.2.1 Gravity

The area is characterised by a gravity low in the west section around BH2 and in eastern section BH4, grading into a gravity gradient in the central section around BH3.

3.6.2.2 Blanketing Layer

The blanketing layer in this zone comprised moderately weathered chert and dolomite, with minor residuum (wad) grading into wad rich horison. Boreholes reflected slight to medium air loss and sample loss with possible cavities within the blanketing material.

The mobilisation potential of the blanketing material is seen to be high for chert and wad respectively and will not act as an aquitard that prevents mobilisation and the ingress water.

Reference should be made to table 3 above for thicknesses and depths to top of each horizon.

3.6.2.3 Bedrock Morphology

Only BH3 was drilled to at least 6 meter into competent dolomite bedrock. Whilst BH2 and BH4 were terminated at 40m due to collapsing holes on chert residuum with wad.

3.6.2.4 Geohydrology

No ground water was intersected in any of the boreholes in this zone.

3.7 Risk Management

The major hazard on Dolomitic land is the downward percolation of surface water, both as stormwater and any other water associated with the proposed development or the process associated to the development.

As indicated in section 2.3 above, Dolomite Rock is water soluble, and cavities can be eroded out of the solid rock, via water passing trough the rock mass. These resulting cavities are then filled with soil (blanketing material) which overlies the bedrock. The erosion of the blanketing soil material into these cavities will result in the appearance of sinkholes and dolines at surface.

Such negative features could result in severe damage or complete destruction of any structures straddling the sinkhole/doline. Sinkholes and dolines are likely to occur in high inherent hazard class areas.

A detailed site specific Dolomite Risk Management Strategy (DRMS) should be developed by the professional team, in association with the Tshwane Municipality according to SANS 1936-4: 2012, to mitigate the hazard associated with the developments on such land. This will need to be undertaken upon completion of the Phase 2 - Design Level Investigation.

Ground water monitoring should form an essential part of this DRMS and dewatering should be prohibited in this area.

In general terms, the basis of a DRMS for all development on dolomitic land

involves the following elements:-

Precautionary and Remedial Measures
Maintenance Programme
Monitoring Programme
Education and Vigilance
Emergency Reaction Plan
Rehabilitation
Data basing
Reassessment

3.8 Conclusions

According to surface observations and phase 1 dolomite stability investigation the site has been delineated into two zones, namely Zone A and Zone B based on the susceptibility of formation of sinkholes and doline subsidence within the school.

SANS 1936-3:2012, states that any upgrade or maintenance works to existing structures and infrastructure on developed sites shall be subject to the same precautions as required for new construction work.

SANS 1936: 2012 parts 3 and 4, is copyright protected and therefore cannot be included on this report. It would be advisable for the client to obtain a copy of this document from SABS.

It is recommended that both Zone A and Zone B be subject to appropriate and stringent precautionary measures as given in appendix 6. It is strongly suggested that these precautions be implemented immediately.

3.8.1 *Zone A - D3 IHC 3/4*

Most of Zone A is currently being utilised as sporting fields, however should further development be required, these are the areas that should be targeted.

It is recommended that a Phase 2 Design Level dolomite stability and a near surface geotechnical investigation be conducted prior to any new development being considered.

3.8.2 *Zone B - D4 IHC 7/8*

Based on this assessment, sinkholes are likely to occur in area exhibiting a high inherent hazard class (Zone B). As mentioned above, these subsidence and sinkholes will be triggered by the ingress of surface water into the underlying dolomite.

Unfortunately the majority of the school structures are located in this area and its our opinion that this section of the school is under potential threat of further dolomite instability.

There are at least three reported and rehabilitated sinkholes and two identified subsidence within Zone B to date. According to surface observations, it is evident that there are poor precautionary measures put in place to control surface water.

It is our opinion that no new developments may take place within the area demarcated Zone B without the following being conducted:-

Phase 2 (design level) dolomite stability investigation - including “footprint drilling”

Detailed near surface geotechnical investigation.

Upon completion of the detailed dolomite stability and geotechnical investigations, it is recommended that a comprehensive Dolomite Risk Management Policy (DRMP) be prepared and implemented across the entire school

This report will need to be reviewed by Council for Geoscience (CGS) and their comments will formulate the necessary work to be undertaken in the future.

Yours faithfully
For:- **Geopractica (Pty) Ltd**

Wallis Evans Pr Sci Nat . BSc MAEG SAIEG

Muhali Mulaudzi BSc Geology

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1. SANS 1936 Parts 1, 2 and 3: 2012 Development of Dolomitic Land

2. SANS 1936 Parts 1, 2 and 3: 2012 Development of Dolomitic Land

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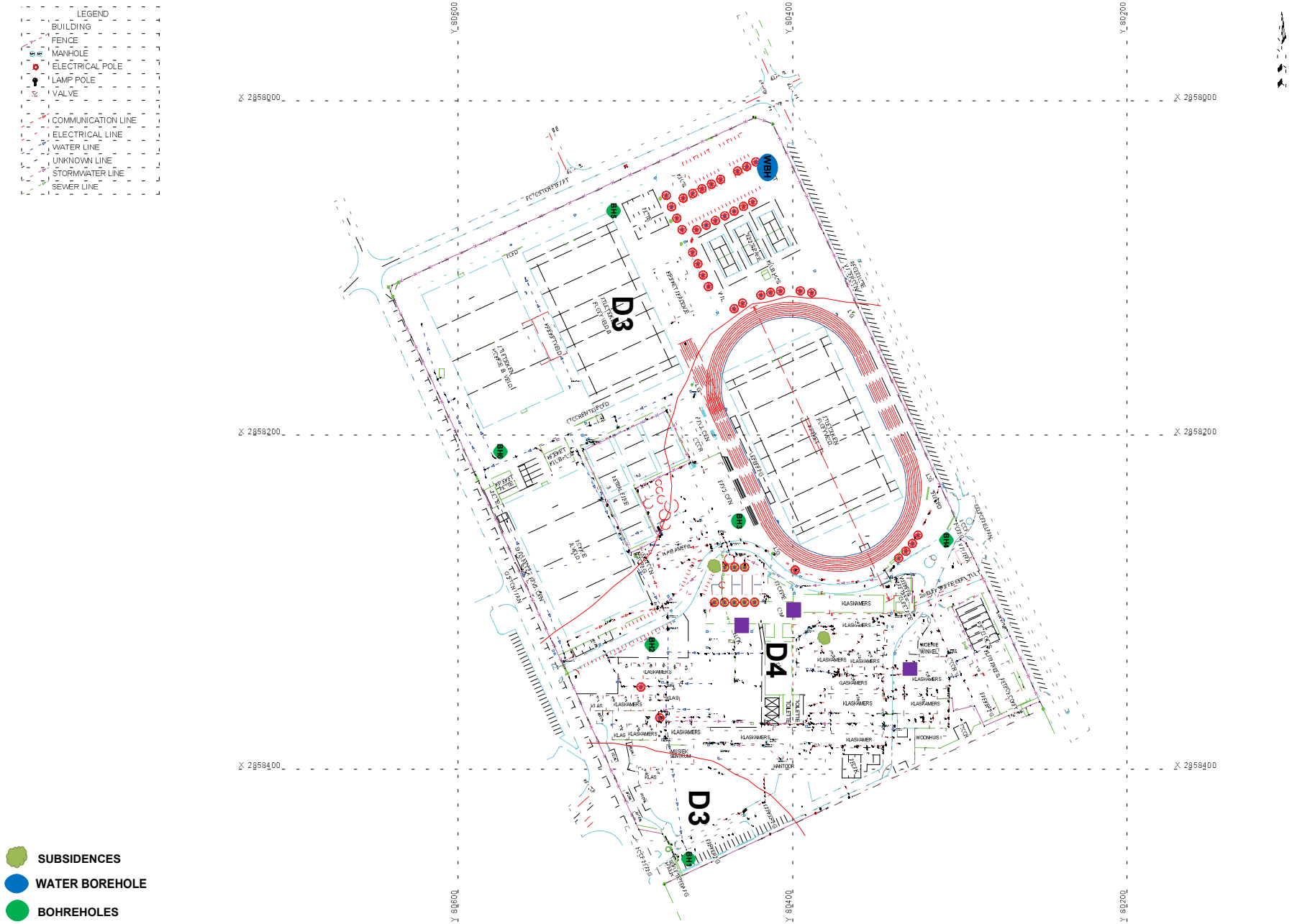
13. Sinkhole and Subsidence record in the Chuinespoort Group Dolomite, Gauteng, South Africa. Samantha Richardson. MSc University of Pretoria.

APPENDIX 1

SITE PLAN

Geopractica	**SITE PLAN** **PM PLUS PROJECTS STRATEGY CONSULTANTS** **Hoerskool - Centurion**	**DATE: August 2018** **Job No: 17298** **Figure: 1**



PROJECT	CLIENT	PLAN	SURVEY
CENTURION HOERSKOOL PRETORIA SERVICES DETECTION	ORSCO Leak, Utility Location & Pipe Relining	REFERENCE: LOCAL SCALE: 1:1000 CONTOURS: 0,5 m	ORSCO (Pty) Ltd Tel. 011 425 3379 13 Road 5 Brentwood Park AH

APPENDIX 2

REGIONAL GEOLOGY MAP

Geopractica

GEOLOGICAL MAP

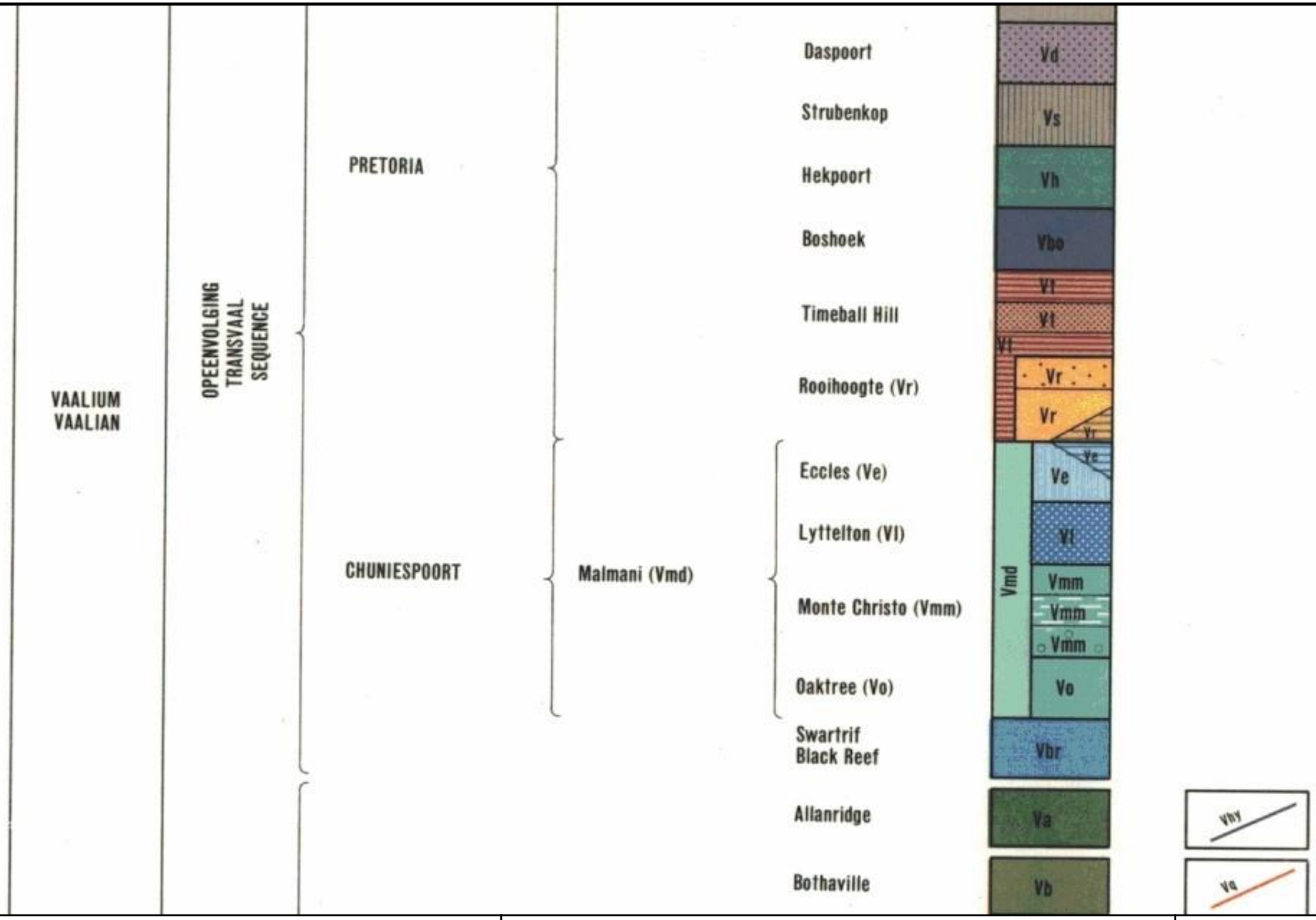
PM PLUS PROJECTS STRATEGY CONSULTANTS

Hoerskool - Centurion

DATE: August 2018

Job No: 17298

Figure: 2



Geopractica

GEOLOGICAL LEGEND

PM PLUS PROJECTS STRATEGY CONSULTANTS

Hoerskool - Centurion

DATE: August 2018

Job No: 17298

Figure: 2-1

APPENDIX 3

BOREHOLE PROBILES

HOLE No: BH1
Sheet 1 of 1

JOB NUMBER: 17298

ROCK FABRIC	GRAIN SIZE	JOINT ROUGHNESS	ROCK HARDNESS
MF -massive	FG -fine grained	SLJ-slickensided	EHR-extremely hard rock
BF -bedded	MG -medium grain	SJ -smooth	VHR-very hard rock
FF -foliated	CG -coarse grain	RJ -rough	HR -hard rock
CF -cleaved			MHR-medium hard rock
SF -schistose	JOINT SPACING	JOINT SHAPE	SR -soft rock
GF -gneissose	VCJ-very close spacg	CUR-curvilinear	VSR-very soft rock
LF -laminated	CJ -close spacing	PLA-planar	
	MJ -medium spacing	UND-undulating	
	WJ -wide spacing	STE-stepped	
	VWJ-very wide spacng	IRR-irregular	

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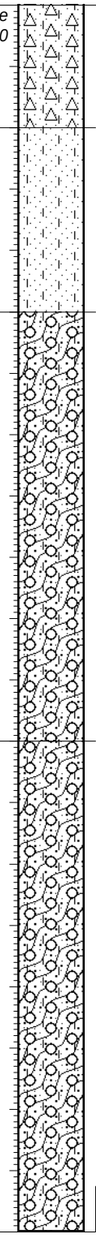
PM Plus
Centurion High School

HOLE No: BH1
Sheet 1 of 1

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)
	0.32	
	0.36	
	0.40	1-5
	0.29	
	0.24	
	0.22	
	0.28	
	0.31	
	0.33	1-3
	0.29	
	0.31	
	0.25	
	0.28	
	0.34	
	0.27	
	0.32	
	0.38	1-5
	0.30	
	0.36	
	0.33	

DEPTH Scale 1:100 — Scale 1:100



0.00 — Red brown, silty sand with abundant angular to sub rounded, highly weathered, white chert fragments: Transported.

2.00 — Pink, silty sand: Karoo.

5.00 — Off white, silty sand with minor angular, highly weathered, quartzite gravels: Karoo.

12.00 — Grey, silty sand with abundant, highly weathered, quartzite gravels and quartz : Karoo.

20.00

NOTES

1) EOH @ 20.0m

2) No water seepage observed

CONTRACTOR : JK Drilling
MACHINE :
DRILLED BY :
PROFILED BY : MM

TYPE SET BY : Sofia
SETUP FILE : STANDARD.SET

INCLINATION : Vertical
DIAM :
DATE : 28/06/2018
DATE : 01/08/2018

DATE : 02/08/2018 15:27
TEXT : ..enturionHighSchoolBH.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: BH1

HOLE No: BH2
Sheet 1 of 2

JOB NUMBER: 17298

ROCK FABRIC	GRAIN SIZE	JOINT ROUGHNESS	ROCK HARDNESS
MF -massive	FG -fine grained	SLJ-slickensided	EHR-extremely hard rock
BF -bedded	MG -medium grain	SJ -smooth	VHR-very hard rock
FF -foliated	CG -coarse grain	RJ -rough	HR -hard rock
CF -cleaved			MHR-medium hard rock
SF -schistose	JOINT SPACING	JOINT SHAPE	SR -soft rock
GF -gneissose	VCJ-very close spacg	CUR-curvilinear	VSR-very soft rock
LF -laminated	CJ -close spacing	PLA-planar	
	MJ -medium spacing	UND-undulating	
	WJ -wide spacing	STE-stepped	
	VWJ-very wide spacng	IRR-irregular	

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Centurion High School

HOLE No: BH2
Sheet 1 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)	DEPTH Scale 1:100	Scale 1:100		
-1	0.28	1-20	1		0.00	Reddish brown, silty sand with abundant, highly weathered, angular, white chert fragments: Transported.
					1.00	
-2	0.20		2			Light grey brown, silty sand with abundant angular, moderately weathered, black chert fragments and traces of leached dolomite: Chert/Dolomite Residuum.
-3	0.24	1-10	3			
-4	0.27		4			
-5	0.22		5		5.00	
						Light grey, silty sand, leached Dolomite Residuum.
-6	0.19		6			
-7	0.21		7			
-8	0.22		8		8.00	
-9	0.18		9			Light grey brown, silty sand with abundant angular, moderately weathered, black chert fragments and traces of leached dolomite: Chert/Dolomite Residuum.
-10	0.22		10			
-11	0.21		11			
-12	0.16		12			
-13	0.25		13			
-14	0.19		14			
-15	0.24		15			
-16	0.27		16		16.00	
						Brown, silty sand with abundant, angular, moderately weathered, black chert fragments with traces of quartz: Chert Residuum.
-17	0.23		17			
-18	0.22		18			
-19	0.29		19			
-20	0.26		20		20.00	
						Greyish black, silty sand with abundant highly weathered, angular, black chert fragments and minor wad: Chert Residuum.
-21	0.15		21			
-22	0.18	1-5	22			

HOLE No: BH2
Sheet 2 of 2

JOB NUMBER: 17298

ROCK FABRIC	GRAIN SIZE	JOINT ROUGHNESS	ROCK HARDNESS
MF -massive	FG -fine grained	SLJ-slickensided	EHR-extremely hard rock
BF -bedded	MG -medium grain	SJ -smooth	VHR-very hard rock
FF -foliated	CG -coarse grain	RJ -rough	HR -hard rock
CF -cleaved			MHR-medium hard rock
SF -schistose	JOINT SPACING	JOINT SHAPE	SR -soft rock
GF -gneissose	VCJ-very close spacg	CUR-curvilinear	VSR-very soft rock
LF -laminated	CJ -close spacing	PLA-planar	
	MJ -medium spacing	UND-undulating	
	WJ -wide spacing	STE-stepped	
	VWJ-very wide spacng	IRR-irregular	

PM Plus
Centurion High School

HOLE No: BH2
Sheet 2 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)	DEPTH Scale 1:100	
-23	0.23		23	
-24	0.25		24	
-25	0.28		25	
-26	0.30		26	
-27	0.34		27	
-28	0.31		28	
-29	0.33		29	
-30	0.29		30	30.00 Black, silty clay (wad) with abundant, highly weathered, black chert fragments: Chert with Wad.
-31	0.32		31	
-32	0.38		32	32.00 No sample return, drilling response suggests chert with wad horizon.
-33	0.24		33	
-34	0.14		34	
-35	0.09		35	35.00 Black, silty clay (wad) with abundant, highly weathered, black chert fragments: Chert with Wad.
-36	0.32		36	
-37	0.35		37	37.00 No sample return, drilling response suggest chert with wad horizon.
-38	0.30		38	
-39	0.28		39	
-40	0.27		40	40.00

NOTES

1) EOH @ 40.0m
2) No water seepage observed
3) BH terminated due to hole collapsing

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DRILLED BY :
PROFILED BY : MM

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SETUP FILE : STANDARD.SET

INCLINATION :
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DATE : 01/08/2018

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ELEVATION :
X-COORD :
Y-COORD :

HOLE No: BH2

HOLE No: BH3
Sheet 1 of 2

JOB NUMBER: 17298

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

JOINT SPACING
VCJ-very close spacg
CJ -close spacing
MJ -medium spacing
WJ -wide spacing
VWJ-very wide spacng

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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Centurion High School

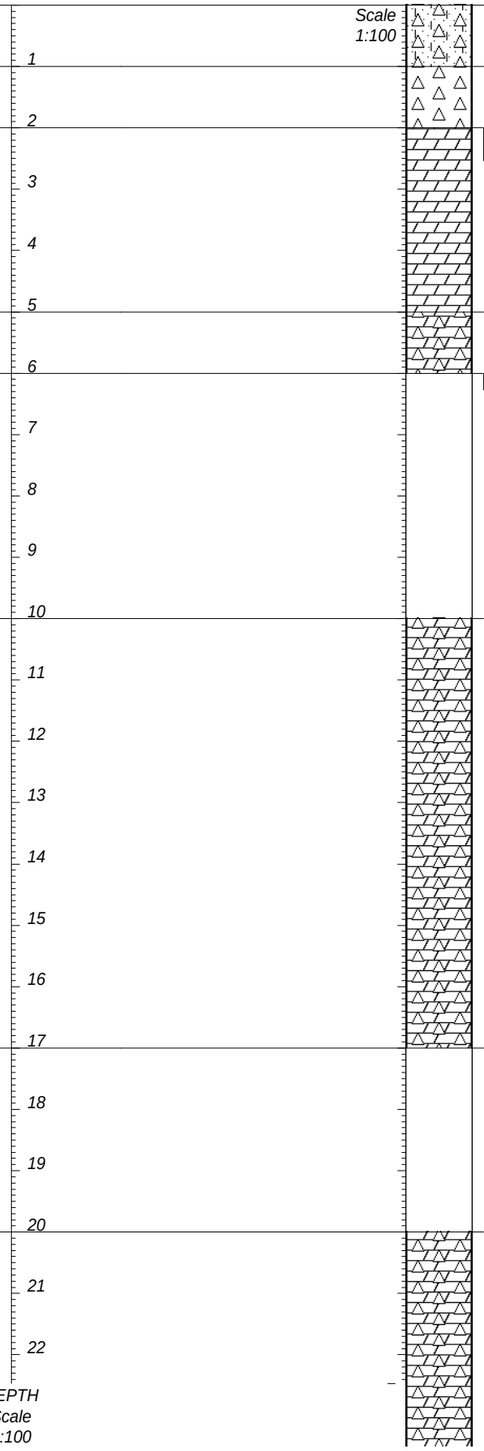
HOLE No: BH3
Sheet 1 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)
-1	0.20	1-20
-2	0.10	
-3	0.33	1-10
-4	1.11	
-5	1.20	
-6	0.14	
-7	0.05	
-8	0.08	
-9	0.04	
-10	0.07	
-11	0.06	
-12	0.09	
-13	0.12	
-14	0.10	
-15	0.09	
-16	0.10	
-17	0.06	1-5
-18	0.03	
-19	0.04	
-20	0.03	
-21	0.13	
-22	0.04	

DEPTH Scale 1:100

Scale 1:100



0.00	Angular moderately weathered, white chert fragments in minor red brown silty sand matrix: Chert Residuum.
1.00	No sample return, drilling response suggests a chert residuum horizon.
2.00	Light grey, angular, highly weathered, dolomite fragments, soft rock: Dolomite.
5.00	No sample return, drilling response suggests a chert dolomite residuum.
6.00	No sample return, drilling response suggests a cavity.
10.00	No sample return, drilling response suggests a possible dolomite/chert residuum.
17.00	No sample return, drilling response suggests a possible cavity.
20.00	No sample return, drilling response suggests a possible chert/dolomite residuum.

HOLE No: BH3
Sheet 2 of 2

JOB NUMBER: 17298

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

JOINT SPACING
VCJ-very close spacg
CJ -close spacing
MJ -medium spacing
WJ -wide spacing
VWJ-very wide spacng

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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PM Plus
Centurion High School

HOLE No: BH3
Sheet 2 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)	DEPTH Scale 1:100	
	1.30		-23	
	0.07		-24	
	0.08		-25	25.00
	3.02		-26	
	3.05		-27	
	3.03		-28	
	3.07		-29	
	3.05		-30	
	3.02		-31	31.00

No sample return, drilling response suggests hard rock dolomite.

NOTES

1) EOH @ 31.0m
2) No water seepage observed
3) BH terminated due to hole collapsing

CONTRACTOR : JK Drilling
MACHINE :
DRILLED BY :
PROFILED BY : MM

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X-COORD :
Y-COORD :

HOLE No: BH3

HOLE No: BH4
Sheet 1 of 2

JOB NUMBER: 17298

ROCK FABRIC	GRAIN SIZE	JOINT ROUGHNESS	ROCK HARDNESS
MF -massive	FG -fine grained	SLJ-slickensided	EHR-extremely hard rock
BF -bedded	MG -medium grain	SJ -smooth	VHR-very hard rock
FF -foliated	CG -coarse grain	RJ -rough	HR -hard rock
CF -cleaved			MHR-medium hard rock
SF -schistose	JOINT SPACING	JOINT SHAPE	SR -soft rock
GF -gneissose	VCJ-very close spacg	CUR-curvilinear	VSR-very soft rock
LF -laminated	CJ -close spacing	PLA-planar	
	MJ -medium spacing	UND-undulating	
	WJ -wide spacing	STE-stepped	
	VWJ-very wide spacng	IRR-irregular	

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PM Plus
Centurion High School

HOLE No: BH4
Sheet 1 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)	DEPTH Scale 1:100
-1	0.22	1-20	1
-2	1.50	0-32	2
-3	0.51		3
-4	0.59		4
-5	0.55		5
-6	0.23	1-15	6
-7	0.24	1-5	7
-8	0.29		8
-9	0.21	1-20	9
-10	0.25		10
-11	0.18		11
-12	0.50		12
-13	0.19		13
-14	0.13		14
-15	0.11		15
-16	0.08		16
-17	0.20		17
-18	0.05		18
-19	0.07		19
-20	0.11		20
-21	0.14		21
-22	0.26		22

Scale 1:100

0.00	Red brown, silty sand with equal amounts of angular, moderately weathered, off white and black chert fragments: Chert Residuum.
4.00	Red brown, silty sand with abundant, moderately weathered, angular black chert fragments: Chert Residuum.
5.00	Black silty clay (wad) with minor highly weathered, angular, black chert fragments: Wad.
8.00	Black, silty clay (wad), with abundant highly weathered angular chert fragments: Chert with Wad.
12.00	No sample return, drilling response suggests a possible chert with wad horizon.
17.00	No sample return, drilling response suggests a possible cavity.
19.00	No sample return, drilling response suggests a possible chert and wad horizon.
20.00	Black, silty clay (wad) with abundant highly weathered, angular, black chert fragments: Chert with Wad.

HOLE No: BH4
Sheet 2 of 2

JOB NUMBER: 17298

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

JOINT SPACING
VCJ-very close spacg
CJ -close spacing
MJ -medium spacing
WJ -wide spacing
VWJ-very wide spacng

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

Geopractica

PM Plus
Centurion High School

HOLE No: BH4
Sheet 2 of 2

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)	DEPTH Scale 1:100
-23	0.18		23
-24	0.17		24
-25	0.15		25
-26	0.24		26
-27	0.28		27
-28	0.42		28
-29	0.22		29
-30	0.29		30
-31	0.38		31
-32	0.47		32
-33	0.41		33
-34	0.25		34
-35	0.37		35
-36	0.40		36
-37	0.51		37
-38	0.27		38
-39	0.13		39
-40	0.10		40

24.00 — No sample return, drilling response suggests a possible chert with wad horizon.

30.00 — Black, silty clay (wad), with abundant highly weathered angular chert fragments: Chert with Wad.

31.00 — No sample return, drilling response suggests possible chert with wad horizon.

40.00

NOTES

1) EOH @ 40.0m

2) No water seepage observed

CONTRACTOR : JK Drilling
MACHINE :
DRILLED BY :
PROFILED BY : MM
TYPE SET BY : Sofia
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 28/06/2018
DATE : 01/08/2018
DATE : 02/08/2018 15:27
TEXT : ..enturionHighSchoolBH.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: BH4

HOLE No: BH5
Sheet 1 of 1

JOB NUMBER: 17298

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

JOINT SPACING
VCJ-very close spacg
CJ -close spacing
MJ -medium spacing
WJ -wide spacing
VWJ-very wide spacng

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

Geopractica

PM Plus
Centurion High School

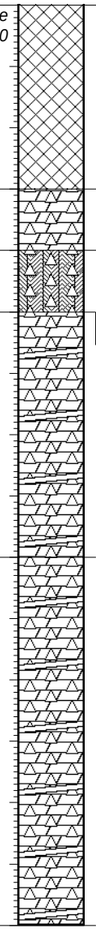
HOLE No: BH5
Sheet 1 of 1

JOB NUMBER: 17298

REDUCED LEVEL	*PENETRATION TIME (min/m)*	*CHIP SIZE (mm)*
-1	0.45	1-15
-2	0.18	
-3	0.14	
-4	0.05	-
-5	1.07	1-5
-6	1.19	1-10
-7	1.33	
-8	1.50	
-9	2.18	
-10	3.03	
-11	3.06	
-12	3.08	
-13	3.01	
-14	3.02	
-15	3.05	

DEPTH Scale 1:100

Scale 1:100



0.00	Red brown, silty sand with abundant, moderately to highly weathered, white chert fragments: Fill?
3.00	No sample return, possible contact between Fill and Chert/Dolomite Residuum.
4.00	Red brown, clayey silt (wad) with traces of highly weathered, angular white chert fragments: Wad.
5.00	Light grey to blue, moderately weathered, soft to medium hard rock: Dolomite with Chert bands.
9.00	Light grey to blue, slightly weathered, hard rock: Dolomite with Chert bands.
15.00	

NOTES

1) EOH @ 15.0m

2) No water seepage observed

CONTRACTOR : JK Drilling
MACHINE :
DRILLED BY :
PROFILED BY : MM

TYPE SET BY : Sofia
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 28/06/2018
DATE : 01/08/2018

DATE : 02/08/2018 15:27
TEXT : ..enturionHighSchoolBH.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: BH5

HOLE No: BH6
Sheet 1 of 1

JOB NUMBER: 17298

ROCK FABRIC	GRAIN SIZE	JOINT ROUGHNESS	ROCK HARDNESS
MF -massive	FG -fine grained	SLJ-slickensided	EHR-extremely hard rock
BF -bedded	MG -medium grain	SJ -smooth	VHR-very hard rock
FF -foliated	CG -coarse grain	RJ -rough	HR -hard rock
CF -cleaved			MHR-medium hard rock
SF -schistose	JOINT SPACING	JOINT SHAPE	SR -soft rock
GF -gneissose	VCJ-very close spacg	CUR-curvilinear	VSR-very soft rock
LF -laminated	CJ -close spacing	PLA-planar	
	MJ -medium spacing	UND-undulating	
	WJ -wide spacing	STE-stepped	
	VWJ-very wide spacng	IRR-irregular	

Geopractica

PM Plus
Centurion High School

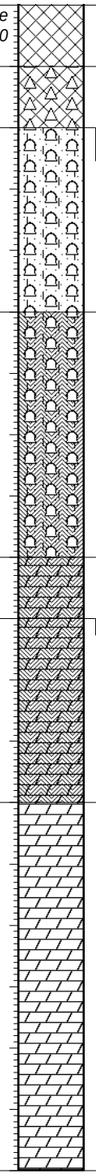
HOLE No: BH6
Sheet 1 of 1

JOB NUMBER: 17298

REDUCED LEVEL	PENETRATION TIME (min/m)	CHIP SIZE (mm)
-1	0.32	0-5
-2	0.37	
-3	0.29	
-4	0.25	
-5	0.20	
-6	0.18	
-7	0.24	
-8	0.21	
-9	1.03	
-10	1.34	2-5
-11	1.49	
-12	1.58	
-13	2.17	
-14	3.05	
-15	3.07	
-16	3.03	
-17	3.09	
-18	3.04	
-19	3.06	

DEPTH Scale 1:100

Scale 1:100



0.00	Reddish brown, silty sand with abundant off white and light grey, highly weathered, angular, chert gravels: Fill.
1.00	Reddish brown, silty sand with abundant light grey, highly weathered, angular, chert gravels: Fill.
2.00	Greyish brown, silty sand with abundant, slightly ferruginised, light grey and yellow, moderately to highly weathered, angular chert gravels: Chert Residuum.
5.00	Dark grey, silty sand with abundant light grey, moderately weathered, angular chert gravels with minor wad: Chert with Wad.
9.00	Dark grey, moderately to highly weathered, very soft rock with traces of wad: Dolomite.
10.00	Light greyish, moderately to highly weathered, soft rock with traces of wad: Dolomite.
13.00	Light greyish, slightly weathered, hard rock: Dolomite.
19.00	

NOTES
1) EOH @ 19.0m
2) No water seepage observed

CONTRACTOR : JK Drilling
MACHINE :
DRILLED BY :
PROFILED BY : MM

TYPE SET BY : Sofia
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 28/06/2018
DATE : 01/08/2018

DATE : 02/08/2018 15:27
TEXT : ..enturionHighSchoolBH.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: BH6

Geopractica

PM Plus
Centurion High School

LEGEND
Sheet 1 of 1

JOB NUMBER: 17298

	GRAVELS	{SA02}
	SAND	{SA04}
	SILT	{SA06}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	DOLOMITE	{SA13}
	QUARTZITE	{SA15}
	BANDS	{SA51}
	CHERT	{SA21}
	WAD	{SA22}
	FILL	{SA32}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

TYPE SET BY : Sofia
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :

DATE : 02/08/2018 15:27
TEXT : ..enturionHighSchoolBH.txt

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

APPENDIX 4

PERMISSIBLE LAND USAGE

Table 2 *(concluded)*

1	2	3	4	5	6	7	8	9	10
Land usage		**Inherent hazard class determined in accordance with the requirements of SANS 1936-2**							
Designation	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Dolomite area designation and footprint investigation requirement							
A1	Agriculture that requires intensive irrigation	See SANS 1936-4							
A2	Agriculture that requires irrigation, including botanical gardens, sports fields, driving ranges, golf courses, parkland and public open spaces	See SANS 1936-4							
DLI = Design level investigation in accordance with the requirements of SANS 1936-2, as deemed appropriate by the competent person. FPI = Design level investigation specifically below the footprint of the structure.									
NOTE 1 D1, D2, D3 and D4 have the meanings assigned in table 1. NOTE 2 Residential coverage ratio = footprint area/site area.									

Table 3 — Permissible infrastructure and social facilities per inherent hazard class

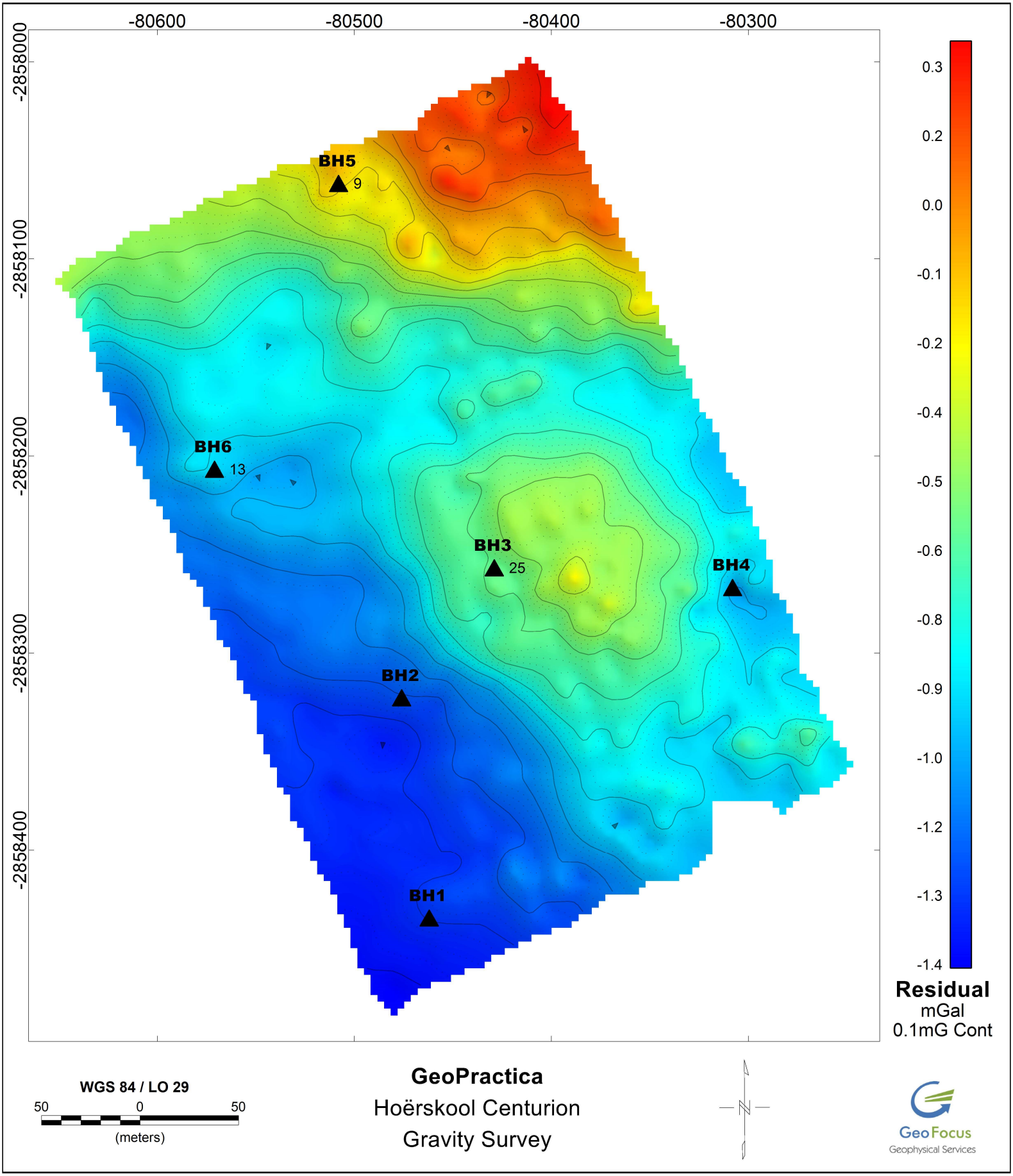
1	2	3	4	5	6	7	8	9	10
Infrastructure and social facilities		**Inherent hazard class determined in accordance with the requirements of SANS 1936-2**							
Designation	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		Dolomite area designation							
IN1	Trunk roads (national and regional roads which facilitate intercity travel) and primary distributor roads (major arterial roads forming the primary network for an urban area as a whole), railway lines, power lines, runways, bulk pipelines, including water, sewer, fuel and gas lines, and pump stations	D2	D3					D4	
IN2	Reservoirs and public swimming pools, water care works, attenuation and retention ponds for stormwater management and artificial lakes	D2	D3				D4		
IN3	Cemeteries	D3					D4		
IN4	Dams, slimes dams	D3	D4						
IN5	Solid waste disposal facilities	D3						D4	
NOTE D1, D2, D3 and D4 have the meanings assigned in table 1.									

ZONE A

ZONE B

APPENDIX 5

GEOPHYSICS


-80600
-80500
-80400
-80300
-2858000
-2858100
-2858200
-2858300
-2858400
BH5
9
BH6
13
BH3
25
BH4
BH2
BH1
0.3
0.2
0.0
-0.1
-0.2
-0.4
-0.5
-0.6
-0.8
-0.9
-1.0
-1.2
-1.3
-1.4
Residual
mGal
0.1mG Cont
WGS 84 / LO 29
50
0
50
(meters)
GeoPractica
Hoërskool Centurion
Gravity Survey
N
GeoFocus
Geophysical Services

APPENDIX 6

DOLOMITE PRECAUTIONARY MEASURES

General precautionary measures to be implemented on all dolomitic sites

1. General measures to be implemented on all dolomitic sites (minimum requirements - NHBRC Standards)

1.1 Wet services of individual and entire development -

a. All wet services should be of good quality in order to ensure low maintenance.

b. Piping materials selected should also be appropriate to local subsurface conditions. If clay pipes are utilized in areas of shallow dolomite, a higher standard of pipe bedding is recommended e.g. stabilized bedding or over excavation and recompaction with an approved material (minimum specification to be G7 material) in layers of 150 mm thickness, compacted to 93% mod AASHTO. Some soils may have low pH values, which will render the use of ferrous material for underground services unsuitable. Chapter II in 'A Technical Guide to Good House Construction' NBRI of the CSIR (July 1984) should be consulted concerning the potential corrosion of pipes.

c. The NHBRC[1] makes the following recommendations:
Waterpiping materials shall be one or more of the following:
* High impact PVC pipes with vitualic joints.
* Other flexible (as defined in SABS 0102, Part 1) water pipes with flexible, self anchoring connections.
Pipes having a diameter of less than 75 mm.
* HDPE type IV.
* Polypropylene.
Pipes should be flexible, while joints should be minimised.

d. Water pipes entering buildings should either be fitted with flexible couplings or kinked with a Z to allow opportunity for relative movement. A flexible connection at the junction with all outlet pipes should be used, which includes WC pan connections.

e. Pressure release systems tend to leak after a couple of years. This leaking water must flow directly into the storm- or sewerage water system.

f. Water reticulation to houses should be kept at a minimum depth of 500 mm up to the structure and above ground wherever possible along the structure.

g. As many services as possible should be placed within a single trench.

h. Encasement of pipes in concrete or soilcrete should be avoided. Preferably place pipes in sleeves. If this cannot be achieved, care must be taken to ensure that differential movement can still be accommodated without the pipe breaking.

i. All storm water, sewerage and water pipes and channels must be watertight. All laid wet services should be tested for leakage on installation using the air test (see NBRI Info Sheet X/BOU 2-34) for water pipes, and the water test for sewerage pipes.

j. Placement of wet services below the footprint of structures must be avoided. No plumbing and drainage pipes should be placed under floor slabs, as far as practicable. Where this situation is unavoidable, reasons must be cited and the pipes must be placed in a sleeve to permit monitoring.

k. Where practical, pipes running parallel to structures should be kept at a distance of at least 5 m from the structure.

l. Each stand should have a rodding eye or some similar access to the sewer connection in addition to the inspection eye.

m. Each stand/unit should have a water meter at a suitable location so that testing of the stand/unit specific water supply is possible. Water leakage testing must be undertaken regularly, as set out in the risk management system.

---

1 National Home Builders Registration Council

n. The roots of trees planted in close proximity to the line of water-bearing services often cause leaks in or malfunctioning of the services. Care should therefore be taken to avoid the unfortunate positioning of trees and other plants.

o. Residents should be informed of where services traverse their garden so that accidental puncturing of pipes can be avoided.

1.2 Entire development

a. The design of wet services should be governed by the need to create low maintenance systems. Wherever possible keep services above ground to facilitate detection of leaks, maintenance and repair.

b. The stability of the center line of all bulk water services should be considered.

c. Piping used in mains and communication pipes should be flexible, while joints should be minimised and, where required, self anchoring type (i.e. not reliant on thrust blocks for their anchorage at fittings, except at valves and end caps).

d. The relevant provision of SABS 1200 DB, L, LB, LC, LD and LE shall be observed in the installation of all underground services.

e. Water mains shall be laid only in road reserves.

f. Provision for future connections shall be made in order to minimise the cutting into pipes to provide such connections.

g. Water pipe entries into the building shall be in accordance with those of the JSD's code of practice [2].

h. The use of pre-manufactured, unjointed manholes are preferred. The manhole should be placed on a properly prepared foundation.

i. Use flexible couplings on either side of manholes.

j. Water-borne sewerage reticulation must be installed. French drains are unacceptable.

k. A detailed sanitation and water reticulation plan should be drawn up for the development according to the local geological setting and engineering geological characteristics. The plan must be incorporated into the services management system of the local authority.

1.3 Stormwater drainage

a. No accumulation of surface water is to be permitted and the entire development must be properly drained.

b. A minimum gradient of 1:150 should be maintained along stormwater systems.

c. Brick and precast concrete walls must be so designed as to provide drainage ports at ground level permitting passage of maximum probable quantaties of water.

d. When courtyards are designed the free flow of surface water should be ensured. Where gutter downpipes are to be found in such a courtyard, a lined canal should permit passage of water into a drain or onto the lawn away from the structure. The courtyard should preferably be paved and no garden beds should be created at gutter discharge points. Lawns must be graded in such a way to facilitate drainage.

e. In order to deal with rainwater run-off from the roofs of structures the following is recommended:
- If guttering is required by the local authority, then the down pipes should discharge into a lined or precast furrow. This furrow should remove the water from the structure. The stormwater should be trained, without ponding, off the property and into the municipal stormwater system.
- If no guttering is to be utilized, then it is recommended that a sealed surface with a width of 1,5 m be cast along those walls of the structure where water will be discharged from the roof. Roof water will cascade off this sloping roof onto the apron

2 JSD Code of Practice reference

into a lined or precast furrow. The stormwater should be drained, without ponding, off the property and into the municipal stormwater system.

- The ground immediately against the buildings shall be shaped to fall in excess of 75 mm over the first 1,5 m beyond the perimeter of the building, from where it shall drain freely away from housing units. Apron slabs, where provided shall have the same fall.

f. All ponds, watercourses and road surfaces shall be rendered impervious.

g. No trees shall be planted within 1,5 times their eventual height from the line of stormwater services.

h. The stormwater drainage system shall incorporate measures to ensure water tightness of conduits and other compartments. Whenever possible, stormwater should be channeled in lined, surface canals.

i. Concrete non-pressure pipes should be of the spigot and socket type with rubber ring seals. Joints in box culverts, channels etc should be sealed.

j. Stormwater drainage conduits shall be constructed at gradients that will not permit the deposition of silt, or sand, of the type present in the catchment area.

1.4 Trenching

a. Trenches and excavation works should be opened and closed as rapidly as possible. Avoid leaving trenches open over weekends or holidays. A berm should be created to divert surface water away from the trenches while they are open. All trenches and excavation works must be properly backfilled and compacted according to specifications given in subclause 5.2.4 of SABS 1200 DA, but specifically to ground surface to prevent them acting as french drains. Once services/cables are installed and backfilling is completed, it must be ensured that ground surface is graded to match the slope of the surrounding area. No rocks in the top layer.

b. Berms should be constructed on the up-slope side of trenches to prevent the inflow of water during storms.

c. The fall of trenches shall be away from buildings. Wherever practical, service trenches shall not be excavated along the length of housing units within the first 3 m beyond the perimeter of such units.

d. No ponding of surface water is to be permitted over, in, or in the vicinity of trenches and excavations.

1.5 Roads

a. Ensure that roadways are in fact placed below the site level so as to facilitate drainage. If the road network is the sole stormwater system, in a township, care must be taken that the roads are surfaced.

b. Ponding of surface water on or next to roads that are not tarred should be avoided.

c. Roadways which have a gradient of less than 1:80 shall be surfaced/sealed.

d. The velocity of the 1 in 20 year stormwater, flowing along unsurfaced roadways shall not exceed 1,5 m/s.

1.6 Swimming pools

The following minimum requirements must exist:

Construction, maintenance and responsibilities for the pools

A) Construction

i) The design, construction and use of the swimming pool should at all times be to the satisfaction of the local city engineer, who should be aware of the requirements of swimming pools in dolomitic areas.

ii) The swimming pool must be designed as an *independent unit, which will not give way or distort*. The sides or floor of the pool should not crack in the event of any ground movement underneath or nearby the swimming pool.

iii) The swimming pool may be constructed from concrete, metal or any other suitable material on condition that the design conforms with condition (Ai) above.

iv) All water pipes, pumps and connections should be installed either in the open, on the surface, or in service canals where these may be inspected or repaired without access problems.

v) The swimming pool should be built so as to prevent any rain water flowing into or towards the pool.

B) Maintenance and responsibilities

i) All back wash water must be discharged *directly* into the main stormwater line.

ii) Any abnormal loss of water from the pool as well as any noticeable ground movement (cracks forming in the ground or in the pool) must be reported by the stand owner to the Home Owners Association or Body Corporate and the local council.

iii) It is important to note that the responsibility of checking pipes to and from the pool, the handling of run-off water from the pool as well as the repairing of cracks in the pool and replacing of leaking pipes lies solely with the stand owner. Negligence could result in instability.

2 Additional precautionary measures for residential affordable, residential group housing (single and double storey) and gentleman's estates

a. Place bulk services in road reserves or servitudes with a minimum width of 5 m. Servitudes may be utilised as parks or 'bridle paths'. If these services are placed mid-block, a building line restriction of a minimum width of 5 m must be imposed. Place water and sewer connections of every two units along their common property boundary. Shared sewer connections should be implemented if this arrangement leads to a reduction in the meterage of service and minimizes the disturbance of the environment. Property and unit entrances should be placed at points furthest from the trenches of these water and sewer connections.

b. It is recommended that structures be placed on earth mattresses, which serve to ensure load distribution and to prevent water ingress. A continuous mattress can be considered for high density development, where it is emplaced in strips for block lengths and with widths exceeding the house footprint by at least 2 m. This exercise must be completed prior to the installation of services.

c. Water and sewer connections to households should be placed within the mattress of enhanced earth. The mattress will retard the flow of water from a leaking service but material will eventually be mobilised sufficiently for structural damage to occur. It is thus evident that testing of water-borne services on a regular basis is very important. Consideration should be given to the placement of sewer lines in inspectable canals as these are not so easy to test. If the mattress is penetrated, wet services must be placed in sleeves for 5 m beyond the structure so that leaking services immediately beyond the mattress cannot result in instability in close vicinity to the foundation.

d. Roadways must be sealed and be constructed below the level of stands.

e. Property and unit entrances should be placed at points away from the trenches of water and sewer connections.

f. Each stand should either have a rodding eye or some similar access to the sewer connection in addition to the inspection eyes so that sensible monitoring may be possible.

3 Additional precautionary measures for High-rise, Light Industrial and Light Commercial sites

a. It is recommended that structures be placed on stiffened rafts on earth mattresses, which serves to ensure load distribution and to prevent water ingress. The mattresses must be emplaced prior to the installation of services.

b. The principal water bearing services must be placed either in the mattress or in sleeves for a distance of at least 5 m beyond the periphery of the building.

c. The surfaces around buildings should be sealed and sloped so that no surface run-off water is allowed to pond against buildings.

d. Downpipes bearing accumulated roof water can be discharged either onto the sealed surfaces to drain away from the structure, or into lined furrows and into stormwater systems.

e. Roadways should be sealed.

f. Portions should be identified at which ‘plugs’ can be installed to stop flow in sewer and water lines at short notice in the event of rupture or sinkhole formation underneath the service. The Local Authority must ensure that contingency plans are in place to deal with such emergencies.

g. No swimming pools should be permitted in this zone.

h. Lined channels are preferred to pipes for stormwater systems in these zones.

i. Structures must be correctly and safely founded.

j. A monitoring programme must be embarked upon by either the owner of the property/buildings, the appropriate Local Council or Metropolitan Substructure to regularly check for any leaks in services, unauthorized structures which could lead to concentration of water and, where necessary, monitor the groundwater level (refer to risk management systems).

k. With respect to commercial, industrial or high-rise structures, the principal waterbearing services should preferably be placed above ground or in sleeves when within 5 m of the structure.

4 Precautionary measures for sites unsuitable for development

a. No buildings should be allowed in this zone.

b. The entire site must be properly sealed.

c. No water-borne services must be allowed in this area. Ablution blocks should be avoided.

d. Surface water run-off management is critical in these areas.

APPENDIX 7

GUIDELINES FOR MONITORING DOLOMITE LAND

Annex A
(informative)

Guidelines for monitoring of dolomite land

A.1 General

A.1.1 Monitoring comprises three activities:

a) infrastructure monitoring, which entails the inspection of water-bearing services, buildings, roads etc.;

b) ground surface monitoring, which entails the inspection of the ground surface as it is disturbed and affected by man's activities; and

c) groundwater level monitoring, which entails the measuring and recording of the dolomite groundwater level in boreholes together with, where appropriate, the record keeping of volumes of water pumped per unit measure of time for specific time periods.

A.1.2 Monitoring practices differ from site to site but might also differ from one monitoring designation area to another within a site. Some inherent hazard class areas might require more stringent precautionary measures and might, as such, need to be monitored on a more frequent basis. This monitoring may be monthly, quarterly, yearly or as designated by a competent person.

A.2 Infrastructure monitoring

A.2.1 The following infrastructure monitoring should be considered on

a) a seasonal interval basis:

   1) visual checks for debris in open stormwater channels at the start of the rainy season and after heavy storms;

   2) visual checks for water flowing out of stormwater manholes at the start of the rainy season and after heavy storms; and

   3) the examination of buildings for cracks at the start of the rainy season.

b) a short interval basis (weekly/monthly):

   1) visual checks for dripping taps and pressure valves outside;

   2) visual checks for damp or moss-grown areas;

   3) visual checks for debris in open stormwater channels;

   4) visual checks for water flowing out of sewer and stormwater manholes;

   5) the examination of buildings, paving, walls, etc. for cracks;

   6) visual check for over-wetting of gardens; and

   7) visual check for blocked drainage ports in garden walls.

c) an intermediate interval basis (four-monthly or six-monthly/annually):

1) the activities in A.2.1(b); and

2) the activities in A.2.2 and A.2.3.

d) a long interval basis (every two years):

inspection to assess the integrity of the system including checking for blockages and leaks.

A.2.2 In certain instances, visual inspections might not be sufficient. It might be necessary to undertake air and water tests on wet services. Consideration should also be given to the design of the infrastructure so that these tests might be possible.

A.2.3 Many high density residential developments have only one water meter for the entire development, which does not allow for the testing of services of individual units and renders identifying the location of a leak difficult. In such circumstances, the following procedure is recommended:

a) Close all taps in the buildings or stopcocks controlling the water supply to buildings, if fitted, for 1 h and monitor the water meter, or monitor meter late at night when residents are normally asleep. A slow increase in the water meter reading or continued operation of the meter will indicate that there is a leakage between the meter and the taps or stopcocks.

b) Open all manholes on the property and observe if waste water or stormwater flows normally.

A.3 Ground surface monitoring

A.3.1 Ground surface monitoring should be undertaken visually on a regular basis by inspecting paved areas after rainstorms (ponding water indicates an area of differential settlement) and by looking for cracks in the ground or in lined and unlined channels.

A.3.2 In areas that have been rehabilitated after an event or where signs of ground settlement have been observed, visual inspections might not be sufficient and ground surface levelling by a surveyor might be required. The results of such levelling should be recorded and stored in the database. Suitable actions should be taken if the levelling surveys show signs of ongoing or accelerating movements.

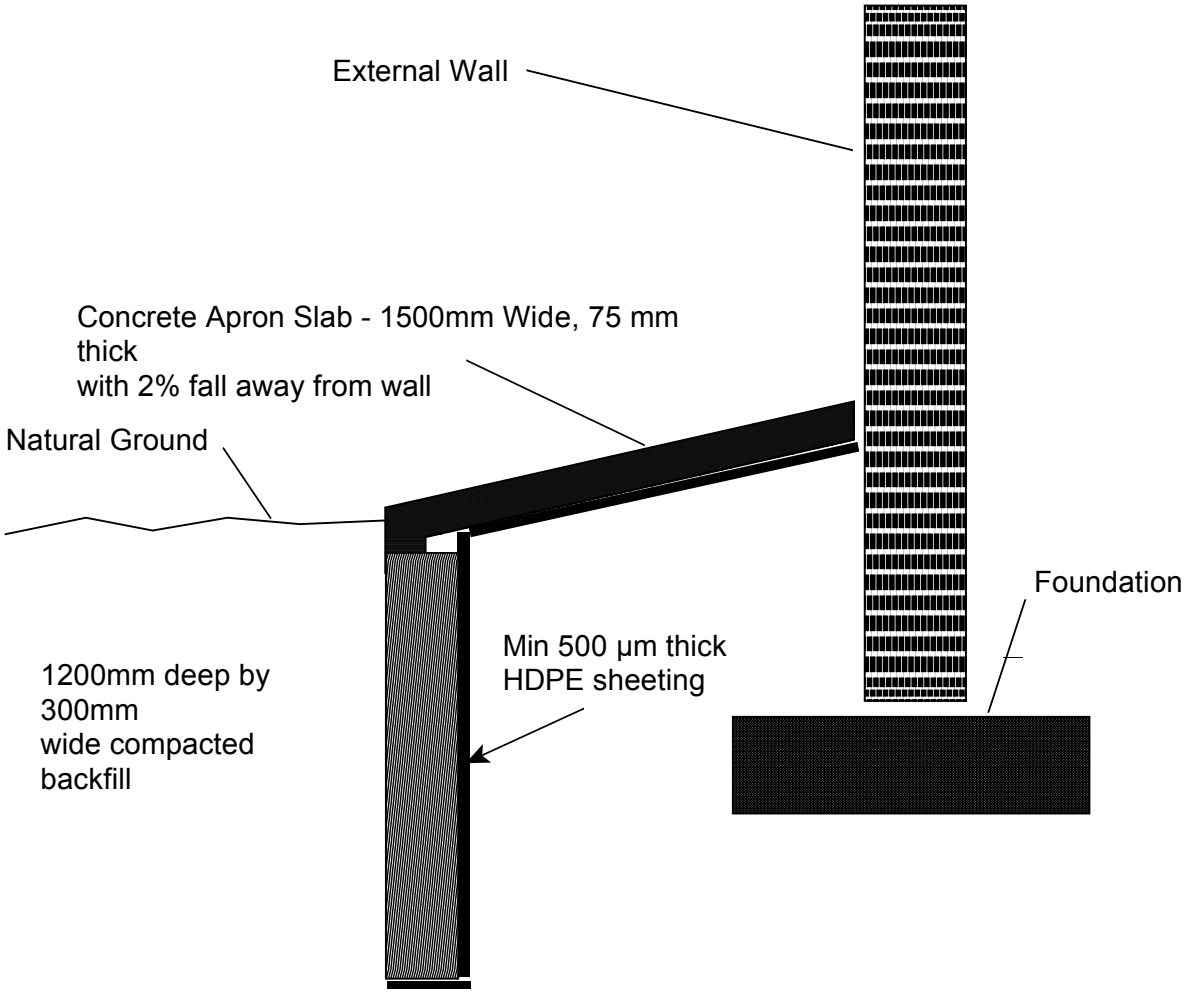
A.4 Groundwater level monitoring

A.4.1 In certain townships, one or more boreholes should be equipped with the necessary equipment to measure fluctuations in groundwater level. The measurement of the groundwater level in such boreholes should be recorded by a designated person (appointed by the local authority) at predetermined intervals. The actual measurements should ultimately be reported to the relevant national department (see foreword).

A.4.2 The local authority should monitor the effect(s) of any large scale abstraction of groundwater for irrigation, water supply or other purposes whether such abstraction is undertaken by the local authority or others. The local authority should also check that the necessary permits have been obtained for any new water abstraction schemes.

APPENDIX 8

APRON SLAB WITH MOISTURE BARRIER



NOTE

1. Transverse saw cut or construction joints at max 2m centres
2. All joints in concrete apron to be sealed with polysulphide

not drawn to scale

Geopractica	**TYPICAL DETAIL OF APRON SLAB WITH A MOISTURE BARRIER** **Proposed Thickener - Tharisa Mine**	**Job No:** 17298 **Date:** August 2018 **Figure:** 4

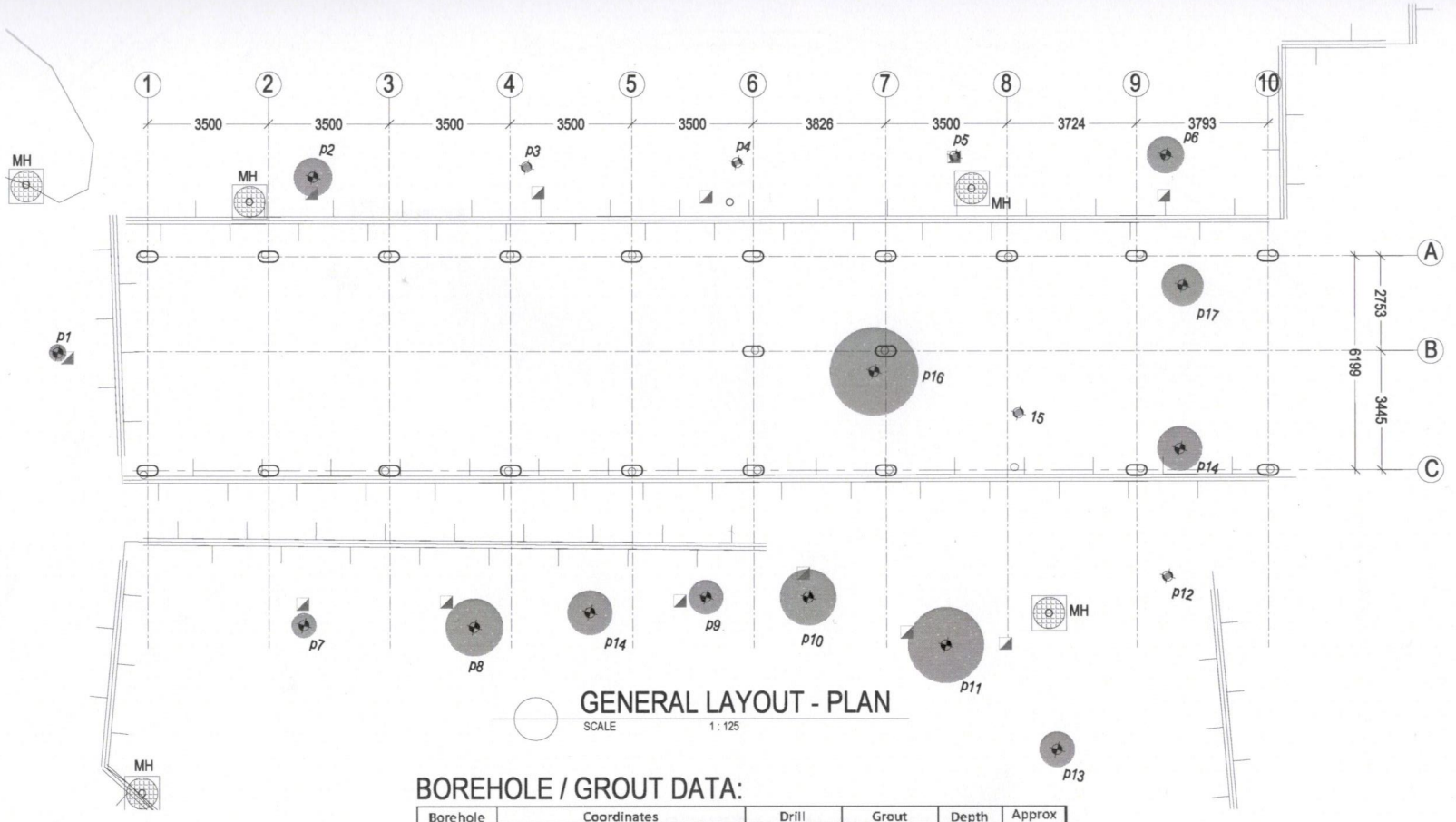
APPENDIX 9

STEFANUTTI STOCKS GEOTECHNICAL
(Sinkhole backfilling July 2017)

Stefanutti Stocks Geotechnical

Grouting to Hoërskool Centurion

Summary of Dolomitic Void Filling To Sinkhole



GENERAL LAYOUT - PLAN

SCALE 1 : 125

BOREHOLE / GROUT DATA:

Borehole Position	Coordinates			Drill Date	Grout Date	Depth (m)	Approx Take (m^3)
	Y	X	Z				
p1	80442.081	2858065.082	1482.933	9-May-2017	16-May-2017	20	3.80
p2	80436.326	2858058.199	1483.093	10-May-2017	16-May-2017	20	19.40
p3	80430.453	2858056.266	1483.120	10-May-2017	18-May-2017	10	0.40
p4	80424.642	2858054.521	1483.033	10-May-2017	18-May-2017	10	0.20
p5	80418.642	2858052.663	1483.079	10-May-2017	18-May-2017	10	0.20
p6	80412.795	2858051.009	1483.099	11-May-2017	15-May-2017	20	18.00
p7	80433.115	2858070.777	1483.615	11-May-2017	24-May-2017	26	10.60
p8	80428.365	2858069.514	1483.594	13-May-2017	23-May-2017	27	58.60
p9	80422.158	2858066.886	1483.720	12-May-2017	24-May-2017	30	23.00
p10	80419.315	2858066.110	1483.342	16-May-2017	23-May-2017	33	68.40
p11	80415.113	2858066.372	1483.512	29-Jun-2017	13-Jul-2017	36	135.50
p12	80409.492	2858062.746	1483.437	29-Jun-2017	13-Jul-2017	17	0.50
p13	80411.228	2858068.428	1483.593	17-May-2017	24-May-2017	23	19.40
p14	80410.129	2858059.096	1482.413	30-Jun-2017	7-Jul-2017	21	27.60
p15	80414.887	2858059.343	1482.245	30-Jun-2017	7-Jul-2017	11	0.40
p16	80419.220	2858059.298	1482.171	4-Jul-2017	7-Jul-2017	12	62.00
p17	80411.313	2858054.516	1483.082	4-Jul-2017	14-Jul-2017	38	43.50
p18	80441.862	2858031.906	1482.428	4-Jul-2017	13-Jul-2017	6	0.50

LEGEND:

- SAKKIE, THEORETICAL POINT
- p1 GROUTING HOLE
- CALCULATED GROUT AREA

No.	DATE	REVISION	By
9	26072017	GROUT 17	LS
8	14072017	GROUT 11,12 and 18	LS
7	12072017	GROUT 13 and 7 HOLES NUMBERING 11-18	LS
6	10072017	HOLES 12,14, 15 to 18	LS
5	24052017	GROUT p9, DRILL p13	LS
4	23052017	GROUT p8, p10	LS
3	18052017	GROUT p3, p4,p5	LS
2	16052017	GROUT p1, p2	LS
1	15052017	GROUT p6	LS

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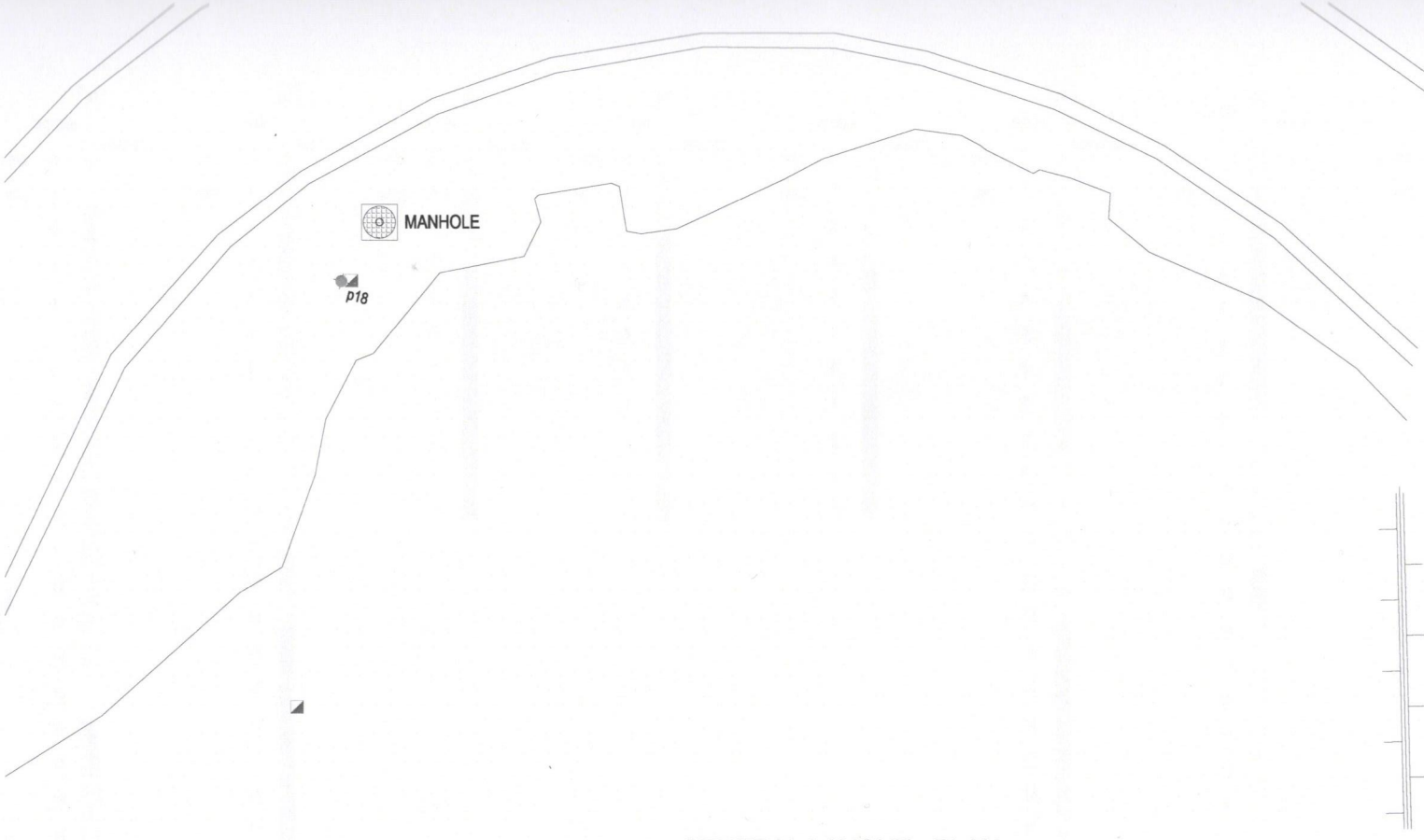
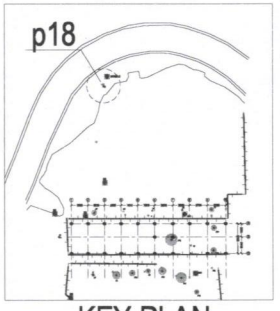
PROJECT
REHABILITATION OF SINKHOLE
CENTURION HIGH SCHOOL

DRAWING TITLE
SURVEY PLAN
CENTURION HIGH SCHOOL

CLIENT
-

PREPARED AY	DATE 26-JUL-2017	SHEET No	02
CHECKED KS	DATE 26-JUL-2017	SHEET SIZE	
DESIGNED KS	DATE 26-JUL-2017		A3
APPROVED MvM	DATE 26-JUL-2017		
DRAWING NO P514 - 001 - 02	SCALE As Shown	REVISION	9





KEY PLAN

GENERAL LAYOUT - PLAN

SCALE 1 : 125

LEGEND:

	SAKKIE, THEORETICAL POINT
p1	GROUTING HOLE
	CALCULATED GROUT AREA

No.	DATE	REVISION	By
3	26072017	-	LS
2	14062017	GROUT 18	LS
1	12062017	HOLE 18	LS

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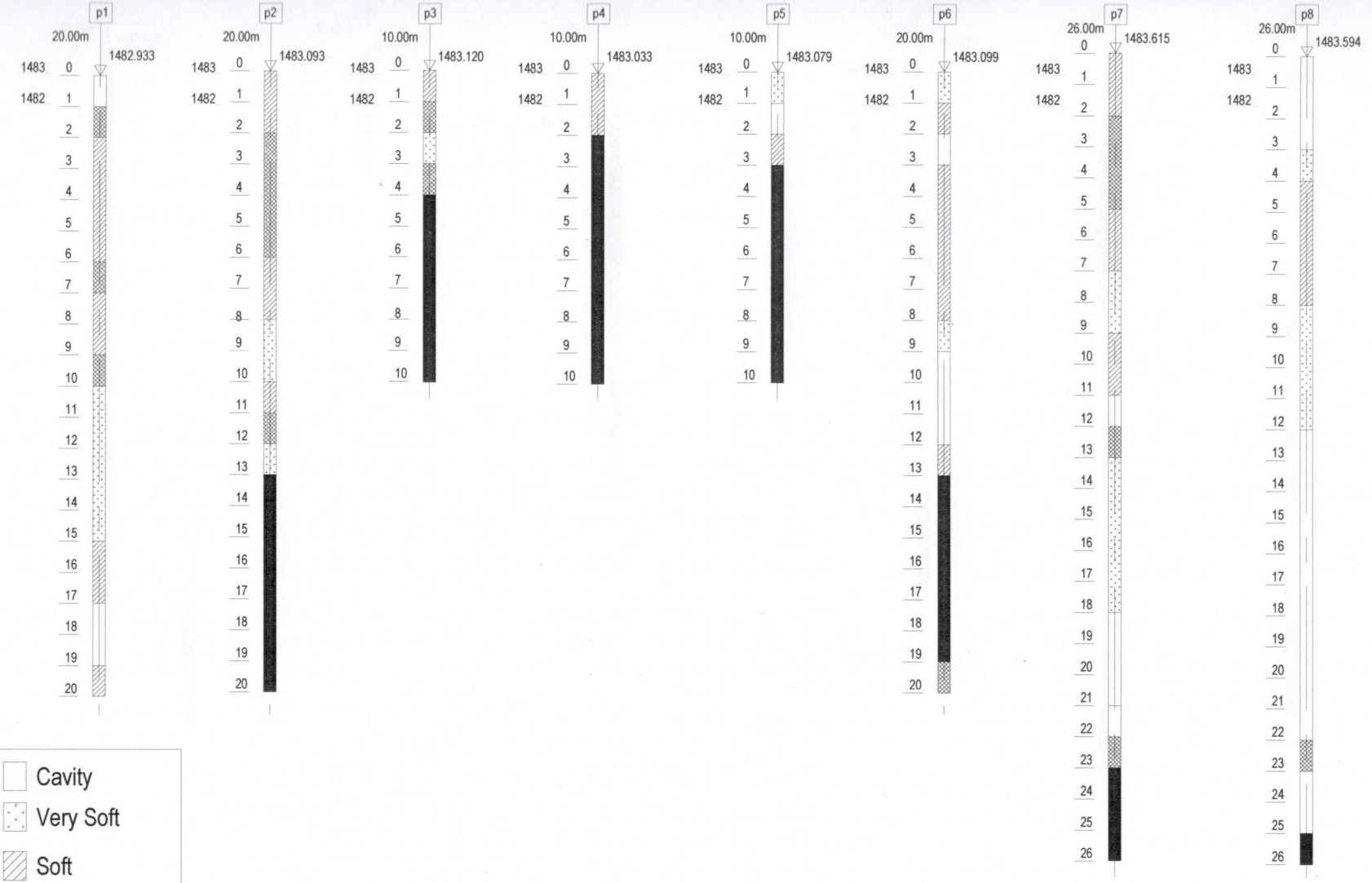
PROJECT
REHABILITATION OF SINKHOLE
CENTURION HIGH SCHOOL

DRAWING TITLE
SURVEY PLAN
CENTURION HIGH SCHOOL

CLIENT
-

PREPARED: AY		DATE: 26-JUL-2017	SHEET No: 03
CHECKED: LS		DATE: 26-JUL-2017	
DESIGNED: KS		DATE: 26-JUL-2017	SHEET SIZE: A3
APPROVED: MeiM		DATE: 26-JUL-2017	
DRAWING NO: P514 - 001 - 03		SCALE: As Shown	REVISION: 3



No.	DATE	REVISION	By
1	11072017	DRILL LOG	LS

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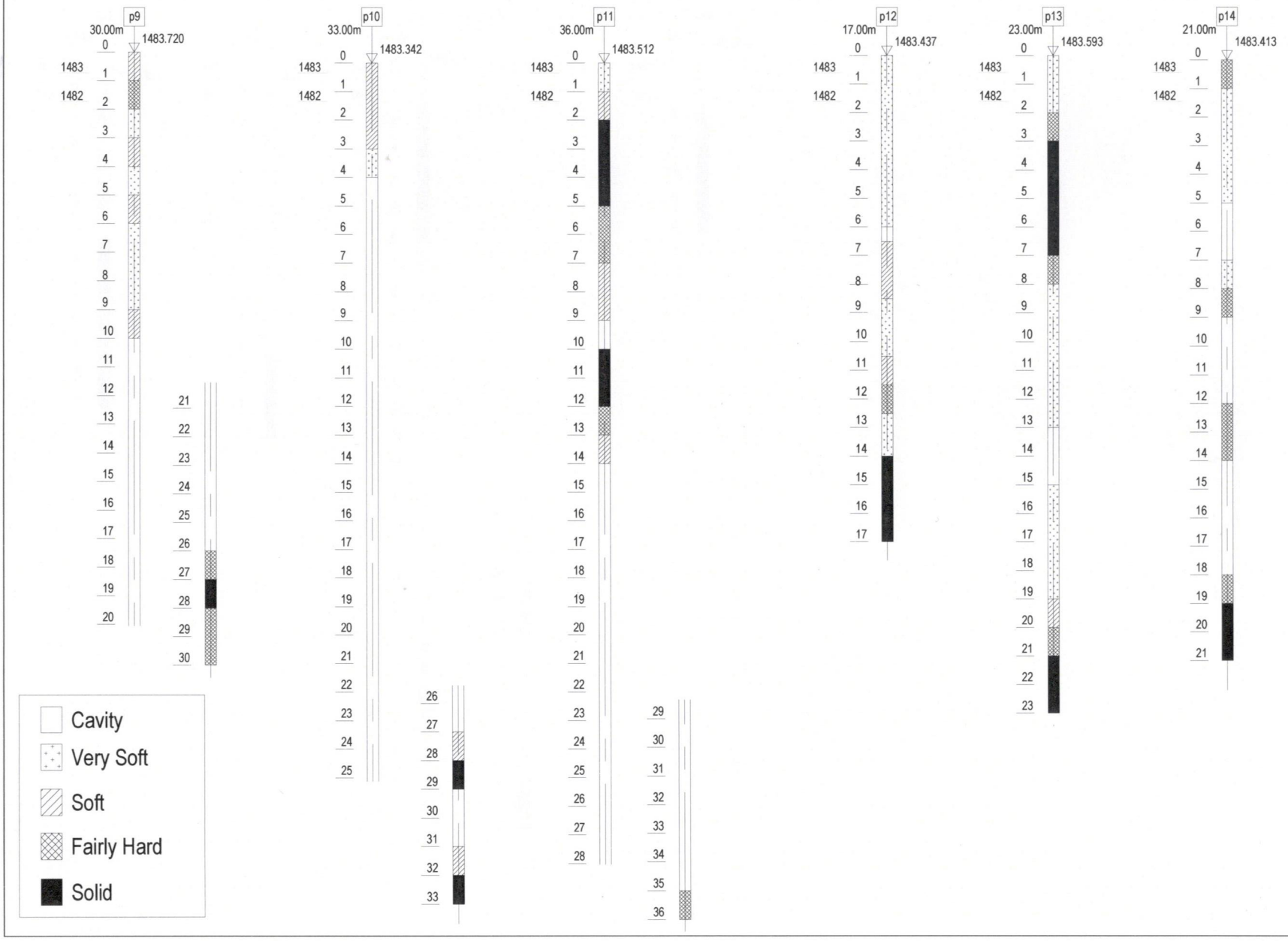
PROJECT:
REHABILITATION OF SINKHOLE
CENTURION HIGH SCHOOL

DRAWING TITLE:
DRILL LOG DATA

CLIENT:
-

PREPARED	AY	DATE 11-JUL-2017	SHEET No 01
CHECKED	LS	DATE 11-JUL-2017	SHEET SIZE A3
DESIGNED	KS	DATE 11-JUL-2017	
APPROVED	MvBM	DATE 11-JUL-2017	
DRAWING NO	P514 - 002 - 01	SCALE As Shown	REVISION 1



No.	DATE	REVISION	By
1	11072017	DRILL LOG	LS

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CENTURION HIGH SCHOOL

DRAWING TITLE:
DRILL LOG DATA

CLIENT:
-

PREPARED AY	DATE 11-JUL-2017	SHEET No.	02
CHECKED LS	DATE 11-JUL-2017		
DESIGNED KS	DATE 11-JUL-2017	SHEET SIZE	A3
APPROVED MdM	DATE 11-JUL-2017		
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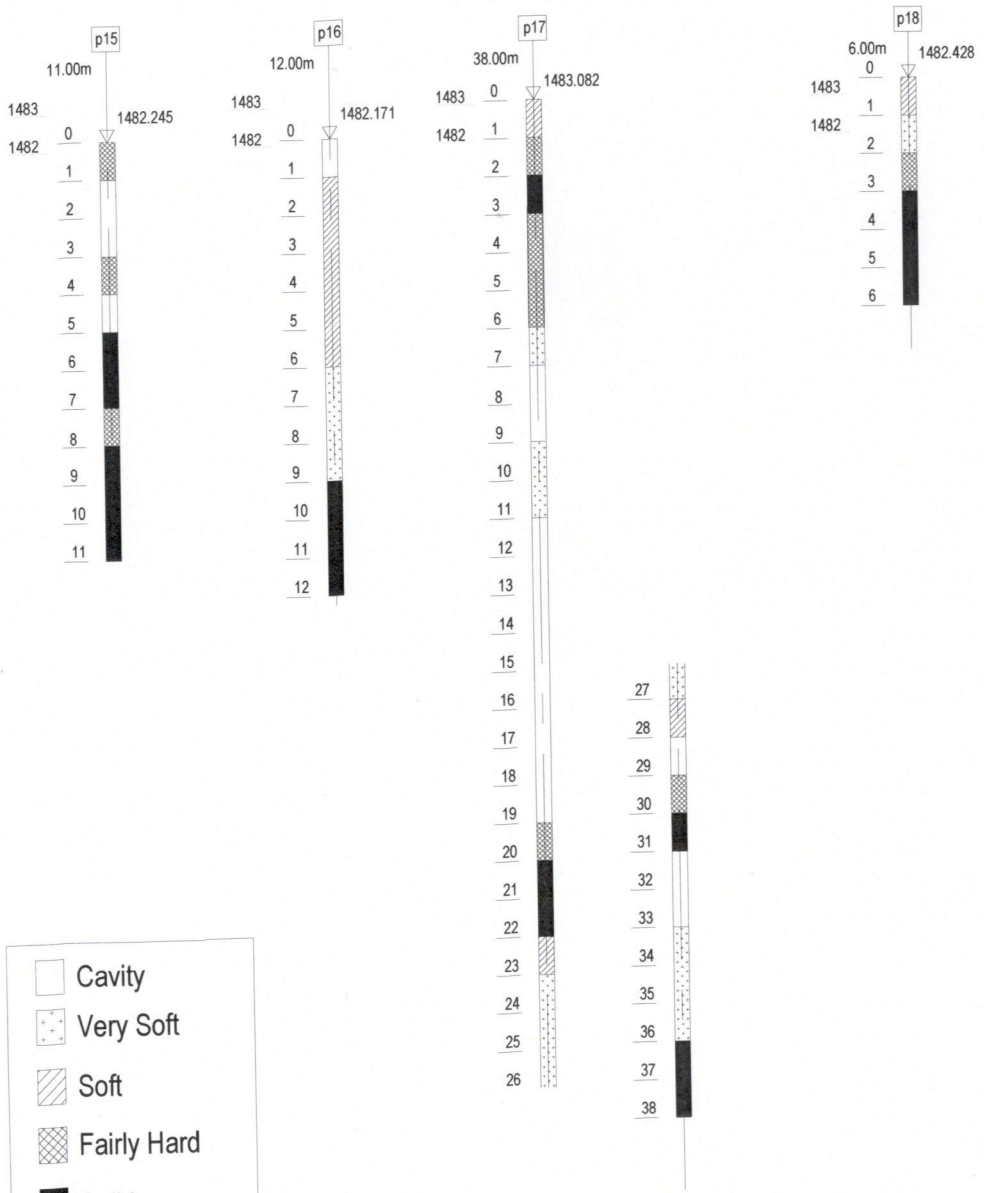

No.	DATE	REVISION	By
1	11072017	DRILL LOG	LS

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CLIENT:

-

PREPARED BY		DATE 11-JUL-2017	SHEET No 03
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DESIGNED KS		DATE 11-JUL-2017	SHEET SIZE A3
APPROVED MwM		DATE 11-JUL-2017	
DRAWING NO P514 - 002 - 03		SCALE As Shown	REVISION 1

HOLE DETAILS

Hole No.	Date Drilled	Drilled depth	Casing depth	Start date grouting	End date grouting	Total volume m^3	Ave pressure (bars)
P1	09/05/2017	20	19	16/05/2017	16/05/2017	3.8	14.2
P2	10/05/2017	20	15	15/05/2017	16/05/2017	19.4	10.5
P3	10/05/2017	10	4.5	16/05/2017	16/05/2017	0.4	8
P4	10/05/2017	10	6	16/05/2017	16/05/2017	0.2	8
P5	10/05/2017	10	6	16/05/2017	16/05/2017	0.2	8
P6	11/05/2017	20	13.5	13/05/2017	15/05.2017	18	3.6
P7	11/05/2017	26	22.5	24/05/2017	25/05/2017	10.6	5.6
P8	12/05/2017	27	25	19/05/2017	22/05/2017	58.6	10.9
P9	12/05/2017	30	25.5	22/05/2017	24/05/2017	23	7.2
P10	16/05/2017	33	27.5	16/05/2017	19/05/2017	68.4	9.4
P11	29/06/2017	36	34	10/07/2017	13/07/2017	135.5	5.8
P12	29/06/2017	17	13.5	13/07/2017	13/07/2017	0.5	3.8
P13	17/05/2017	23	19	24/05/2017	24/05/2017	19.4	11.8
P14	30/06/2017	21	18	05/07/2017	07/07/2017	27.6	12.3
P15	30/06/2017	11	8	07/07/2017	07/07/2017	0.4	2.2
P16	04/07/2017	12	9	06/07/2017	07/07/2017	62	4.4
P17	04/07/2017	38	36	13/07/2017	14/07/2017	43.5	10.3
P18	04/07/2017	6	4	13/07/2017	13/07/2017	0.5	4.2
	Total (m)	**370**			**TOTAL (m3)**	**492**	

Grout Delievery Notes Summary

Delivery Note #	Supplier	Start Time	Truck #	Person Deliver To	30MPa Grout m3	Member	Remarks
32706	Metier	8:55	CM86	J Barnard	6.0	P06	
32710	Metier	10:40	CM124	J Barnard	6.0	P06	
51809	Metier	10:10	CM84	J Barnard	6.0	P06	
51814	Metier	12:20	CM124	J Barnard	6.0	P02	
51821	Metier	13:58	CM84	J Barnard	6.0	P02	
51828	Metier	15:10	CM126	J Barnard	6.0	P02	
69035	Metier	8:52	CM56	J Barnard	1.4	P02	Shared
69035	Metier	9:10	CM56	J Barnard	0.4	P03	Shared
69035	Metier	9:52	CM56	J Barnard	0.2	P04	Shared
69035	Metier	10:35	CM56	J Barnard	0.2	P05	Shared
69035	Metier	11:12	CM56	J Barnard	3.8	P01	Shared
69065	Metier	16:23	CM143	J Barnard	6.0	P10	
51878	Metier	9:23	CM120	J Barnard	6.0	P10	
51888	Metier	10:20	CM143	J Barnard	6.0	P10	
51894	Metier	12:26	CM100	J Barnard	6.0	P10	
51898	Metier	13:15	CM143	J Barnard	6.0	P10	
32821	Metier	8:10	CM126	J Barnard	6.0	P10	
32825	Metier	9:54	CM141	J Barnard	6.0	P10	
32831	Metier	10:50	CM98	J Barnard	6.0	P10	
32841	Metier	13:20	CM114	J Barnard	6.0	P10	
32846	Metier	14:29	CM94	J Barnard	6.0	P10	
32854	Metier	8:15	CM122	J Barnard	6.0	P10	
32867	Metier	9:18	CM114	J Barnard	2.4	P10	Shared
32867	Metier	10:05	CM114	J Barnard	3.6	P08	Shared
32873	Metier	13:20	CM86	J Barnard	6.0	P08	
52028	Metier	7:59	CM117	J Barnard	6.0	P08	
52036	Metier	9:08	CM87	J Barnard	6.0	P08	
52041	Metier	10:51	CM117	J Barnard	6.0	P08	
52046	Metier	12:30	CM14	J Barnard	6.0	P08	
52047	Metier	13:58	CM87	J Barnard	6.0	P08	
52052	Metier	16:38	CM117	J Barnard	6.0	P08	
52053	Metier	15:53	CM14	J Barnard	6.0	P08	
52056	Metier	7:55	CM117	J Barnard	6.0	P08	
52058	Metier	9:05	CM03	J Barnard	1.0	P08	Shared
52058	Metier	9:46	CM03	J Barnard	5.0	P09	Shared
52078	Metier	13:35	CM117	J Barnard	6.0	P09	
52087	Metier	14:53	CM03	J Barnard	6.0	P09	
52101	Metier	7:09	CM100	J Barnard	6.0	P09	
52106	Metier	9:22	CM84	J Barnard	6.0	P13	
52118	Metier	11:52	CM87	J Barnard	6.0	P13	
52124	Metier	14:05	CM116	J Barnard	6.0	P13	
52130	Metier	15:13	CM87	J Barnard	1.4	P13	Shared
52130	Metier	16:01	CM87	J Barnard	5.0	P07	Shared

52157	Metier	11:02	CM87	J Barnard	5.6	P07	
52909	Metier	8:25	CM117	J Barnard	6.0	P14	
52910	Metier	9:35	CM14	J Barnard	6.0	P14	
52921	Metier	11:21	CM117	J Barnard	6.0	P14	
52913	Metier	12:15	CM14	J Barnard	6.0	P14	
34187	Metier	8:45	CM114	J Barnard	6.0	P16	
34195	Metier	9:35	CM86	J Barnard	6.0	P16	
34208	Metier	11:55	CM66	J Barnard	6.0	P16	
34212	Metier	12:46	CM126	J Barnard	6.0	P16	
34214	Metier	13:47	CM86	J Barnard	6.0	P16	
34222	Metier	15:21	CM117	J Barnard	6.0	P16	
52912	Metier	8:23	CM66	J Barnard	6.0	P16	
52932	Metier	9:45	CM03	J Barnard	6.0	P16	
52939	Metier	11:06	CM66	J Barnard	6.0	P16	
34240	Metier	13:22	CM84	J Barnard	6.0	P16	
34246	Metier	11:59	CM83	J Barnard	2.0	P16	Shared
34246	Metier	11:59	CM83	J Barnard	0.4	P15	Shared
34246	Metier	11:59	CM83	J Barnard	3.6	P14	Shared
34249	Metier	8:10	CM126	J Barnard	6.0	P11	
34259	Metier	11:04	CM117	J Barnard	6.0	P11	
34255	Metier	9:52	CM94	J Barnard	6.0	P11	
34253	Metier	9:13	CM83	J Barnard	6.0	P11	
34272	Metier	13:49	CM83	J Barnard	6.0	P11	
34264	Metier	12:05	CM84	J Barnard	6.0	P11	
71263	Metier	8:09	CM02	J Barnard	6.0	P11	
71264	Metier	8:52	CM06	J Barnard	6.0	P11	
71273	Metier	9:40	CM97	J Barnard	6.0	P11	
71275	Metier	10:45	CM56	J Barnard	6.0	P11	
71282	Metier	12:30	CM57	J Barnard	6.0	P11	
71288	Metier	14:31	CM124	J Barnard	6.0	P11	
71304	Metier	8:12	CM02	J Barnard	6.0	P11	
71305	Metier	9:05	CM06	J Barnard	6.0	P11	
71320	Metier	11:05	CM02	J Barnard	6.0	P11	
71324	Metier	12:30	CM06	J Barnard	6.0	P11	
71331	Metier	13:48	CM02	J Barnard	6.0	P11	
71338	Metier	15:55	CM67	J Barnard	6.0	P11	
71342	Metier	7:29	CM56	J Barnard	6.0	P11	
71343	Metier	8:15	CM57	J Barnard	5.5	P11	Shared
71343	Metier	8:30	CM57	J Barnard	0.5	P18	Shared
71344	Metier	9:00	CM67	J Barnard	6.0	P11	
71359	Metier	10:59	CM57	J Barnard	6.0	P11	
71370	Metier	14:03	CM57	J Barnard	4.0	P11	Shared
71370	Metier	14:15	CM57	J Barnard	0.5	P12	Shared
71370	Metier	14:36	CM57	J Barnard	1.5	P17	Shared
71371	Metier	16:46	CM79	J Barnard	6.0	P17	
71382	Metier	7:52	CM124	J Barnard	6.0	P17	
71383	Metier	8:40	CM02	J Barnard	6.0	P17	

71390	Metier	9:29	CM57	J Barnard	6.0	P17	
71400	Metier	11:32	CM02	J Barnard	6.0	P17	
71410	Metier	14:10	CM57	J Barnard	6.0	P17	
71411	Metier	15:08	CM02	J Barnard	6.0	P17	
				Total	**492.0**		