PROCLAMATION STAGE GEOTECHNICAL REPORT TO CENTURUS ON THE PROPOSED HIGHVELD EXTENSION 49, CENTURION, INCLUDING COMMERCIAL, OFFICE AND RESIDENTIAL DEVELOPMENT.

IR565
A PROCLAMATION STAGE GEOTECHNICAL REPORT TO CENTURUS ON THE PROPOSED HIGHVELD EXTENSION 49, CENTURION, INCLUDING COMMERCIAL, OFFICE AND RESIDENTIAL DEVELOPMENT.

SUMMARY

This report presents the results of proclamation stage geotechnical investigations carried out on the proposed Highveld Extension 49 commercial, office and residential development in Centurion. The site is located on dolomite and chert of the Monte Christo Formation, Chuniespoort Group, Transvaal Supergroup. Intrusive rocks and materials of the Pretoria Dyke occur extensively under the eastern sector of the site. These investigations involved field inspections, a review of available data (including gravity surveys, borehole and test pit data) and completion of an infill drilling and test pitting programme.

The site was previously investigated and covered in two reports:

- Intracconsult report IR482, dated 20 February 2002, entitled: "A proclamation report to Centurus on the proposed Swartland commercial and office park, Centurion."

- BKS report, Reference No. P801561, dated September 1999, "Dolomite stability investigation for the proposed township Highveld Extension 34."

This report covers two areas, namely:

- Area A pertaining to the commercial and office park development.

- Area B covering the proposed Residential 2 and apartment area. Offices may also be erected within this designated area.
Relevant information contained in the Intraconsult and the BKS reports has been merged into this single report for overall planning purposes. Limited additional geophysical, drilling and backhoe work has been undertaken. Based on the geological, geophysical and geohydrological data gathered during this investigation the stability of the site is described in terms of four Dolomite Stability Zones. These Dolomite Stability Zones are defined as follows:

Dolomite Stability Zone 1: Area characterised as reflecting a low Inherent Risk of sinkhole and doline formation with respect to water ingress. Inherent Risk Class 1.

Dolomite Stability Zone 2: Area characterised as reflecting a medium Inherent Risk of sinkhole and doline formation with respect to water ingress. Inherent Risk Class 4.

Dolomite Stability Zone 3: Area characterised as reflecting a high Inherent Risk of small and medium size sinkhole and doline formation with respect to water ingress. Inherent Risk Class 6.

Dolomite Stability Zone 4: Area characterised as reflecting a high Inherent Risk of large size sinkhole and doline formation with respect to water ingress. Inherent Risk Class 7.

Monitoring of the groundwater level in the region must form an integral part of the Dolomite Risk Management System of the local authority.

The Area A i.e. the commercial and office park area, straddles Zone 1, 2, 3 and 4 areas, and may be utilised for the proposed land use. Detailed geotechnical investigations are required on the footprint of each proposed structure.

The Area B i.e. Residential 2 and apartments area, straddles Zones 1 and 2 and may be planned for proposed land use. If designed for 25 units/hectare or less, planning can proceed on the current basis of the available geotechnical data provided approval is granted by the Council for Geoscience and the NHBRC. If multistoried apartments are to be erected in the future then detailed footprint investigations are required. In addition, if office complexes are proposed, detailed geotechnical investigations will be required on the footprint area.

Appropriate water precautionary measures are provided together with recommendations aimed at the adoption of a pro-active waterbearing services maintenance strategy. A general discussion on the founding of structures and services infrastructure is given. Particular emphasis is placed upon the need to manage stormwater falling onto, moving across and exiting this site.

It is emphasised that these Dolomite Stability and soil zones are intended to provide general guidance for the planning of this site. Detailed geotechnical investigations are required on the footprint areas of structures in Area A and apartments or commercial structures erected within Area B. In these instances final precautionary measures and foundation designs will be determined by the results of these investigations.
A PROCLAMATION STAGE GEOTECHNICAL REPORT TO CENTURUS ON THE PROPOSED HIGHVELD EXTENSION 49, CENTURION, INCLUDING COMMERCIAL, OFFICE AND RESIDENTIAL DEVELOPMENT.

SUMMARY

CONTENTS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>INTRODUCTION</td>
</tr>
<tr>
<td>2.</td>
<td>TERMS OF REFERENCE AND SCOPE OF WORK</td>
</tr>
<tr>
<td>3.</td>
<td>EXISTING INFORMATION</td>
</tr>
<tr>
<td>4.</td>
<td>GENERAL LOCATION AND DESCRIPTION OF THE SITE</td>
</tr>
<tr>
<td>5.</td>
<td>PROCEDURES USED IN THESE INVESTIGATIONS</td>
</tr>
<tr>
<td>6.</td>
<td>GEOLOGY AND GEOHYDROLOGY</td>
</tr>
<tr>
<td>7.</td>
<td>DOLOMITE STABILITY CHARACTERISATION</td>
</tr>
<tr>
<td>8.</td>
<td>SOILS CLASSIFICATION</td>
</tr>
<tr>
<td>9.</td>
<td>CONCLUSIONS AND RECOMMENDATIONS</td>
</tr>
<tr>
<td>10.</td>
<td>GENERAL RECOMMENDATIONS</td>
</tr>
</tbody>
</table>

TABLES:

RISK CHARACTERISATION OF BOREHOLE DATA: HIGHVELD EXTENSION 49, CENTURION. TABLES 1 to 3.

DRAWINGS:

PROPOSED HIGHVELD EXTENSION 49: RESIDUAL GRAVITY MAP AND BOREHOLE POSITIONS. DRAWING IR565/1

DOLOMITE RISK CHARACTERISATION: PROPOSED HIGHVELD EXTENSION 49. DRAWING IR565/2

SOILS MAP: PROPOSED HIGHVELD EXTENSION 49. DRAWING IR565/3
1. INTRODUCTION

This report presents and comments on the results and observations of geotechnical investigations carried out on the site for the proposed Highveld Extension 49, Centurion. The report documents, the terms of reference, available data used in the study, investigating procedures, risk characterisation method used to zone the site, geology, geohydrology, risk zonation, soil zonation, conclusions and recommendations. The report pertains to two distinct areas, namely:

- the commercial and office park development (Area A).
- the Residential 2/Apartment development (Area B). Office development may be incorporated in this particular area.

2. TERMS OF REFERENCE AND SCOPE OF WORK

The terms of reference and scope of the work to be undertaken were discussed with Mr Misha Tolksdorff of Centurus. Intraconsult outlined budget and technical proposals in letter IR482, dated 29 November 2002. Intraconsult was appointed and instructed to proceed with the investigations in accordance with these proposals by Centurus on the 3 December 2002.

3. EXISTING INFORMATION

The following information has been used in the current investigation and assessment of the site:

- Intraconsult report IR482, dated 20 February 2002, entitled: "A proclamation report to Centurus on the proposed Swartland commercial and office park, Centurion."

- BKS report, Reference No. P801561, dated September 1999, "Dolomite stability investigation for the proposed township Highveld Extension 34."

- Topographic map of the Director of Surveys at a scale of 1 : 50 000: Sheet 2628CC, Lyttelton.

- Geological Map of the GSO: Scale 1: 50 000 Sheet 2628CC Lyttelton.


Code of Practice: Assessment of the performance of housing units in South Africa. The Joint Structural Division of SAICE and IStructE. June 2000.

Council for Geoscience, letter G016/1/5/3, dated 20 March 2002 and entitled: "Comment on the suitability of the proposed Swartland Commercial and Office Park, Centurion."


4. GENERAL LOCATION AND DESCRIPTION OF THE SITE.

The site is located immediately south of the N1 national freeway, east of Doringkloof, west of Highveld Extension 13 and north of the proposed Ollevehoutbosch Drive, in Centurion. The site straddles the Hennops River. The area is open and currently unused.

A Location Plan is provided in Figure 1.

5. PROCEDURES USED IN THESE INVESTIGATIONS

These investigations have involved the following:

5.1 Assimilation of available data.

The geotechnical reports pertaining to the two areas merged to create Highveld Extension 49 are covered in the following reports:

- Intraconsult report IR482, dated 20 February 2002, entitled: "A proclamation report to Centurus on the proposed Swartland commercial and office park, Centurion."

- BKS report, Reference No. P801561, dated September 1999, "Dolomite stability investigation for the proposed township Highveld Extension 34."

These reports were commented on by the Council for Geoscience (20/3/2002 and 7/10/1999).

5.2 Field Inspection

In order to develop a clearer perspective of the actual site conditions on the area previously investigated by BKS, field inspections were completed during the early stages of this investigation. The object of these field inspections was to evaluate access, geomorphology, geology (outcrop/scattered outcrop etc), storm water runoff etc.
5.3 Geophysical Surveys

5.3.1 Gravity survey

Engineering and Exploration Geophysical Services undertook geophysical surveys on the eastern site area during December 2001 and the western sector during 1999. These gravity surveys were conducted according to prevailing practice. A 30m grid was set and elevations and positions (LO29) were determined using a differential GPS. Gravity readings were taken using a Scintrex Autograv.

Data reduction followed normal procedures. Data were reduced to relative Bouguer values using an elevation correction factor of 0.21 mgals/metre. A plane was fitted by regression to and then removed from Bouguer data set. The plane is taken to represent the regional gravity trend and the residual gravity was derived by removing this plane from the Bouguer data. The residual field was adjusted by a constant after drilling data was made available, so that the values on average better represent depth to bedrock at the boreholes (Drawings IR565/1 and Appendix 4).

Gravity data available from the BKS report is included on Drawing 565/1.

5.3.2 Apparent conductivity and magnetic field survey.

An apparent conductivity and magnetic field survey was carried out in the eastern sector of the site i.e. Area B, to further assist in delineating north-south striking Pretoria Dyke and related sill (See Appendix 4). A Geonics EM34-3 was used to measure the apparent conductivity. The coil separation was set to twenty metres and readings were taken with both horizontal and vertical coil directions. Magnetic field readings were at the same locations as the conductivity readings. Station positions were recovered with the aid of a hand held GPS.

5.3 Rotary Percussion Boreholes

Thirty boreholes were previously drilled on and in the immediate area of the site and are contained in the original Intraconsult and BKS reports.

A rotary-percussion borehole drilling programme has been carried out during this phase largely to confirm the lateral continuity of the sill. These boreholes also assist in the formulation of a perspective concerning the subsurface and geohydrological conditions on the site (Appendix 1).

All the drilling work was undertaken using a down-the-hole rotary percussion rig and a 750 c.f.m compressor delivering 250 psi to a 155mm diameter button bit or scraper. Chip samples were retrieved from the return air stream through each metre drilled, while the penetration times per metre were recorded (when using the button bit) with an electronic stop watch. The retrieved samples are described according to current practice.
The summarised borehole information gathered and recorded during these investigations is provided in Tables 1 to 3. The positions of the boreholes are indicated on Drawing IR565/1. This borehole information is discussed in greater detail in Sections 7 and 8 below.

5.4 Trial Holes

Soil profiles were available for the area east of the Hennops River. Additional test pits were excavated west of the river during the current phase of work. The trial holes were excavated at selected positions using a 75 kW power backhoe machine. Each trial hole was entered and inspected by an engineering geologist who also described the soils profiles using the visual and tactile procedures advocated by Jennings et al (1973). Each horizon of the soil profile being described in terms of the six descriptors, namely moisture condition, colour, consistency, structure, soil type and origin (MCCSSO). Detailed descriptions of the trial hole profiles are given in Appendix 1 below. The position of each trial hole is shown on Drawings IR565/3.

5.5 Soil Sampling and Testing

For accurate classification and identification purposes, particle size distributions and Atterberg Limit tests have been carried out on disturbed samples recovered from various soil type horizons encountered during these investigations. Bulk samples were collected for pavement design purposes. Undisturbed block samples were cut from selected soils to determine their potential behavioral characteristics.

The results of these tests are fully reported on in Appendix 2 and discussed in Sections 8 and 9.

6. GEOLOGY AND GEOHYDROLOGY

The site is located on dolomite and chert of the Monte Christo Formation, Chuniespoort Group and their weathered soil derivatives. Residual dolomite (wad), chert residuum and colluvial deposits overlie the dolomite bedrock. Weathered and unweathered syenite of the Pretoria Dyke underlies a large portion of this site (Appendix 4).

In the eastern sector of the site the apparent conductivity and magnetic field survey was used to better delineate the location of the intrusive sill and Pretoria Dyke. The Pretoria Dyke appears as a rectilinear on the gravity survey (Drawing IR565/1). No gravity anomalies were detected in relation to the sill. Apart from the northerly trending positive gravity anomaly, the Pretoria Dyke is marked by a high amplitude magnetic anomaly. Magnetic peaks mark the edges of the dyke. The eastern edge of the dyke is also marked by a dip in vertical-dipole values, a response associated with sub vertical conductor. Here the conductor is probably a weathered contact zone. In the absence of magnetic anomalies the extent of the syenite is inferred from zones of higher apparent conductivity. Based on the survey the potential distribution of the dyke and sill are shown on Figure 4 in Appendix 4.
The various lithological units encountered on the site is as follows:

<table>
<thead>
<tr>
<th>LITHOLOGY</th>
<th>LITHOSTRATIGRAPHIC UNIT</th>
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<tbody>
<tr>
<td>Silts, sand gravels, pedocretes</td>
<td>Recent deposits of mixed origin.</td>
</tr>
<tr>
<td>Clayey sands</td>
<td>Syenite, Pretoria Dyke and sill.</td>
</tr>
<tr>
<td>Clayey silts (wad) clays, sands</td>
<td>Chuniespoort Group</td>
</tr>
<tr>
<td>Chert</td>
<td>Monte Christ Formation, Chuniespoort Group.</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Monte Christ Formation, Chuniespoort Group.</td>
</tr>
</tbody>
</table>

The most important information gathered during the drilling programme on the site is as follows (Drawing IR565/1):

- Two boreholes drilled in a north-south trending positive gravity anomaly located in the eastern sector of the site intercept a thin colluvial horizon (3m and 1m in Boreholes 3625 and 3721 respectively) overlying substantial horizons of intrusive. The intrusive typically is weathered grading into hard rock syenite (Boreholes 3625 and 3721, Appendix 1 and Drawing IR565/1). This feature is interpreted as the Pretoria Dyke.

- The majority of boreholes drilled in the broad gravity low occupying the central and western sector of the site located east of the river, intercepted intrusive as anticipated on Figure 4, Appendix 4:
  a) A thin colluvial horizon e.g. 1m in Boreholes 4325, 4421, 4722 and 5222 and 2m in Borehole 4529, overlying,
  b) Weathered and hard rock intrusive. All the boreholes terminated in intrusive rock or weathered intrusive e.g. Boreholes 15.5/6.5, 17.0/1.1, H, F, D, 4325, 4421, 4722 and 5222, etc, Table 1 and Drawing IR482/1.

In the central area of this sector, the apparent conductivity and magnetics show that the sill is absent. Boreholes G and 3925 confirm this situation intercepting colluvium, alluvium chert residuum and dolomite (Table 1 and 3, Drawing IR565/1).

- The eastern and western extremes of the site, east of the river are anticipated to primarily be underlain by shallow dolomite bedrock. Intrusive material or rock does not overlie the dolomite bedrock. Boreholes 5825 shows a thin colluvial horizon directly overlying dolomite bedrock. Borehole 28/8/14.5 at the base of the slope, shows colluvium, overlying chert and dolomite residuum and dolomite bedrock at 22m (Drawing IR565/1). Borehole 3122 intercepts a thin colluvial horizon (1m), chert residuum and dolomite bedrock at 6m. Boreholes 3423 and 3925 intercept colluvium, alluvium and dolomite bedrock. The bedrock is intercepted at 10m in Borehole 3423 and 12 in Borehole 3925.
Borehole FP1 was drilled in the centre of the flood plain on the western side of the site. This borehole intercepted 5m of alluvium and syenite to 30m. The borehole was terminated at this depth in syenite. Borehole 30.0/9.5 drilled in the flood plain on a gravity high intercepts 1m of colluvium, chert residuum to 5m, dolomite residuum (wad) to 9m and dolomite bedrock at 9m. Borehole 28.8/14.5, drilled against the embankment and in the floodplain to the north west, intercepts colluvium, chert and dolomite residuum and dolomite bedrock at 22m.

West of the river, no intrusive was encountered in the boreholes drilled. The following was recorded in the boreholes drilled:

a) Borehole C drilled near the river on the gradient of a gravity high, intercepted 40m of alluvium.

b) Boreholes 42.0/3.0, 35.0/3.0 and 37.5/9.5 were drilled in a prominent north-south orientated gravity low area. These boreholes typically intercepted a thin colluvial horizon, chert residuum, dolomite residuum and dolomite bedrock. Borehole 37.5/9.5 intercepted a thin horizon of intrusive. Dolomite bedrock was recorded at 28m, 8m and >30m respectively in these boreholes.

The extreme western corner of the site (west of the river) is underlain by a gravity high. The following conditions were intercepted:

a) Borehole A intercepted a thin colluvial blanket (2m), chert and dolomite residuum to 31m and dolomite bedrock at 31m. The borehole showed sample and air loss from 28-31m, interpreted as dolomite residuum (Table 3 and Appendix 1).

b) Borehole 53.0/4.5 located on the gravity high intercepts dolomite bedrock at ground surface.

c) Boreholes 50.5/1.0 and 47.5/5.0 intercept very similar subsurface conditions to those recorded in Borehole A (Drawing 565/1 and Tables 1 to 3).

The majority of boreholes drilled on this site were recorded as dry. Boreholes 37.5/3.0 and 28.8/14.5 intercepted groundwater respectively at 23.2 and 21.5m below ground level.

The site is located in the West Doornkloof Sub-catchment. Department of Water Affairs indicates an anticipated groundwater level of 1 420 mamsl.
7. DOLOMITE STABILITY CHARACTERISATION (Refer Tables 1 to 3 and Appendix 1).

7.1 Characterisation Procedure

The available information, geophysical data, borehole data and geohydrological information gathered during the investigation has been pooled and reviewed permitting the formulation of a perspective concerning the characterisation of the potential stability of the delineated site.

The predominant mobilising agencies considered in this investigation are major groundwater level fluctuations (>6m), ingress water, ground vibrations and gravity.

Use is made of a generalised list of evaluation factors to evaluate the risk of sinkhole and doline formation. These factors are as follows:

- Receptacle development;
- Mobilising agencies, particularly ingress water from leaking services;
- Potential sinkhole development space;
- Nature of the blanketing layer;
- Mobilisation potential of the blanketing layer;
- Bedrock morphology.

Receptacles or disseminated receptacles refer to any voids or cavities in the dolomite bedrock or in the overburden capable of receiving mobilised materials. Receptacles are assumed to be present as no reliable geophysical tool exists to determine the location of these features.

The potential sinkhole development space, where used, refers to the expected maximum size sinkhole that conservatively can be expected to be generated if sustained ingress of water were to occur. This factor is related to the depth of the receptacles or disseminated receptacles. The gravity survey, combined with borehole information strongly guides the appraisal of this factor. The nature of the material covering the receptacles, be they above or in the bedrock, determines the susceptibility of the subsurface material to erosion by ingress water. The presence of materials such as shales or intrusives, which can act as aquitards, serve to reduce the mobilisation potential and enhance the stability.

In the case of dramatic groundwater level fluctuations the susceptibility of the soil material to mobilisation (i.e. consolidation settlement - doline formation, or ravelling and arch failure - sinkhole formation, due to pore pressure changes in soils), is strongly influenced by the position of the original groundwater level in the subsurface profile.

In view of the factors discussed above the following characteristics have been extracted from the gathered information during the assessment process:

- borehole position relative to the gravity data (Drawing IR565/1).
- collar elevation.
depth to present groundwater level.
- depth to dolomite bedrock.
- depth to potential receptacles (Tables 1 to 3).
- nature and thickness of blanketing layer i.e. material type, penetration times, etc (Tables 1 to 3).
- position of the bedrock with respect to the groundwater level.
- thickness and nature of the soil materials above the groundwater level (original) i.e. type soil and potential geotechnical characteristics.
- thickness and nature of the soil materials below the present groundwater level.

The risk of sinkhole and doline formation is expressed in three broad categories, namely low, medium and high risk areas. The following reference to incidences, gives a perspective of the magnitude of problems encountered in each of the of risk zones in research areas. It is important to note that these figures are largely derived from developments not effectively and appropriately designed or maintained.

<table>
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<tr>
<th>RISK CHARACTERISATION</th>
<th>GROUND-MOVEMENT EVENTS PER HECTARE IN A 20 YEAR PERIOD (STATISTICS BASED ON INAPPROPRIATE AND POOR SERVICE DESIGN AND MAINTENANCE)</th>
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<tbody>
<tr>
<td>LOW</td>
<td>0 up to and including 0.1 events per hectare anticipated but occurrence of events cannot be totally excluded.</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>Greater than 0.1 and less than an equal to 1.0 events per hectare</td>
</tr>
<tr>
<td>HIGH</td>
<td>Greater than 1.0 events per hectare.</td>
</tr>
</tbody>
</table>

7.2 Stability Characterisation (See Tables 1 to 3, Drawing IR565/2)

The geophysical data, borehole data and geohydrological information gathered during this investigation on the site has been pooled and reviewed, permitting the formulation of a broad perspective on the potential subsurface conditions on the site. Summarised information concerning the risk characterisation of the boreholes drilled on the sites are provided in Tables 1 to 3 of this report.

Other studies in the area indicate that the groundwater level is recorded well below the level of the Hennops River. The groundwater level may be located within the blanketing layer on sub areas of the site, particularly near the river. It is anticipated that significant lowering of the groundwater level may generate ground movement on site. However, a lowering of the groundwater level within the dolomite aquifer will generate stability problems within the densely
developed Centurion area. The Department of Water Affairs constantly monitors groundwater levels in the region. It is essential that the local authority place pro-active groundwater level monitoring on its Dolomite Risk Management Strategy.

Based on the geological, geophysical and geohydrological data gathered during this investigation the stability of the various sites are described in terms of three Dolomite Stability Zones. These Dolomite Stability Zones are defined as follows:

**Dolomite Stability Zone 1:** Area characterised as reflecting a low Inherent Risk of sinkhole and doline formation with respect to water ingress. Inherent Risk Class 1.

This zone is typically underlain by the following conditions:

- Gravity high and plain area.
- Area indicated by apparent conductivity and magnetic field as being underlain by dyke and sill.
- Boreholes typically intercept a thin colluvial horizon e.g. 3m in Borehole 3625, 1m to 2m in Boreholes 4722, 4421, 4529, F, D, 15.5/6.5 and 17.0/1.1, etc.
- Alluvium is encountered in boreholes on the site. In this zone Borehole 4020 intercepts 9m of alluvium.
- Substantial thicknesses of intrusive material is intercepted in the boreholes drilled e.g. in excess of 21m in Borehole 17.0/1.1, in excess of 28m in Boreholes 15.5/6.5, H, 4325 and 4722, 4421 and 5222, in excess of 30-40m in Boreholes D, E, F (Appendix 1, Table 1 and Drawing IR482/1).
- Hard rock intrusive is intercepted in certain boreholes e.g. at 20 to 30m in Borehole 3625, 30 to 40m in Borehole D and at 27m in Borehole 3721.
- The boreholes drilled are dry. However, perched groundwater conditions are anticipated to develop during wet seasons on the intrusive which may act as an aquitard.
- Intrusive material related to the Pretoria Dyke blankets potential receptacles located at depth. These materials are anticipated to enhance the stability, acting as an aquitard, retarding ingress of water, assisting in precluding subsurface erosion and sinkhole formation. Where alluvium overlies the intrusive the transported material is anticipated to further enhance the stability, reinforcing a low mobilisation potential for the zone. Where the intrusive material is laterally discontinuous, the potential for subsurface erosion will increase. The PDS is taken as large with bedrock depths at 27 to 34m.