

REPORT
ON
THE DOLOMITIC STABILITY INVESTIGATION
FOR
THE PROPOSED NEW DEVELOPMENT
GERHARDSVILLE EXTENSION 2
SITUATED ON
A PART OF
PORTION 16
AND
A PART OF
PORTION 66
OF
THE FARM KNOPJESLAAGTE 385-JR

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May 2019

Client

WFA CHRISTIAN BUSINESS SCHOOL

EXECUTIVE SUMMARY

Louis Kruger Geotechnics cc was appointed do a dolomitic stability investigation for the proposed new development Gerhardsville Extension 2 situated on a Part of Portion 16 and a Part of Portion 66 of The Farm Knopjeslaagte 385-JR according to SANS 1936-1: 2012 - Development Of Dolomite Land and according to the Home Building Manual (National Home Builders Registration Council, 2015). 16 and a Part of Portion 66 of The Farm Knopjeslaagte 385-JR. At present the site is undeveloped. The proposed development consists of a college combined with dormitories and with associated sports facilities. **Since the layout has not been finalized, the investigation was done to provide the client with an indication of the types of development that is considered suitable for the site.**

The initial investigation (Louis Kruger Geotechnics 2007) was only done on Portions 1, 2 and 7 of the farm Rickaletta 387 JR and Portions 16, 64, 66 and 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doornrandje 386 JR and consisted of a gravity survey and the drilling of 28 percussion boreholes. **Only three of these boreholes could be used for the current investigation.** Based on the results of the initial investigation and the proposed development nine additional boreholes were drilled on the site. The results of the percussion boreholes are summarized in the following table:

BH	Dolomitic residuum	Syenite or slate	Dolomitic residuum	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	-	0-9m	-	9-15m	-	15-22m	None	None	None
6965	-	0-23m	-	-	-	23-29m	None	None	None
7061	-	-	0-3m	-	-	3-10m	None	None	None
L1	0-1m	10-27m	-	1-10m	-	-	None	None	None
L2	-	0-25m	-	-	-	-	None	None	None
L3	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
L4	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
L5	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
L6	0-10m	-	-	10-14m	14-22m	22-29m	None	None	6-7m
L7	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
L8	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
L9	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None

Ground water was encountered in eight boreholes. In the boreholes where thin syenite is present or syenite is absent and ground water was encountered, **the ground water level is situated within the dolomite bedrock.** In the boreholes where residual syenite and syenite was encountered, **the water level is situated within the syenite.** Analysis of the eight boreholes shows that dewatering will not affect the stability of the boreholes. **Therefore only surface water was considered as mobilization medium**

The site is zoned as follows:

- **The 10 meter radius around boreholes L7 and L8 is zoned as IHC 6/6**
- **The remainder of the site is zoned as IHC 2/3//2/3.**

The risk classification and zoning were discussed with Mr Sifiso Ngubelanga of the Council for Geosciences and he provisionally agreed with the classification

According SANS 1936-1: 2012 the dolomitic stability zones are considered suitable for the following:

- **IHC 6: 10 meter radius around boreholes L7 and L8**
No residential development (dormitories). Suitable for commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.
It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.

- **IHC 2/3/2/3: The remainder of the site**
Commercial and miscellaneous non-residential usage
Commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.
It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.
Residential development (dormitories)
 - (a) ***Attached homes in buildings exceeding 3 storeys***
 - AHH3: Up to 160 attached homes per hectare in buildings exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)
 - (b) ***Attached homes in buildings not exceeding 3 storeys***
 - AHL2: Up to 80 attached homes per hectare in buildings not exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)
 - (c) ***Detached homes***
 - DH3: Detached home or own site or an effective site having an area not less than 1000 sqm (**subject to footprint investigations and subject to the recommendations listed in Section 15**)

- **No wet services is recommended in the 10 meter radiuses around boreholes L7 and L8.**

- The client should note that some form of geotechnical remedial will be necessary. Such measures could include piling, grouting and earth mattresses, it should be noted that irrespective of the number of storeys, geotechnical remediation will be required. **It is important to note that all foundations should be capable of spanning a 5 m diameter sinkhole.** Foundation design confirmation/certification must be submitted to the Council for Geosciences along with the NHBRC enrolment application

REPORT ON THE DOLOMITIC STABILITY INVESTIGATION FOR THE PROPOSED NEW DEVELOPMENT GERHARDSVILLE EXTENSION 2 SITUATED ON A PART OF PORTION 16 AND A PART OF PORTION 66 OF THE FARM KNOPJESLAAGTE 385-JR

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Figure 1: Locality

Figure 2: Regional Geology

Figure 3: Gravity and Percussion borehole positions

Figure 4: Percussion Borehole Positions

Figure 5: Dolomitic Stability Zoning

Appendix A : Percussion borehole profiles

Appendix B : Driller's logs

Appendix C: Drainage Precautionary measures

REPORT ON THE DOLOMITIC STABILITY INVESTIGATION FOR THE PROPOSED NEW DEVELOPMENT GERHARDSVILLE EXTENSION 2 SITUATED ON A PART OF PORTION 16 AND A PART OF PORTION 66 OF THE FARM KNOPJESLAAGTE 385-JR

1. INTRODUCTION

Louis Kruger Geotechnics cc was appointed do a dolomitic stability investigation for the proposed new development Gerhardsville Extension 2 situated on a Part of Portion 16 and a Part of Portion 66 of The Farm Knopjeslaagte 385-JR according to SANS 1936-1: 2012 - Development Of Dolomite Land and according to the Home Building Manual (National Home Builders Registration Council, 2015). The following aspects are addressed in this report:

- Geology and soil profile
- Geohydrology
- Dolomitic stability

2. AVAILABLE INFORMATION

The following information was available:

- 1 : 50 000 Geological map 2528CC Lyttelton
- “Report on the engineering geological investigation on Portions 1, 2 and 7 of the farm Rickaletta 387 JR and Portions 16, 64, 66 and 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doorrandje 386 JR”, Louis Kruger Geotechnics, September 2007
- Site Plan
- Colour aerial photographs, Tshwane Metropolitan Council
- Tshwane Internet Geographical information System

3. TERMS OF REFERENCE

The initial investigation (Louis Kruger Geotechnics 2007) was done to provide the owners of the property with information which they could use to determine possible land uses. In 2019 Louis Kruger Geotechnics cc was appointed do a dolomitic stability investigation for a proposed new development on a small part of the site. The appointment included assessment of the available information, percussion drilling, report compilation and liaison with The Council for Geosciences. The locality of the site is shown on Figure 1.

4. PRESENT AND PROPOSED LAND USE

The proposed site covers 18 hectares and is situated on a Part of Portion 16 and a Part of Portion 66 of The Farm Knopjeslaagte 385-JR. At present the site is undeveloped. The proposed development consists of a college combined with dormitories and with associated sports facilities. **Since the layout has not been finalized, the investigation was done to provide the client with an indication of the types of development that is considered suitable for the site.**

The Site



LOCALITY

FIGURE 1
NTS

5. **GEOLOGY**

The 1:50 000 geological map shows that the site is underlain by dolomite of the Chuniespoort Group, Transvaal Sequence and by syenite. The geology is shown on Figure 2. The geology was confirmed during the investigation, both dolomite and syenite was encountered in the boreholes.

6. **METHOD OF INVESTIGATION**

6.1 Previous investigations

The initial investigation (Louis Kruger Geotechnics 2007) was only done on Portions 1, 2 and 7 of the farm Rickaletta 387 JR and Portions 16, 64, 66 and 127 of the farm Knopjeslaagte 385 JR and Portion 107 of the farm Doornrandje 386 JR and consisted of a gravity survey and the drilling of 28 percussion boreholes. **Only three of these boreholes could be used for the current investigation.**

6.2 Current investigation

6.2.1 *Percussion drilling*

Based on the results of the initial investigation and the proposed development nine additional boreholes were drilled on the site.

6.2.2 *Stability assessment*

After completion of the drilling, the stability of each individual borehole and the entire site was assessed according to the standard method proposed by The Council for Geosciences (Technical guidelines Series No 1, 1995, amended 2001) and the site was zoned according to SANS 1936-1: 2012 - Development Of Dolomite Land and according to the Home Building Manual (National Home Builders Registration Council, 2015). The results of the drilling and the dolomitic stability evaluation were discussed with Mr S Ngubelanga of the Council for Geosciences and a report was compiled.

7. **RESULTS OF PREVIOUS INVESTIGATIONS**

7.1 Gravity results

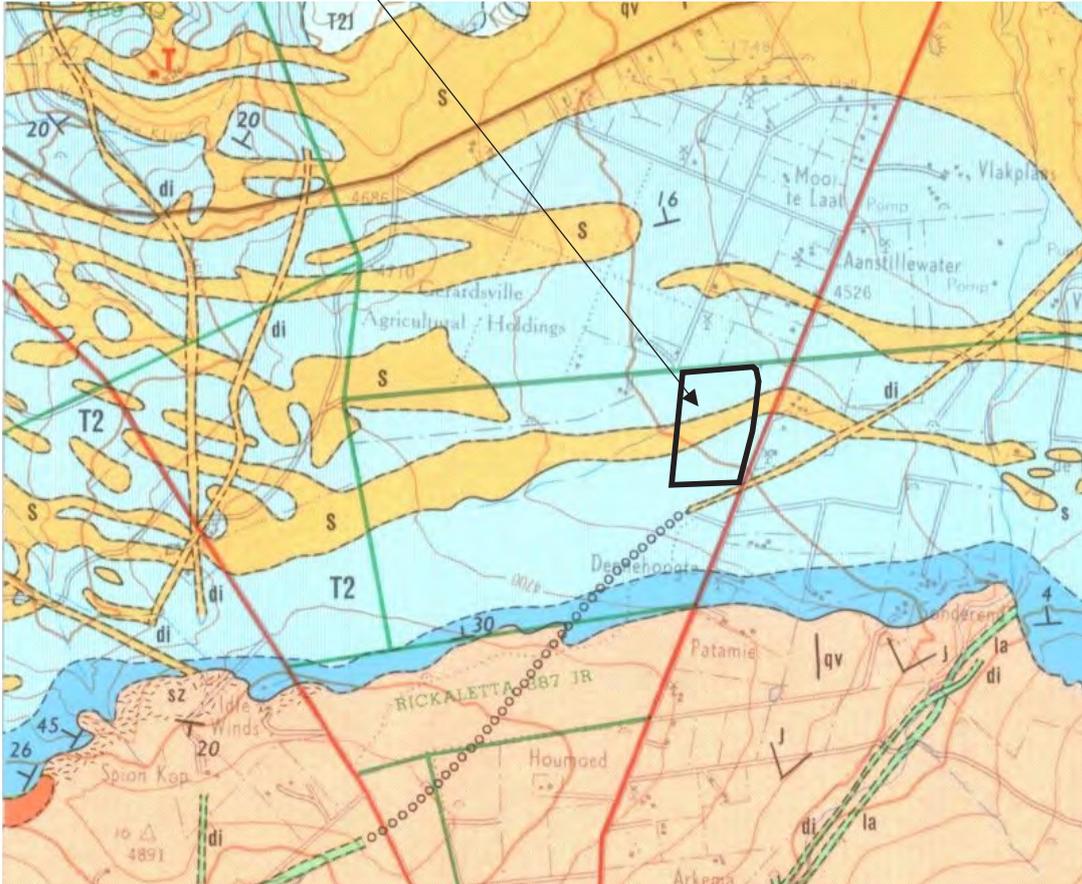
The residual gravity for the current site is shown on Figure 3

7.2 Percussion borehole results

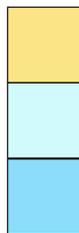
Only three of these boreholes could be used for the current investigation. The borehole logs are included in Appendix A, the borehole positions are shown on Figures 3 and 4, and are summarized in the following table:

BH	Dolomitic residuum	Syenite or slate	Dolomitic residuum	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	-	0-9m	-	9-15m	-	15-22m	None	None	None
6965	-	0-23m	-	-	-	23-29m	None	None	None
7061	-	-	0-3m	-	-	3-10m	None	None	None

THE SITE



From the 1 : 50 000 Geological Series 2528 CC Lyttelton (Council for Geoscience)



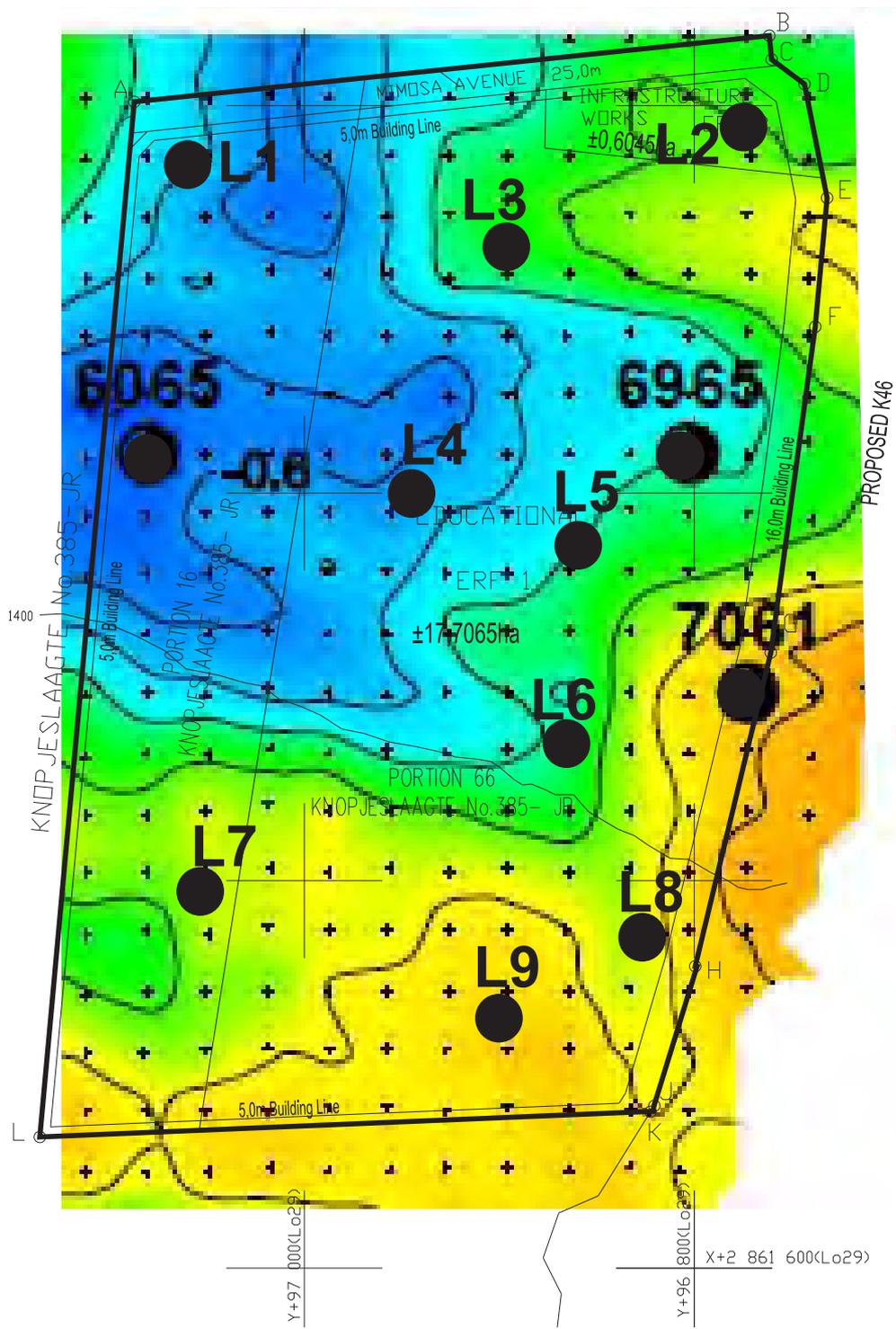
Syenite

Chert, chert breccia, chert rubble

Dolomite locally with shale band near base

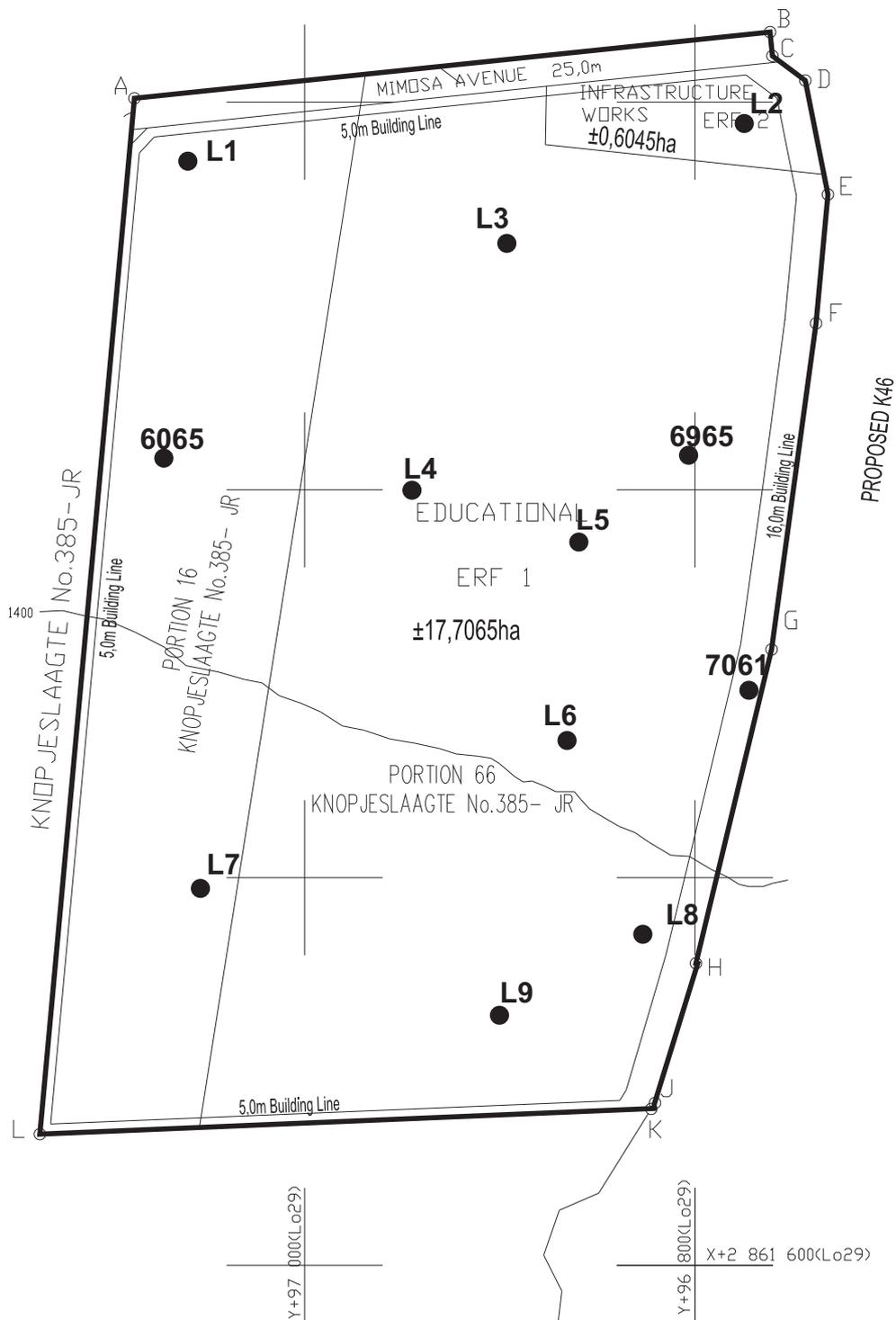
REGIONAL GEOLOGY

FIGURE 2
NTS



GRAVITY
AND
PERCUSSION BOOREHOLE POSITIONS

FIGURE 3
1:3 500



PERCUSSION BOOREHOLE POSITIONS

FIGURE 4
1:3 500

8. RESULTS OF THE CURRENT INVESTIGATION

8.1 Percussion borehole results

Nine percussion boreholes were drilled on the site. The borehole positions are shown on Figures 3 and 4. The borehole logs are attached as Appendix A, the drillers logs are attached as Appendix B and the results are summarized in the following table:

BH	Dolomitic residuum	Syenite or slate	Dolomitic residuum	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
L1	0-1m	10-27m	-	1-10m	-	-	None	None	None
L2	-	0-25m	-	-	-	-	None	None	None
L3	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
L4	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
L5	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
L6	0-10m	-	-	10-14m	14-22m	22-29m	None	None	6-7m
L7	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
L8	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
L9	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None

9. SUMMARY OF PERCUSSION BOREHOLES RESULTS

The borehole positions are shown on Figures 3 and 4. The borehole logs for both investigations are attached as Appendix A and the results are summarized in the following table

BH	Dolomitic residuum	Syenite or slate	Dolomitic residuum	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	-	0-9m	-	9-15m	-	15-22m	None	None	None
6965	-	0-23m	-	-	-	23-29m	None	None	None
7061	-	-	0-3m	-	-	3-10m	None	None	None
L1	0-1m	10-27m	-	1-10m	-	-	None	None	None
L2	-	0-25m	-	-	-	-	None	None	None
L3	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
L4	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
L5	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
L6	0-10m	-	-	10-14m	14-22m	22-29m	None	None	6-7m
L7	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
L8	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
L9	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None

10. GEOHYDROLOGY

The information from four boreholes, situated between 3 and 4 kilometers from the proposed site, was obtained from the National Ground Water Archive (NGA) of The Department of Water Affairs. However one borehole is situated on the granites to the south of the site, the remaining three boreholes are situated north of the site. Due to the presence of a major east west striking syenite sill and the distance from the site, the water levels in these boreholes are not considered relevant to the site.

The ground water rest levels are shown in the following table:

BH	Syenite or slate	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Water level	Comments
6065	0-9m	9-15m	-	15-22m	Dry	In dolomite
6965	0-23m	-	-	23-29m	9,5m	In syenite
7061	-	-	-	3-10m	Dry	In dolomite
L1	10-27m	1-10m	-	-	6m	In syenite
L2	0-25m	-	-	-	8m	In syenite
L3	5-10m	-	10-22m	22-30m	Dry	In dolomite
L4	0-9m	9-19m	19-27m	27-35m	12m	In dolomite
L5	0-5m	5-14m	14-21m	21-30m	12m	In dolomite
L6	-	10-14m	14-22m	22-29m	13.7m	In dolomite
L7	-	-	8-19m	19-27m	12m	In dolomite
L8	-	-	12-18m	18-26m	Collapsed	In dolomite
L9	-	4-11m	11-21m	21-30m	12m	In dolomite

In the boreholes where thin syenite is present or syenite is absent and ground water was encountered, **the ground water level is situated within the dolomite bedrock.** In the boreholes where residual syenite and syenite was encountered, **the water level is situated within the syenite.**

The eight boreholes in which ground water was encountered are discussed individually

- In borehole 6965 the water level is situated at 9,5 meters, between the water level and the dolomite bedrock are 6 meters of syenite and 8 meters slate, no dolomitic residuum is present below the water level. **Therefore lowering of the water level would not affect the stability of the borehole.**
- In borehole L1 the water level is situated at 6 meters within highly- to moderately weathered dolomite, below the water level are 2 meters of within highly- to moderately weathered dolomite, 8 meters of moderately weathered syenite and 9 meters syenite bedrock, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L2 the water level is situated at 8 meters, below the water level are 9 meters of moderately weathered syenite and 9 meters syenite bedrock, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.

- In borehole L4 the water level is situated at 12 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock are 7 meters of highly- to moderately weathered dolomite and 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L5 the water level is situated at 14 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock is 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L6 the water level is situated at 13.7 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock are 4 meters of highly- to moderately weathered dolomite and 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L7 the water level is situated at 13.7 meters within moderately weathered dolomite, between the water level and the dolomite bedrock is 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L9 the water level is situated at 9 meters within moderately weathered dolomite, between the water level and the dolomite bedrock is 9 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.

11. **DOLOMITIC STABILITY ANALYSES**

The dolomitic stability of the site was evaluated according to the standard method proposed by Technical guidelines Series No 1, Council for Geosciences, 1995, the Approach to Residential Development on Dolomite, Council for Geosciences (October 2004), The Consultants Guide: Approach to Sites on Dolomite land, Council for Geosciences (November 2007) and SANS 1936-1: 2012-Development Of Dolomite Land.

The parameters assessed to evaluate the stability were the following:

- Receptacles
- Mobilization media
- The characteristics of the blanketing layer
- The mobilization potential of the blanketing layer
- The potential development space

11.1 Receptacles

Air- and sample losses occurred in thirteen boreholes. Therefore it is assumed that cavities and disseminated receptacles, large enough to accommodate all the mobilized material can be expected in the dolomite bedrock and the blanketing layer.

11.2 Mobilization media

Ground water was encountered in eight boreholes. In the boreholes where thin syenite is present or syenite is absent and ground water was encountered, **the ground water level is situated within the dolomite bedrock**. In the boreholes where residual syenite and syenite was encountered, **the water level is situated within the syenite**.

The eight boreholes in which ground water was encountered are discussed individually

- In borehole 6965 the water level is situated at 9,5 meters, between the water level and the dolomite bedrock are 6 meters of syenite and 8 meters slate, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L1 the water level is situated at 6 meters within highly- to moderately weathered dolomite, below the water level are 2 meters of within highly- to moderately weathered dolomite, 8 meters of moderately weathered syenite and 9 meters syenite bedrock, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L2 the water level is situated at 8 meters, below the water level are 9 meters of moderately weathered syenite and 9 meters syenite bedrock, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L4 the water level is situated at 12 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock are 7 meters of highly- to moderately weathered dolomite and 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L5 the water level is situated at 14 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock is 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L6 the water level is situated at 13.7 meters within highly- to moderately weathered dolomite, between the water level and the dolomite bedrock are 4 meters of highly- to moderately weathered dolomite and 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L7 the water level is situated at 13.7 meters within moderately weathered dolomite, between the water level and the dolomite bedrock is 8 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.
- In borehole L9 the water level is situated at 9 meters within moderately weathered dolomite, between the water level and the dolomite bedrock is 9 meters moderately weathered dolomite, no dolomitic residuum is present below the water level. Therefore lowering of the water level would not affect the stability of the borehole.

It is concluded that dewatering will not affect the stability of the boreholes. **Therefore only surface water was considered as mobilization medium**

11.3 Blanketing layer

The blanketing layer is summarized in the following Table:

BH	Dol res	Sy/ Slate	Dol res	Highly weath dolomite	Mod weath dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	-	0-9m	-	9-15m	-	15-22m	None	None	None
	9 meters slate underlain by 6 meters highly weathered dolomite. Dolomite at 15 meters. No sample or air losses. No low penetration times								
6965	-	0-23m	-	-	-	23-29m	None	None	None
	23 meters syenite and slate. Dolomite at 23 meters. No sample or air losses. No low penetration times								
7061	-	-	0-3m	-	-	3-10m	None	None	None
	3 meters dolomitic residuum (chert). Dolomite at 3 meters. No sample or air losses. No low penetration times								
L1	0-1m	10- 27m	-	1-10m	-	-	None	None	None
	1 meter dolomitic residuum, underlain by 9 meters highly and moderately weathered dolomite, underlain by 17 meters syenite (9 meters hard rock syenite). No sample or air losses. No low penetration times								
L2	-	0-25m	-	-	-	-	None	None	None
	25 meters syenite (8 meters hard rock syenite). No sample or air losses. No low penetration times								
L3	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
	5 meters dolomitic residuum (chert and wad) underlain by 5 meters syenite underlain by 12 meters highly and moderately weathered dolomite. Dolomite at 22m. No sample or air losses. No low penetration times								
L4	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
	9 meters syenite underlain by 10 meters highly weathered dolomite, underlain by 8 meters moderately weathered dolomite. Dolomite at 27m. No sample or air losses. No low penetration times								
L5	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
	5 meters syenite underlain by 9 meters highly weathered dolomite, underlain by 7 meters moderately weathered dolomite. Dolomite at 21m. No sample or air losses. No low penetration times								
L6	-	-	0-10m	10-14m	14-22m	22-29m	None	None	6-7m
	10 meters dolomitic residuum (chert), underlain by 4 meters highly weathered dolomite, underlain by 8 meters moderately to slightly weathered dolomite. Dolomite at 22 meters. No sample or air losses. Low penetration times 6-7 meters.								
L7	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
	8 meters dolomitic residuum (chert), underlain by underlain by 11 meters moderately to slightly weathered dolomite. Dolomite at 19 meters. Sample and air losses 4-8 meters. Low penetration times 5-7 meters.								
L8	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
	12 meters dolomitic residuum (chert), underlain by underlain by 6 meters moderately to slightly weathered dolomite. Dolomite at 18 meters. Sample and air losses 4-28 meters. Low penetration times 3-8 meters.								
L9	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None
	12 meters dolomitic residuum (chert), underlain by 7 meters highly weathered dolomite, underlain by 10 meters moderately to slightly weathered dolomite. Dolomite at 21 meters. No sample or air losses. No low penetration times								

11.4 Mobilization potential

The mobilization potential for the individual blocks is summarized in the following Tables:

BH	Mobilization Potential	Dol res	Sy/ Slate	Dol res	Highly weath dolomite	Mod weath dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	Medium	-	0-9m	-	9-15m	-	15-22m	None	None	None
		9 meters slate underlain by 6 meters highly weathered dolomite. Dolomite at 15 meters. No sample or air losses. No low penetration times								
6965	Medium	-	0-23m	-	-	-	23-29m	None	None	None
		23 meters syenite and slate. Dolomite at 23 meters. No sample or air losses. No low penetration times								
7061	Medium	-	-	0-3m	-	-	3-10m	None	None	None
		3 meters dolomitic residuum (chert). Dolomite at 3 meters. No sample or air losses. No low penetration times								
L1	Medium	0-1m	10-27m	-	1-10m	-	-	None	None	None
		1 meter dolomitic residuum, underlain by 9 meters highly and moderately weathered dolomite, underlain by 17 meters syenite (9 meters hard rock syenite). No sample or air losses. No low penetration times								
L2	Small Medium	-	0-25m	-	-	-	-	None	None	None
		25 meters syenite (8 meters hard rock syenite). No sample or air losses. No low penetration times								
L3	Medium	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
		5 meters dolomitic residuum (chert and wad) underlain by 5 meters syenite underlain by 12 meters highly and moderately weathered dolomite. Dolomite at 22m. No sample or air losses. No low penetration times								
L4	Medium	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
		9 meters syenite underlain by 10 meters highly weathered dolomite, underlain by 8 meters moderately weathered dolomite. Dolomite at 27m. No sample or air losses. No low penetration times								
L5	Medium	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
		5 meters syenite underlain by 9 meters highly weathered dolomite, underlain by 7 meters moderately weathered dolomite. Dolomite at 21m. No sample or air losses. No low penetration times								
L6	Medium	-	-	0-10m	10-14m	14-22m	22-29m	None	None	6-7m
		10 meters dolomitic residuum (chert), underlain by 4 meters highly weathered dolomite, underlain by 8 meters moderately to slightly weathered dolomite. Dolomite at 22 meters. No sample or air losses. Low penetration times 6-7 meters.								
L7	High	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
		8 meters dolomitic residuum (chert), underlain by underlain by 11 meters moderately to slightly weathered dolomite. Dolomite at 19 meters. Sample and air losses 4-8 meters. Low penetration times 5-7 meters.								
L8	High	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
		12 meters dolomitic residuum (chert), underlain by underlain by 6 meters moderately to slightly weathered dolomite. Dolomite at 18 meters. Sample and air losses 4-28 meters. Low penetration times 3-8 meters.								
L9	Medium	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None
		12 meters dolomitic residuum (chert), underlain by 7 meters highly weathered dolomite, underlain by 10 meters moderately to slightly weathered dolomite. Dolomite at 21 meters. No sample or air losses. No low penetration times								

11.5 Potential development space

The potential development space was calculated by application of the standard method and by using the angles of draw mentioned by Buttrick and Van Schalkwyk. The potential development space is summarized in the following tables:

BH	Pot Dev Space	Dol res	Sy/ Slate	Dol res	Highly weath dolomite	Mod weath dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	Small Medium	-	0-9m	-	9-15m	-	15-22m	None	None	None
		9 meters slate underlain by 6 meters highly weathered dolomite. Dolomite at 15 meters. No sample or air losses. No low penetration times								
6965	Small	-	0-23m	-	-	-	23-29m	None	None	None
		23 meters syenite and slate. Dolomite at 23 meters. No sample or air losses. No low penetration times								
7061	Small Medium	-	-	0-3m	-	-	3-10m	None	None	None
		3 meters dolomitic residuum (chert). Dolomite at 3 meters. No sample or air losses. No low penetration times								
L1	Small Medium	0-1m	10-27m	-	1-10m	-	-	None	None	None
		1 meter dolomitic residuum, underlain by 9 meters highly and moderately weathered dolomite, underlain by 17 meters syenite (9 meters hard rock syenite). No sample or air losses. No low penetration times								
L2	Small	-	0-25m	-	-	-	-	None	None	None
		25 meters syenite (8 meters hard rock syenite). No sample or air losses. No low penetration times								
L3	Small Medium	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
		5 meters dolomitic residuum (chert and wad) underlain by 5 meters syenite underlain by 12 meters highly and moderately weathered dolomite. Dolomite at 22m. No sample or air losses. No low penetration times								
L4	Small Medium	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
		9 meters syenite underlain by 10 meters highly weathered dolomite, underlain by 8 meters moderately weathered dolomite. Dolomite at 27m. No sample or air losses. No low penetration times								
L5	Small Medium	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
		5 meters syenite underlain by 9 meters highly weathered dolomite, underlain by 7 meters moderately weathered dolomite. Dolomite at 21m. No sample or air losses. No low penetration times								
L6	Small Medium	-	-	0-10m	10-14m	14-22m	22-29m	None	None	6-7m
		10 meters dolomitic residuum (chert), underlain by 4 meters highly weathered dolomite, underlain by 8 meters moderately to slightly weathered dolomite. Dolomite at 22 meters. No sample or air losses. Low penetration times 6-7 meters.								
L7	Small Medium	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
		8 meters dolomitic residuum (chert), underlain by underlain by 11 meters moderately to slightly weathered dolomite. Dolomite at 19 meters. Sample and air losses 4-8 meters. Low penetration times 5-7 meters.								
L8	Small Medium	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
		12 meters dolomitic residuum (chert), underlain by underlain by 6 meters moderately to slightly weathered dolomite. Dolomite at 18 meters. Sample and air losses 4-28 meters. Low penetration times 3-8 meters.								
L9	Small Medium	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None
		12 meters dolomitic residuum (chert), underlain by 7 meters highly weathered dolomite, underlain by 10 meters moderately to slightly weathered dolomite. Dolomite at 21 meters. No sample or air losses. No low penetration times								

11.6 Risk assessment for sinkholes

The risk assessment for individual boreholes according to Buttrick et al (2002), the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004 and SANS 1936-1: Development of Dolomite Land is summarized in the following Table:

BH	Risk		Dolomitic residuum	Syenite/ Slate	Highly to moderately weathered dolomite	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	Medium Medium	Small Medium	-	0-9m	9-15m	-	15-22m	None	None	None
6965	Medium	Small	-	0-23m	-	-	23-29m	None	None	None
7061	Medium Medium	Small Medium	0-3m	-	-	-	3-10m	None	None	None
L1	Medium Medium	Small Medium	0-1m	10-27m	1-10m	-	-	None	None	None
L2	Medium	Small	-	0-25m	-	-	-	None	None	None
L3	Medium Medium	Small Medium	0-5m	5-10m	-	10-22m	22-30m	None	None	None
L4	Medium Medium	Small Medium	-	0-9m	9-19m	19-27m	27-35m	None	None	None
L5	Medium Medium	Small Medium	-	0-5m	5-14m	14-21m	21-30m	None	None	None
L6	Medium Medium	Small Medium	0-10m	-	10-14m	14-22m	22-29m	None	None	6-7m
L7	High High	Small Medium	0-8m	-	-	8-19m	19-27m	4-8m	4-8m	5-7m
L8	High High	Small Medium	0-12m	-	-	12-18m	18-26m	4-28m	4-28m	3-8m
L9	Medium Medium	Small Medium	0-4m	-	4-11m	11-21m	21-30m	None	None	None

11.7 Risk assessment for doline formation

The risk assessment for individual boreholes according to Buttrick et al (2002), the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004 and SANS 1936-1: Development of Dolomite Land is summarized in the following Table

BH	Risk	Dol res	Sy/ Slate	Dol res	Highly weath dolomite	Mod weath dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	Low	-	0-9m	-	9-15m	-	15-22m	None	None	None
		9 meters slate underlain by 6 meters highly weathered dolomite. Dolomite at 15 meters. No sample or air losses. No low penetration times								
6965	Low	-	0-23m	-	-	-	23-29m	None	None	None
		23 meters syenite and slate. Dolomite at 23 meters. No sample or air losses. No low penetration times								
7061	Medium	-	-	0-3m	-	-	3-10m	None	None	None
		3 meters dolomitic residuum (chert). Dolomite at 3 meters. No sample or air losses. No low penetration times								
L1	Low	0-1m	10-27m	-	1-10m	-	-	None	None	None
1 meter dolomitic residuum, underlain by 9 meters highly and moderately weathered dolomite, underlain by 17 meters syenite (9 meters hard rock syenite). No sample or air losses. No low penetration times										
L2	Low	-	0-25m	-	-	-	-	None	None	None
		25 meters syenite (8 meters hard rock syenite). No sample or air losses. No low penetration times								
L3	Low	0-5m	5-10m	-	-	10-22m	22-30m	None	None	None
		5 meters dolomitic residuum (chert and wad) underlain by 5 meters syenite underlain by 12 meters highly and moderately weathered dolomite. Dolomite at 22m. No sample or air losses. No low penetration times								

BH	Risk	Dol res	Sy/ Slate	Dol res	Highly weath dolomite	Mod weath dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
L4	Low	-	0-9m	-	9-19m	19-27m	27-35m	None	None	None
		9 meters syenite underlain by 10 meters highly weathered dolomite, underlain by 8 meters moderately weathered dolomite. Dolomite at 27m. No sample or air losses. No low penetration times								
L5	Medium	-	0-5m	-	5-14m	14-21m	21-30m	None	None	None
		5 meters syenite underlain by 9 meters highly weathered dolomite, underlain by 7 meters moderately weathered dolomite. Dolomite at 21m. No sample or air losses. No low penetration times								
L6	Low	-	-	0-10m	10-14m	14-22m	22-29m	None	None	6-7m
		10 meters dolomitic residuum (chert), underlain by 4 meters highly weathered dolomite, underlain by 8 meters moderately to slightly weathered dolomite. Dolomite at 22 meters. No sample or air losses. Low penetration times 6-7 meters.								
L7	Low	-	-	0-8m	-	8-19m	19-27m	4-8m	4-8m	5-7m
		8 meters dolomitic residuum (chert), underlain by underlain by 11 meters moderately to slightly weathered dolomite. Dolomite at 19 meters. Sample and air losses 4-8 meters. Low penetration times 5-7 meters.								
L8	Medium	-	-	0-12m	-	12-18m	18-26m	4-28m	4-28m	3-8m
		12 meters dolomitic residuum (chert), underlain by underlain by 6 meters moderately to slightly weathered dolomite. Dolomite at 18 meters. Sample and air losses 4-28 meters. Low penetration times 3-8 meters.								
L9	High	-	-	0-4m	4-11m	11-21m	21-30m	None	None	None
		12 meters dolomitic residuum (chert), underlain by 7 meters highly weathered dolomite, underlain by 10 meters moderately to slightly weathered dolomite. Dolomite at 21 meters. No sample or air losses. No low penetration times								

11.8 Classification

The classification for the individual boreholes **in the non-dewatering scenario** according to the standard method proposed by The Council for Geosciences (Technical guidelines Series No 1, 1995, amended 2001), the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004, The Consultants Guide: Approach to Sites on Dolomite land, Council for Geosciences, November 2007 and SANS 1936-1: 2012: Development Of Dolomite Land is shown in the following Table.:

BH	Risk		IHC	Moderately To slightly weathered dolomite	Dolomite	Air losses	Sample losses	Pen time <15sec
6065	Medium Medium	Small Medium	3	-	15-22m	None	None	None
6965	Medium	Small	2	-	23-29m	None	None	None
7061	Medium Medium	Small Medium	3	-	3-10m	None	None	None
L1	Medium Medium	Small Medium	3	-	-	None	None	None
L2	Medium	Small	2	-	-	None	None	None
L3	Medium Medium	Small Medium	3	10-22m	22-30m	None	None	None
L4	Medium Medium	Small Medium	3	19-27m	27-35m	None	None	None
L5	Medium Medium	Small Medium	3	14-21m	21-30m	None	None	None
L6	Medium Medium	Small Medium	3	14-22m	22-29m	None	None	6-7m
L7	High High	Small Medium	3/6	8-19m	19-27m	4-8m	4-8m	5-7m
L8	High High	Small Medium	6	12-18m	18-26m	4-28m	4-28m	3-8m
L9	Medium Medium	Small Medium	3	11-21m	21-30m	None	None	None

12. DOLOMITIC STABILITY ZONING

The site is zoned as follows:

- **The 10 meter radius around boreholes L7 and L8 is zoned as IHC 6//6**
- **The remainder of the site is zoned as IHC 2/3//2/3.**

The dolomitic stability zoning is shown on Figure 5.

The risk classification and zoning were discussed with Mr Sifiso Ngubelanga of the Council for Geosciences and he provisionally agreed with the classification

13. DEVELOPMENT TYPE

According SANS 1936-1: 2012 the dolomitic stability zones are considered suitable for the following:

- **IHC 6: 10 meter radius around boreholes L7 and L8**

No residential development (dormitories). Suitable for commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.

It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.

- **IHC 2/3//2/3: The remainder of the site**

Commercial and miscellaneous non-residential usage

Commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.

It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.

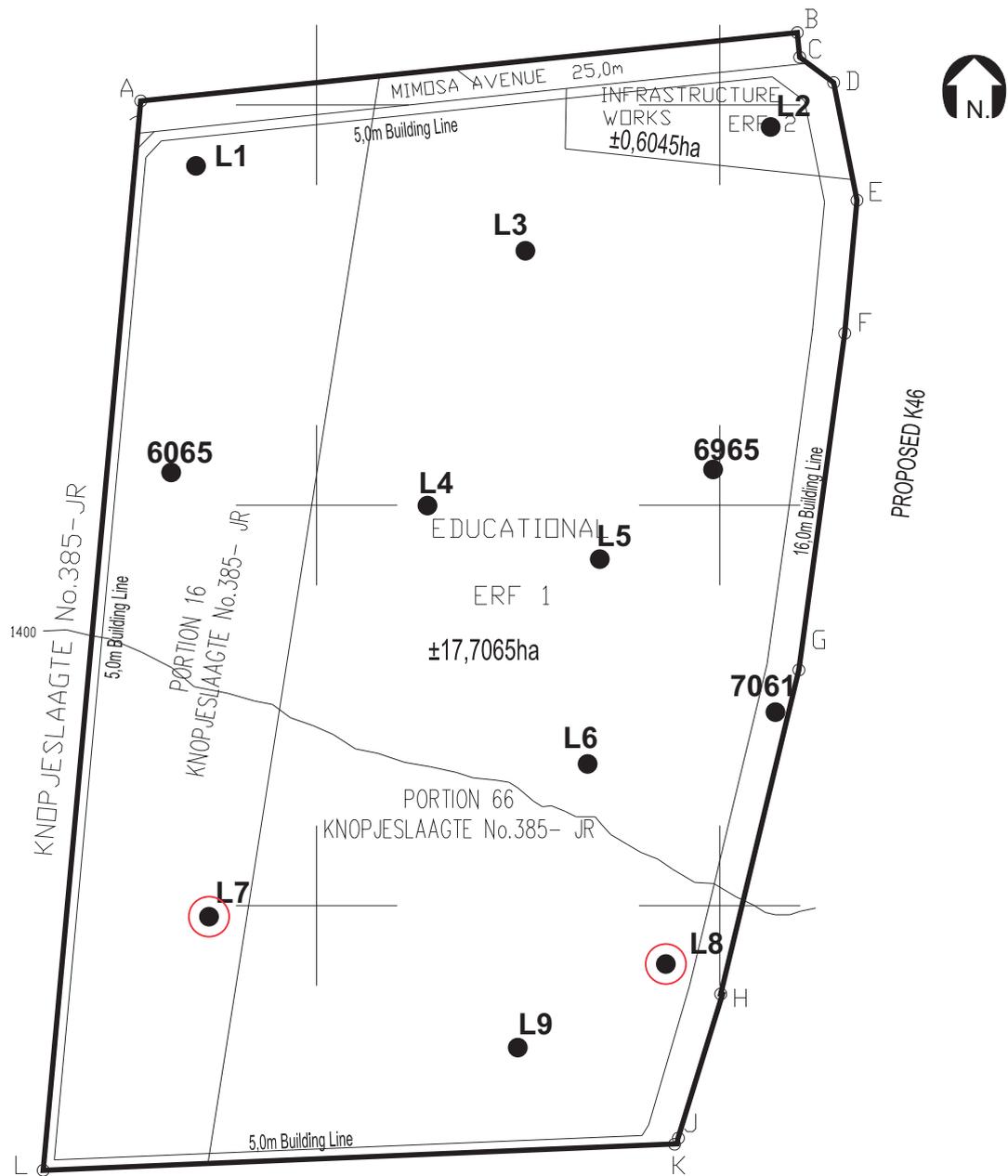
Residential development (dormitories)

(a) Attached homes in buildings exceeding 3 storeys

- AHH3: Up to 160 attached homes per hectare in buildings exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)

(b) Attached homes in buildings not exceeding 3 storeys

- AHL2: Up to 80 attached homes per hectare in buildings not exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)



The 10 meter radiusses around boreholes L7 and L8 is zoned as IHC 6//6 (No residential development (dormitories)). Suitable for commercial developments < 3 storeys)

The remainder of the site is zoned as IHC 2//3//2//3. (Suitable for residential development (dormitories) and commercial developments < 3 storeys)

All of the above is subject to footprint drilling and the recommendations listed in Section 15 of the report.

DOLOMITIC STABILITY ZONING	FIGURE 5 1:3 500
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(c) **Detached homes**

- DH3: Detached home or own site or an effective site having an area not less than 1000 sqm (**subject to footprint investigations and subject to the recommendations listed in Section 15**)

14. **NHBRC ZONING**

According to the standard method proposed by The Council for Geosciences (Technical guidelines Series No 1, 1995, amended 2001), the Approach to Residential Development on Dolomite, Council for Geosciences, October 2004, The Consultants Guide: Approach to Sites on Dolomite land, Council for Geosciences, November 2007 and SANS 1936-1 the site is zoned as follows:

- **IHC 6: 10 meter radiuses around boreholes L7 and L8: NHBRC Zone D3 for commercial developments < 3 storeys, parking areas and parking garages and NHBRC Zone D4 for all other development types**
- **IHC 3/4/5: The remainder of the site: Zone D3 for commercial developments < 3 storeys, parking areas, parking garages and residential developments as specified in the previous section**

15. **RECOMMENDATIONS TO BRING THE DEVELOPMENT TO AN ACCEPTABLE DEVELOPMENT RISK**

It is important to note that the recommendations are based on percussion borehole results and the interpolation of information. It is therefore possible that variations from the expected conditions can occur.

According SANS 1936-1: 2012 the dolomitic stability zones are considered suitable for the following:

- **IHC 6: 10 meter radiuses around boreholes L7 and L8**

Commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.

It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.

- **IHC 3/4/5: The remainder of the site**

Commercial and miscellaneous non-residential usage

Commercial developments < 3 storeys, including railway stations, shops, wholesale stores, offices, places of worship, theatrical, indoor sports or public assembly venues, other institutional land uses such as universities, schools, colleges, libraries, exhibition halls and museums, light (dry) industrial developments, dry manufacturing, commercial uses such as warehousing, packaging, and electrical sub-stations, filling stations.

It is important to note that the suitability is subject to footprint drilling and the recommendations listed in Section 15.

Residential development

(a) **Attached homes in buildings exceeding 3 storeys**

- AHH3: Up to 160 attached homes per hectare in buildings exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)

(b) **Attached homes in buildings not exceeding 3 storeys**

- AHL2: Up to 80 attached homes per hectare in buildings not exceeding 3 storeys (**subject to footprint investigations and subject to the recommendations listed in Section 15**)

(c) **Detached homes**

- DH3: Detached home or own site or an effective site having an area not less than 1000 sqm (**subject to footprint investigations and subject to the recommendations listed in Section 15**)
- **No wet services is recommended in the 10 meter radiuses around boreholes L7 and L8.**
- The client should note that some form of geotechnical remedial will be necessary. Such measures could include piling, grouting and earth mattresses, it should be noted that irrespective of the number of storeys, geotechnical remediation will be required. **It is important to note that all foundations should be capable of spanning a 5 m diameter sinkhole.** Foundation design confirmation/certification must be submitted to the Council for Geosciences along with the NHBRC enrolment application
- A certified Site Development Plan should be submitted to the Council for Geosciences for their co-signature.
- **If ownership, the layout, density and/or land use change, the influence of the dolomitic stability on the development should be re-assessed and all the relevant documentation has to be resubmitted to the Council for Geosciences for comment.**
- The developer should take note of the risk if water is at anytime allowed to penetrate the soil profile. Exceptionally stringent water precautionary measures should be implemented.
- The percussion boreholes should be protected during construction. If the construction includes excavations, it vital that the boreholes be sealed at the final level of excavation since it could act as points of water ingress resulting in instability.
- If irrigation is provided for gardens, this aspect should be specifically addressed as a special precautionary measure.
- A construction report for the development must be compiled to ensure that adverse conditions are identified and re-evaluated timeously. The developer should take note that if adverse conditions are encountered it will result in changes in the risk classification. This could impact on the proposed development.

- Water features, water bearing canals and swimming pools should not be allowed, unless structure specific investigations are done.
- The drainage precautionary measures and additional precautionary measures listed in Appendix C should be strictly adhered to.
- A *specific* Risk Management Strategy must be drawn up for the development and managed by the client on behalf of the local authority. Doline and sinkhole formation can be minimized by establishing a **Dolomite Risk Management Plan**¹ for the development and adhering to the recommendations at all times. As a crucial part of the Risk Management Plan, attention must be given to;
 - (i) the surface drainage for the entire development i.e. **Stormwater Management Plan**², the plan must also be integrated with a **Regional Stormwater Management Plan** which pertains to the area outside the boundaries of the site.
 - (ii) as well as monitoring and maintenance of all wet services i.e. **Wet Services Plan**³.
- The risk management plan should be incorporated in the Risk Management Plan of the Local Authority.

I trust the information is sufficient



L.J Kruger Pr. Sci. Nat.

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- a. ¹A comprehensive strategy to be implemented by a responsible group, who have a direct interest in the sustainability of a specific development (such as Irene Estate) which addresses all aspects of good governance on dolomitic land (stormwater management, pro-active maintenance, monitoring, emergency reaction planning, comprehensive database, vigilance etc.)
- b. ²A formalized plan whereby consideration is given to the flow direction and volume of stormwater, and the capacity of the storm water system so that all surface water can drain off the structures, off the property and directly into the regional stormwater system.
- c. ³A formalized plan whereby all wet services (mains and stand specific) can be monitored (i.e. must know where they are located, what piping was utilized) according the priority areas assigned by the consultant and maintained (replaced if punctured or old).

APPENDIX A

PERCUSSION BOREHOLE

PROJECT: ROSEFARM

SITE: KNOPJESLAAGTE 385 JR

CLIENT: J ROSE

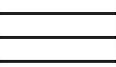
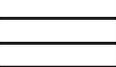
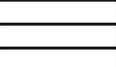
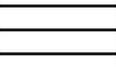
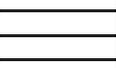
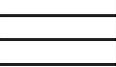
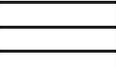
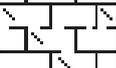
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MACHINE: 16 BAR PERCUSSION

DATE: 02/07/2007

BOREHOLE: 6065

PAGE: 1

PENETRATION MIN . SEC	GROUND WATER	LEGEND	DESCRIPTION
0.27			1
0.29			2
0.25			3
0.21			4
0.18			5
0.20			6
0.17			7
0.19			8
0.15			9
0.18			10
0.24			11
0.27			12
1.29			13
1.52			14
0.56			15
2.15			16
3.2			17
3.29			18
			

Slightly moist, black, sandy gravel consisting of medium sized, angular, medium hard rock slate fragments - Slate

Slightly moist, brown, sandy gravel consisting of small, angular, moderately weathered dolomite fragments - Dolomitic residuum

Slightly moist, grey, silty sandy gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite

PERCUSSION BOREHOLE

PROJECT: ROSEFARM

SITE: KNOPJESLAAGTE 385 JR

CLIENT: J ROSE

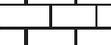
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DATE: 02/07/2007

BOREHOLE: 6065

PAGE: 2.

PENETRATION MIN . SEC	GROUND WATER	LEGEND	DESCRIPTION
3.25			19
3.22			20
3.30			21
3.28			22
			23
			24
			25
			26
			27
			28
			29
			30
			31
			32
			33
			34
			35
			36

Slightly moist, grey, silty sandy gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite

EOH
No sample or air losses
No ground water

PERCUSSION BOREHOLE

PROJECT: ROSEFARM

SITE: KNOPJESLAAGTE 385 JR

CLIENT: J ROSE

LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 02/07/2007

BOREHOLE: 6965

PAGE: 1

PENETRATION MIN . SEC	GROUND WATER	LEGEND	DESCRIPTION
0.28			1 Slightly moist, red brown, silty sand with subangular chert fragments - Colluvium
0.30			2 Slightly moist, khaki, silty sand - Residual syenite
0.35			3
0.32			4
0.38			5
0.30			6
0.28			7
0.26			8
0.24			9 Slightly moist, olive silty sand with soft rock syenite fragments - Residual syenite
0.29			10
0.27			11
0.31			12
0.26			13
0.28			14
0.24			15
0.22			16 Slightly moist, black, sandy gravel consisting of medium sized, angular, medium hard rock slate fragments - Slate
0.20			
0.21			
0.21			

PERCUSSION BOREHOLE

PROJECT: ROSEFARM

SITE: KNOPJESLAAGTE 385 JR

CLIENT: J ROSE

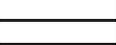
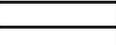
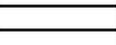
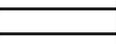
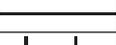
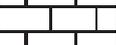
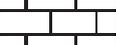
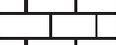
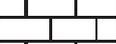
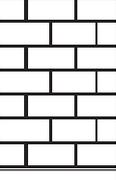
LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 02/07/2007

BOREHOLE: 6965

PAGE: 2.

PENETRATION MIN . SEC	GROUND WATER	LEGEND	DESCRIPTION
0.35			19
0.37			20
0.44			21
0.57			22
0.59			23
3.19			24
3.26			25
3.30			26
3.32			27
3.29			28
3.33			29
			30
			31
			32
			33
			34
			35
			36

Slightly moist, black, sandy gravel consisting of medium sized, angular, medium hard rock slate fragments - Slate

Slightly moist, grey, silty sandy gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite

EOH
No sample or air losses
Ground water encountered at 21 meters

PERCUSSION BOREHOLE

PROJECT: ROSEFARM

SITE: KNOPJESLAAGTE 385 JR

CLIENT: J ROSE

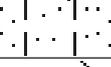
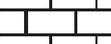
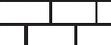
LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 02/07/2007

BOREHOLE: 7061

PAGE: 1

PENETRATION MIN . SEC	GROUND WATER	LEGEND	DESCRIPTION
0.25			1 Slightly moist, red brown, silty sand with subangular chert fragments - Colluvium
0.29			2 Slightly moist, dark brown to black, silty clay wad with scattered highly weathered chert fragments - Dolomitic residuum
1.37			3
3.26			4
3.29			5
3.32			6 Slightly moist, grey, silty sandy gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite
3.34			7
3.26			8
3.30			9
3.33			10 EOH
			11 No sample or air losses
			12 No ground water
			13
			14
			15
			16
			17
			18

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

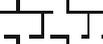
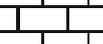
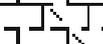
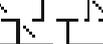
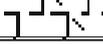
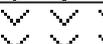
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L1 (X 97088.7353 Y 2861326.1746)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
			Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
0.28		1	
			Slightly moist, greyish brown, sandy gravel consisting of small and medium, angular, highly- to moderately weathered dolomite fragments - Highly weathered dolomite
0.23		2	
			Slightly moist, dark brown, clayey gravel consisting of small, angular, highly- to moderately weathered dolomite fragments with ±30% wad - Highly weathered dolomite
0.51		3	
			Slightly moist becoming wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.07		4	
			
1.15		5	
			
1.20		6	
			
1.12		7	
			
1.03		8	Wet, dark brown, clayey gravel consisting of small, angular, highly- to moderately weathered dolomite fragments with ±20-30% wad - Highly weathered dolomite
			
0.39		9	
			
0.57		10	
			
1.17		11	
			
1.25		12	Wet, dark brown, clayey gravel consisting of small, angular, moderately and highly weathered syenite fragments - Syenite
			
1.19		13	
			
1.29		14	
			
1.38		15	
			
1.47		16	Wet, dark brown, sandy gravel consisting of small, angular, slightly and moderately weathered syenite fragments - Syenite
			
1.55		17	
			
1.51		18	

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L1 (X 97088.7353 Y 2861326.1746)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
2.06		▽	19
2.17		▽	20
2.33		▽	21
3.19		▽	22
3.25		▽	23
3.31		▽	24
3.27		▽	25
3.35		▽	26
3.24		▽	27
			End of hole
			28
			Ground water rest level at 6 meters
			29
			No air or sample losses
			30
			31
			32
			33
			34
			35
			36

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

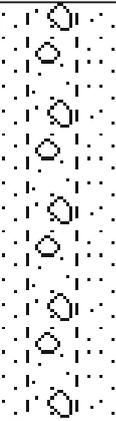
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L2 (X 96803.9905 Y 2861306.7517)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.33			Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
0.38		1	
0.35		2	
0.41		3	
0.36		4	
0.48		5	
0.44		6	
0.58		7	
1.05			Slightly moist, khaki, silty gravel consisting of medium, angular, highly weathered syenite fragments - Syenite
1.18		8	
1.27		9	
1.34		10	
1.41		11	
1.49		12	
1.44		13	
1.50		14	
1.57			Slightly moist, olive khaki, silty gravel consisting of medium, angular, highly to slightly weathered syenite fragments - Syenite
2.03		15	
		16	
		17	
			Slightly moist, olive grey, silty gravel consisting of small angular, slightly weathered syenite fragments - Syenite
		18	

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L2 (X 96803.9905 Y 2861306.7517)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
2.23		▽	19
3.12		▽	20
3.17		▽	21 Slightly moist, olive grey, silty gravel consisting of small angular, slightly weathered syenite fragments - Syenite
3.21		▽	22
3.28		▽	23
3.34		▽	24
3.19		▽	25 End of hole
			26 Ground water rest level at 8 meters
			27 No air or sample losses
			28
			29
			30
			31
			32
			33
			34
			35
			36

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

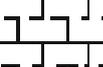
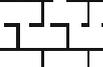
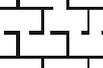
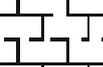
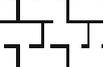
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L3 (X 96925.5016 Y 2861368.5646)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.30			1 Slightly moist, brown, clayey gravel consisting of small, angular, highly weathered chert fragments - Dolomitic residuum
0.27			2
0.21			3 Slightly moist, black, clayey gravel consisting of small, angular, highly weathered chert fragments with ±40% wad - Dolomitic residuum
0.37			4
0.56			5
1.11			6
1.19			7 Slightly moist, olive khaki, silty gravel consisting of medium, angular, moderately weathered syenite fragments - Syenite
1.22			8
1.14			9
1.05			10
1.00			11
0.56			12
0.53			13
1.07			14 Slightly moist becoming wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.13			15
1.20			16
1.27			17
1.33			18

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

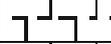
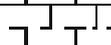
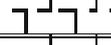
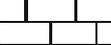
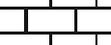
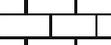
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L3 (X 96925.5016 Y 2861368.5646)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
1.30			19
1.37			20
1.48			21
1.52			22
2.00			23
2.28			24
3.13			25
3.19			26
3.15			27
3.26			28
3.22			29
3.29			30
			31
			32
			33
			34
			35
			36

Slightly moist becoming wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite

Slightly moist, grey, sandy gravel consisting of small angular, slightly weathered dolomite fragments - Dolomite

End of hole

No ground water

No air or sample losses

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L4 (X 96974.0384 Y 2861495.8304)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.47		1	Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
0.50		2	
0.31		3	
0.28		4	
0.30		5	Slightly moist, khaki, silty sand with of small, angular, highly weathered syenite fragments - Syenite
0.33		6	
0.35		7	
0.39		8	
0.42		9	Slightly moist, greyish brown, sandy gravel consisting of small, angular, highly- to moderately weathered dolomite fragments - Highly weathered dolomite
0.37		10	
0.33		11	
0.29		12	
0.36		13	
0.30		14	
0.44		15	
0.40		16	
0.47		17	
0.38		18	

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

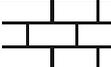
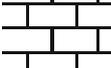
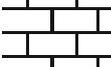
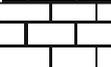
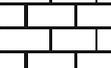
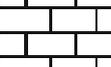
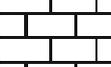
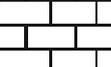
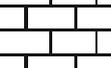
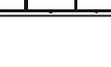
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L4 (X 96974.0384 Y 2861495.8304)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.45			19 Slightly moist, greyish brown, sandy gravel consisting of small, angular, highly- to moderately weathered dolomite fragments - Highly weathered dolomite
1.04			20
1.15			21
1.23			22
1.27			23 Slightly moist becoming wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.31			24
1.44			25
1.50			26
1.58			27
2.19			28
2.23			29
3.05			30 Slightly moist, grey, sandy gravel consisting of small angular, slightly weathered dolomite fragments - Dolomite
3.06			31
3.09			32
3.05			33
3.07			34
3.05			35 End of hole
			36 Ground water rest level at 12 meters
			No air or sample losses

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

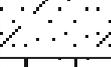
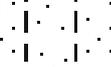
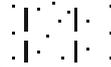
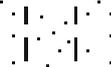
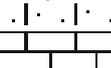
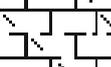
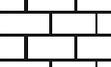
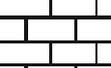
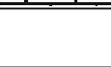
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L5 (X 96888.6544 Y 2861522.5567)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION	
0.31			1	Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
0.26			2	
0.29			3	Slightly moist, khaki, silty gravel consisting of medium, angular, highly weathered syenite fragments - Syenite
0.32			4	
0.25			5	
0.23			6	Slightly moist, greyish brown, sandy gravel consisting of small, angular, highly- to moderately weathered dolomite fragments - Highly weathered dolomite
0.37			7	
0.49			8	
1.12			9	
1.18			10	
1.31			11	Slightly moist, dark brown, sandy gravel consisting of small, angular, highly- to moderately weathered dolomite fragments - Highly weathered dolomite
1.15			12	
0.46			13	
0.40			14	
0.59			15	
1.08			16	Wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.17			17	
1.24			18	

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

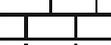
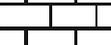
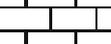
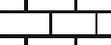
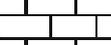
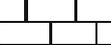
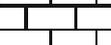
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L5 (X 96888.6544 Y 2861522.5567)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
1.30			19
1.37			20
1.51			21
2.03			22
2.18			23
2.25			24
3.03			25
3.05			26
3.09			27
3.07			28
3.04			29
3.06			30
			31
			32
			33
			34
			35
			36

Wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite

Wet, dark brown, clayey gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite

End of hole
Ground water rest level at 12 meters
No air or sample losses

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

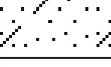
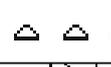
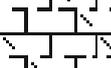
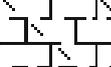
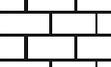
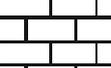
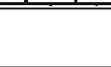
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L6 (X 96894.6755 Y 2861624.8610)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.29			1 Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
0.35			2
0.48			3
0.58			4
0.30			5 Slightly moist becoming wet, dark brown, clayey, gravel consisting of medium and small, angular, highly- to moderately weathered chert fragments - Dolomitic residuum
0.22			6
0.13			7
0.15			8
0.46			9
0.55			10
1.08			11
0.50			12 Wet, dark brown, clayey gravel consisting of small, angular, highly- to moderately weathered dolomite fragments with ±30% wad - Highly weathered dolomite
0.28			13
0.53			14
1.05			15
1.13			16 Wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.20			17
1.29			18

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

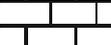
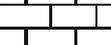
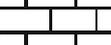
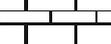
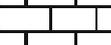
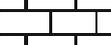
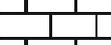
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L6 (X 96894.6755 Y 2861624.8610)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
1.36			19
1.40			20
1.46			21
1.54			22
2.29			23
3.00			24
3.03			25
3.06			26
3.10			27
3.08			28
3.04			29
			30
			31
			32
			33
			34
			35
			36

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L7 (X 97082.2948 Y 2861701.1257)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.32			
0.43		1	
2.26		2	Slightly moist, brown speckled white, clayey, sand with small, angular, highly- to moderately weathered chert fragments - Dolomitic residuum
1.48		3	
0.21		4	
0.08		5	
0.05		6	No sample or air return - Suspected dolomitic residuum
0.47		7	
0.56		8	
1.07		9	
1.16		10	
1.24		11	
1.29		12	Slightly moist, light brownish grey, sandy gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.15		13	
1.08		14	
1.27		15	
1.39		16	
1.47		17	
		18	

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

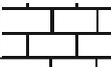
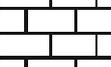
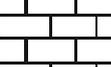
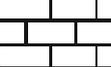
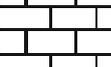
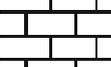
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L7 (X 97082.2948 Y 2861701.1257)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
1.52			19
2.10			20
2.31			21
3.04			22
3.00			23
3.06			24
3.11			25
3.09			26
3.05			27
			End of hole
			28
			Ground water rest level at 12 meters
			29
			Air and sample losses 4-8 meters
			30
			31
			32
			33
			34
			35
			36

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L8 (X 96855.9061 Y 2861724.7678)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.38			1 Slightly moist, brown speckled white, clayey, sand with small, angular, highly- to moderately weathered chert fragments - Dolomitic residuum
0.57			2
0.28			3
0.11			4
0.04			5
0.03			6
0.03			7
0.04			8 No sample or air return - Suspected dolomitic residuum
0.17			9
0.30			10
0.36			11
0.48			12
1.09			13
1.18			14
1.27			15 No sample or air return - Suspected moderately weathered dolomite
1.33			16
1.44			17
1.51			18

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

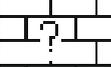
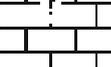
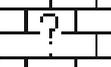
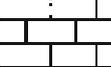
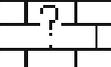
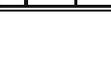
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L8 (X 96855.9061 Y 2861724.7678)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
2.19			19
2.33			20
3.03			21
3.06			22
3.02			23
3.07			24
3.09			25
3.01			26
			27
			28
			29
			30
			31
			32
			33
			34
			35
			36

No sample or air return - Suspected dolomite

End of hole

No ground water rest level hole collapsed

Air and sample losses 4-28 meters

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

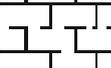
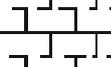
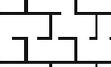
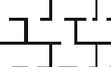
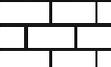
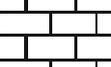
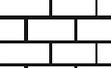
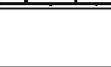
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L9 (X 96929.2724 Y 2861766.5201)

PAGE: 1.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
0.34			1 Slightly moist, brown, clayey sand with scattered small chert fragments - Colluvium
1.43			2
2.12			3 Slightly moist, dark brown to black, silty clay wad with highly weathered chert fragments - Dolomitic residuum
2.00			4
0.30			5
0.45			6
0.51			7 Slightly moist becoming wet, dark brown, clayey gravel consisting of small, angular, highly- to moderately weathered dolomite fragments with ±30% wad - Highly weathered dolomite
1.03			8
0.31			9
0.24			10
0.58			11
1.06			12
1.11			13
1.16			14 Wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite
1.02			15
1.00			16
1.15			17
1.26			18

PERCUSSION BOREHOLE

PROJECT: Ptn 66

SITE: Knopjeslaagte 385 JR

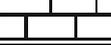
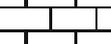
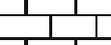
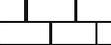
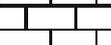
CLIENT: WFA Christian Business School LOGGED BY: LJK

MACHINE: 16 BAR PERCUSSION

DATE: 09/05/2019

BOREHOLE: L9 (X 96929.2724 Y 2861766.5201)

PAGE: 2.

PENETRATION MIN / SEC	GROUND WATER	LEGEND	DESCRIPTION
1.32			19
1.38			20
1.53			21
2.17			22
2.03			23
2.14			24
3.02			25
3.04			26
3.06			27
3.10			28
3.05			29
3.08			30
			31
			32
			33
			34
			35
			36

Wet, dark brown, clayey gravel consisting of small, angular, moderately to slightly weathered dolomite fragments - Moderately weathered dolomite

Wet, dark brown, clayey gravel consisting of small, angular, slightly weathered dolomite fragments - Dolomite

End of hole

Ground water rest level at 12 meters

No air or sample losses

APPENDIX B

Posbus/PO Box 536
Celtis Ridge
0130

Tel: 012 668 9905/6
Faks/Fax: 012 668 9907
Sel/Cell: 082 554 9443
Email: francois@jayk.co.za

Kliënt: GERHARDSVILLE X2
Client: _____
Projek / Terrein: _____
Project / Terrain: _____
Gat Nr.: _____
Hole No.: L3
Gatposisie: _____
Hole Position: _____

Totale Diepte: 30M
Total Depth: _____
Voering - In & Uit (m): _____
Casing - In & Out (m): _____
Voering gelaat (m): _____
Casing installes (m): _____
Voering permanent beskadig (m): _____
Casing permanently damaged (m): _____

Datum: 09-05-2019
Date: _____
Lugdruk: _____
Air Pressure: 18 BAR
Beiteldeursnee (mm): _____
Bit Diameter (mm): _____
Water aangetref (m): _____
Water struck (m): _____
Rusvlak (m): _____
Rest level (m): _____

Diepte Depth (m)	Penetrasie tyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate			Lugverlies Air Loss			Vog toestand Moisture condition			Gat val toe Hole collap- sing		Voering Casing		Monster herwinning Sample recovered			OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)	
		Holte/Cavity	Baie sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid	Baie ongereeld/Very irregular	Ongereeld/Irregular	Gereeld/Regular	Geen/None	Effend/Slightly	Medium	Totaal/Total	Water aangestref/found	Nat/Wet	Klam/Moist	Droog/Dry	Water aangewend/applied	Diepte geïnstalleer Depth installed	Goed/Good	Medium	Swak/Poor		Geen/None
0-1	0:30																							CHERT/clay
1-2	0:27																							CHERT/clay/Sieniet
2-3	0:21																							WAD
3-4	0:37																							Dolomite/WAD
4-5	0:56																							Sieniet
5-6	1:11																							
6-7	1:19																							
7-8	1:22																							
8-9	1:14																							
9-10	1:05																							Sieniet
10-11	1:00																							Dolomite
11-12	0:56																							
12-13	0:53																							
13-14	1:07																							
14-15	1:13																							
15-16	1:20																							Dolomite
16-17	1:27																							
17-18	1:33																							
18-19	1:30																							
19-20	1:37																							
20-21	1:48																							Sieniet
21-22	1:52																							
22-23	2:00																							Hard Sieniet
23-24	2:28																							
24-25	3:13																							Solies Hard Sieniet
25-26	3:19																							
26-27	3:15																							
27-28	3:26																							
28-29	3:22																							
29-30	3:29																							Solies Hard Sieniet

Opmerkings:
Remarks: We did move the borehole 9M from the old Reservoir dam

DATA BESKRYF DEUR: Thomas OPERATEUR: ELVIS
DATA DESCRIBED BY: _____ OPERATOR: _____



Posbus/PO Box 536
Celtis Ridge
0130

Tel: 012 668 9905/6
Faks/Fax: 012 668 9907
Sel/Cell: 082 554 9443
Email: francois@jayk.co.za

Kliënt: GERTHARDVILLE X2
 Projek / Terrain: _____
 Project / Terrain: _____
 Gat Nr.: _____
 Hole No.: L4
 Gatposisie: _____
 Hole Position: _____

Totale Diepte: 35M
 Total Depth: _____
 Voering - In & Uit (m): _____
 Casing - In & Out (m): _____
 Voering gelaat (m): _____
 Casing installes (m): _____
 Voering permanent beskadig (m): _____
 Casing permanently damaged (m): _____

Datum: 09-05-2019
 Date: _____
 Lugdruk: 18 BAR Lugvolume: _____
 Air Pressure: _____ Air Capacity: _____
 Beiteldeursnee (mm): _____
 Bit Diameter (mm): _____
 Water aangetref (m): _____
 Water struck (m): _____
 Rusvlak (m): _____
 Rest level (m): _____

Diepte Depth (m)	Penetrasie tyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate		Lugverlies Air Loss			Vog toestand Moisture condition			Gat val toe Hole collapsing	Voering Casing	Monster herwinning Sample recovered				OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)					
		Holte/Cavity	Bate sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid	Bate ongereeld/Irregular	Ongereeld/Irregular	Gereeld/Regular	Geen/None	Effend/Slightly	Medium	Totaal/Total	Water aangetref/found			Nat/Wet	Klam/Moist	Droog/Dry	Water aangewend/applied		Diepte geïnstalleer Depth installed	Goed/Good	Medium	Swak/Poor	Geen/None
0-1	047																								Clay	
1-2	050																									Steniet
2-3	031																									
3-4	028																									
4-5	030																									
5-6	033																									
6-7	035																									Steniet
7-8	039																									
8-9	042																									
9-10	037																									
10-11	033																									
11-12	029																									Steniet
12-13	036																									
13-14	030																									Steniet/WAD
14-15	044																									Dolomite
15-16	040																									
16-17	047																									
17-18	038																									SHALE
18-19	045																									Dolomite
19-20	104																									
20-21	115																									
21-22	123																									
22-23	127																									
23-24	131																									Dolomite
24-25	144																									
25-26	150																									Sag Dolomite
26-27	158																									
27-28	219																									
28-29	223																									
29-30	305																									Solis Dolomite

Opmerkings: _____
 Remarks: _____

DATA BESKRYF DEUR: THOMAS OPERATEUR: ELVIS
 DATA DESCRIBED BY: _____ OPERATOR: _____



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Kliënt: GER Hardsville x2
Client: GER Hardsville x2
Projek / Terrain: LS
Gat Nr.: LS
Hole No.: LS
Gatposisie:
Hole Position:

Totale Diepte: 30M
Total Depth:
Voering - In & Uit (m):
Casing - In & Out (m):
Voering gelaat (m):
Casing installes (m):
Voering permanent beskadig (m):
Casing permanently damaged (m):

Datum: 09-05-2019
Date:
Lugdruk: 18 BAR Lugvolume:
Air Pressure: 18 BAR Air Capacity:
Beiteldeursnee (mm):
Bit Diameter (mm):
Water aangetref (m):
Water struck (m):
Rusvlak (m):
Rest level (m):

Diepte Depth (m)	Penetrasietyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate		Lugverlies Air Loss			Vog toestand Moisture condition			Gat val toe Hole collapsing	Voering Casing	Monster herwinning Sample recovered				OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)			
		Hoite/Cavity	Base sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid	Base ongereeld/Very irregular	Ongereeld/Irregular	Gereeld/Regular	Geen/None	Effend/Slightly	Medium	Totaal/Total	Water aangetref/found	Nat/Wet	Klam/Moist	Droog/Dry	Water aangewend/applied	Diepte geïnstalleer Depth installed	Goed/Good	Medium	Swak/Poor	Geen/None	
0-1	031	to																						CO-ORDINATES: LO: <u>29</u> Y: <u>0096888</u> X: <u>2861522</u> <u>Sieniet</u>
1-2	026	to																						<u>Sieniet/WAS</u>
2-3	029	to																						<u>Sieniet</u>
3-4	032	to																						<u>CHERT/WAS</u>
4-5	025	to																						<u>WAS</u>
5-6	023	to																						<u> </u>
6-7	037	to																						<u>Dolomite/WAS</u>
7-8	049	to																						<u>Dolomite</u>
8-9	112	to log																						<u> </u>
9-10	118	to																						<u> </u>
10-11	131	to																						<u> </u>
11-12	115	to																						<u> </u>
12-13	046	to log																						<u>Dolomite</u>
13-14	040	to																						<u>Dolomite/WAS</u>
14-15	059	to																						<u> </u>
15-16	108	to log																						<u>Dolomite</u>
16-17	117	to																						<u> </u>
17-18	124	to																						<u> </u>
18-19	130	to																						<u> </u>
19-20	137	to																						<u> </u>
20-21	151	to																						<u>Sag Dolomite</u>
21-22	203	to log																						<u> </u>
22-23	218	to																						<u> </u>
23-24	225	to																						<u> </u>
24-25	303	to log																						<u>Solid Dolomite</u>
25-26	305	to																						<u> </u>
26-27	309	to																						<u> </u>
27-28	307	to																						<u> </u>
28-29	304	to																						<u> </u>
29-30	306	to																						<u>Solid Dolomite</u>

Opmerkings:
Remarks:

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Kliënt: GERHARDSVILLE X2
Client: _____
Projek / Terrain: _____
Project / Terrain: _____
Gat Nr.: _____
Hole No.: L6
Gatposisie: _____
Hole Position: _____

Totale Diepte: 29M
Total Depth: _____
Voering - In & Uit (m): _____
Casing - In & Out (m): _____
Voering gelaat (m): _____
Casing installes (m): _____
Voering permanent beskadig (m): _____
Casing permanently damaged (m): _____

Datum: 09-05-2019
Date: _____
Lugdruk: 18 BAR Lugvolume: _____
Air Pressure: _____ Air Capacity: _____
Beiteldeursnee (mm): _____
Bit Diameter (mm): _____
Water aangetref (m): _____
Water struck (m): _____
Rusvlak (m): _____
Rest level (m): _____

Diepte Depth (m)	Penetrasie tyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate	Lugverlies Air Loss					Vog toestand Moisture condition	Gat val toe Hole collap- sing	Voering Casing	Monster herwinning Sample recovered				OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)			
		Holte/Cavity	Bate sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid		Bate ongereeld/Very irregular	Ongereeld/Irregular	Gereeld/Regular	Geen/None	Effend/Slightly				Medium	Totaal/Total	Water aangetref/found	Nat/Wet		Klam/Moist	Droog/Dry	Water aangewend/applied
0-1	0:29																						mini chert/clay
1-2	0:35																						
2-3	0:48																						
3-4	0:58																						Clay/WAD
4-5	0:30																						
5-6	0:22																						
6-7	0:13																						WAD
7-8	0:15																						
8-9	0:46																						Dolomite/WAD
9-10	0:55																						
10-11	1:08																						
11-12	0:50																						
12-13	0:28																						Dolomite/CHERT
13-14	0:53																						
14-15	1:05																						Dolomite
15-16	1:13																						
16-17	1:20																						
17-18	1:29																						
18-19	1:36																						
19-20	1:40																						Dolomite
20-21	1:46																						SPG Dolomite
21-22	1:54																						
22-23	2:29																						
23-24	3:00																						Solus Dolomite
24-25	3:03																						
25-26	3:06																						
26-27	3:10																						
27-28	3:08																						
28-29	3:04																						Solus Dolomite
29-30	:																						

Opmerkings:
Remarks:

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Client: _____
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Project / Terrain: _____
Gat Nr.: _____
Hole No.: L7
Gatposisie: _____
Hole Position: _____

Totale Diepte: 27M
Total Depth: _____
Voering - In & Uit (m): _____
Casing - In & Out (m): _____
Voering gelaat (m): _____
Casing installes (m): _____
Voering permanent beskadig (m): _____
Casing permanently damaged (m): _____

Datum: 09-05-2019
Date: _____
Lugdruk: 18 BAR Lugvolume: _____
Air Pressure: _____ Air Capacity: _____
Beiteldeursnee (mm): _____
Bit Diameter (mm): _____
Water aangetref (m): _____
Water struck (m): _____
Rusvlak (m): _____
Rest level (m): _____

Diepte Depth (m)	Penetrasietyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate					Lugverlies Air Loss					Vog toestand Moisture condition			Gat val toe Hole collapsing		Voering Casing		Monster herwinning Sample recovered			OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)
		Hoite/Cavity	Bate sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid	Bate ongeregeld/Very irregular	Ongeregeld/Irregular	Geregeld/Regular	Geen/None	Effen/Slightly	Medium	Totaal/Total	Water aangetref/found	Nat/Wet	Klam/Moist	Droog/Dry	Water aangewend/applied	Diepte geïnstalleer Depth installed	Goed/Good	Medium	Swak/Poor	Geen/None				
0-1	0:32																								CO-ORDINATES: LO: <u>29</u> Y: <u>0097082</u> X: <u>2861701</u>		
1-2	0:43																								mini chert/clay		
2-3	2:26																								TAAI clay		
3-4	1:48																								Clay		
4-5	0:21																								NO SAMPLE		
5-6	0:08																										
6-7	0:05																										
7-8	0:47																										
8-9	0:56																								Dolomite		
9-10	1:07																										
10-11	1:16																										
11-12	1:24																										
12-13	1:29																										
13-14	1:15																								Dolomite		
14-15	1:08																										
15-16	1:27																										
16-17	1:39																										
17-18	1:47																								Sag Dolomite		
18-19	1:52																										
19-20	2:10																										
20-21	2:31																										
21-22	3:04																								Solis Dolomite		
22-23	3:00																										
23-24	3:06																										
24-25	3:11																										
25-26	3:09																										
26-27	3:05																								Solis Dolomite		
27-28	:																										
28-29	:																										
29-30	:																										

Opmerkings: _____
Remarks: _____

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Kliënt: GERTHARDSDVILLE
Client: _____
Projek / Terrain: _____
Gat Nr.: _____
Hole No.: L9
Gatposisie: _____
Hole Position: _____

Totale Diepte: 30M
Total Depth: _____
Voering - In & Uit (m): _____
Casing - In & Out (m): _____
Voering gelaat (m): _____
Casing installes (m): _____
Voering permanent beskadig (m): _____
Casing permanently damaged (m): _____

Datum: 09-05-2019
Date: _____
Lugdruk: 18 BAR
Air Pressure: _____
Beiteldeursnee (mm): _____
Bit Diameter (mm): _____
Water aangetref (m): _____
Water struck (m): _____
Rusvlak (m): _____
Rest level (m): _____

Diepte Depth (m)	Penetrasietyd Penetration time min: sek/m	Formasie Formation					Hamer tempo Hammer rate			Lugverlies Air Loss			Vog toestand Moisture condition			Gat val toe Hole collapsing		Voering Casing	Monster herwinning Sample recovered			OPMERKINGS/REMARKS (bv tipe materiaal / eg. type of material)		
		Holte/Cavity	Bate sag/Very soft	Sag/Soft	Redelik hard/Fairly hard	Solied/Solid	Bate ongereeld/Very irregular	Ongereeld/Irregular	Gereeld/Regular	Geen/None	Effend/Slightly	Medium	Totaal/Total	Water aangetref/found	Nat/Wet	Klam/Moist	Droog/Dry		Water aangewend/applied	Diepte geïnstalleer Depth installed	Goed/Good		Medium	Swak/Poor
0-1	0:34																							CO-ORDINATES: LO: <u>29</u> Y: <u>0096929</u> X: <u>2861766</u>
1-2	1:43																							Clay
2-3	2:12																							CHERT/Clay
3-4	2:00																							TAA clay/CHERT
4-5	0:30																							WAA
5-6	0:45																							Dolomite
6-7	0:51																							
7-8	1:03																							
8-9	0:31																							Dolomite/WAA
9-10	0:24																							
10-11	0:58																							Dolomite
11-12	1:06																							
12-13	1:11																							
13-14	1:16																							
14-15	1:02																							
15-16	1:00																							Dolomite
16-17	1:15																							
17-18	1:26																							
18-19	1:32																							
19-20	1:38																							
20-21	1:03																							Sag Dolomite
21-22	2:17																							
22-23	2:03																							
23-24	2:14																							
24-25	3:02																							Solied Dolomite
25-26	3:04																							
26-27	3:06																							
27-28	3:10																							
28-29	3:08																							
29-30	3:08																							Solied Dolomite

Opmerkings: _____
Remarks: _____

DATA BESKRYF DEUR: THOMAS OPERATEUR: ELVIS
DATA DESCRIBED BY: _____ OPERATOR: _____



APPENDIX C

**DRAFT SOUTH AFRICAN STANDARD (DSS):
PUBLIC ENQUIRY STAGE**

Document number	SANS 1936-3		
Reference	7135/1936-3/SP		
Date of circulation	2011-12-20	Closing date	2012-02-21

Number and title:

SANS 1936-3: DEVELOPMENT OF DOLOMITE LAND — PART 3: DESIGN AND CONSTRUCTION OF BUILDINGS, STRUCTURES AND INFRASTRUCTURE

Remarks:**PLEASE NOTE:**

- The technical committee, SABS SC 59P: *Construction standards – Geotechnical standards* responsible for the preparation of this standard has reached consensus that the attached document should become a South African standard. It is now made available by way of public enquiry to all interested and affected parties for public comment, and to the technical committee members for record purposes. Any comments should be sent by the indicated closing date, either by mail, or by fax, or by e-mail to

SABS Standards Division
Attention: Compliance and Development department
Private Bag X191
Pretoria
0001

Fax No.: (012) 344-1568 (for attention: dsscomments)
E-mail: dsscomments@sabs.co.za

Any comment on the draft must contain in its heading the number of the clause/subclause to which it refers. A comment shall be well motivated and, where applicable, contain the proposed amended text.

- The public enquiry stage will be repeated if the technical committee agrees to significant technical changes to the document as a result of public comment. Less urgent technical comments will be considered at the time of the next amendment.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR PUBLIC COMMENT. IT MAY NOT BE REFERRED TO AS A SOUTH AFRICAN STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT SOUTH AFRICAN STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN LAW.

ISBN 978-0-626-

SANS 1936-3:2012

Edition 1

SOUTH AFRICAN NATIONAL STANDARD

Development of dolomite land

Part 3: Design and construction of buildings, structures and infrastructure

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SABS



SANS 1936-3:2012

Edition 1

Table of changes

Change No.	Date	Scope

Acknowledgement

The SABS Standards Division wishes to acknowledge the work of the National Department of Public Works, the South African Civil Engineering, Engineering Geological and Geotechnical Engineering Fraternity, and the National Dolomite Risk Management Working Committee established on instruction of the Cabinet Committee on Governance and Administration in developing this document.

Foreword

This South African standard was approved by National Committee SABS SC 59P, *Construction standards – Geotechnical standards*, in accordance with procedures of the SABS Standards Division, in compliance with annexure 3 of the WTO/TBT agreement.

This document was published in xxxx 2012.

Reference is made in 3.14 to the "relevant national legislation". In South Africa this means section 19(2)(a) of the Engineering Profession Act, 2000 (Act No. 46 of 2000).

Reference is made in 3.19 to the "relevant national legislation". In South Africa this means the Engineering Profession Act, 2000 (Act No. 46 of 2000) or the Natural Scientific Professions Act, 2003 (Act No. 27 of 2003).

Reference is made in 4.2.2 to the "relevant compulsory specifications". In South Africa this means a standard, or part of a standard, that has been declared to be compulsory by the Minister of Trade and Industry in terms of section 13 of the National Regulator for Compulsory Specifications Act, 2008 (Act No. 5 of 2008).

Reference is made in 4.2.2 to the "relevant national legislation". In South Africa this means the National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977).

Reference is made in 4.6.1 to the "relevant national authority". In South Africa this means the Department of Water Affairs.

Reference is made in 4.6.1 to the "relevant national legislation". In South Africa this means the National Water Act, 1998 (Act No. 36 of 1998).

Reference is made in 4.6.2 to the "relevant national authorities". In South Africa this means the Department of Water Affairs, the Council for Geoscience, and the local authority.

Foreword *(concluded)*

SANS 1936 consists of the following parts under the general title *Development of dolomite land*:

Part 1: General principles and requirements.

Part 2: Geotechnical investigations and determinations.

Part 3: Design and construction of buildings, structures and infrastructure.

Part 4: Risk management.

Introduction

The development of dolomite land continues to present a challenge in South Africa. While opportunities exist in the development of such land, the adverse effects relating to the formation of sinkholes and subsidences, whether naturally or as a result of the development, cannot be ignored.

In the absence of risk mitigation measures, sinkhole formation can result in loss of life. In addition, sinkholes and subsidences can cause severe damage to buildings and infrastructure and affect their serviceability.

Avoiding the hazard associated with dolomite land by prohibiting development of any kind on such land is not practical as between four and five million South Africans currently reside or work on such land. Twenty-five per cent of Gauteng, the commercial, mining and manufacturing centre of South Africa, is located on dolomite land. At the other end of the spectrum, undue acceptance of risk is not an option given the potential severity of the consequences and the Government's obligations in terms of the Bill of Rights. Systematic risk mitigation measures are therefore required.

South African research shows that 96 % of sinkholes and subsidences that have occurred to date were man-induced, generated by ingress of water from leaking water-bearing infrastructure, poor stormwater management, etc. or due to artificial lowering of the groundwater level. Consequently, intervention through an integrated, comprehensive and pro-active dolomite risk management strategy has the potential to reduce the incidences of ground instability events (sinkhole and subsidence formation) by reducing the likelihood of water gaining entry into the subsurface profile, or controlling de-watering/recharging of the dolomite aquifer.

The objective of SANS 1936 is to set requirements for the development of dolomite land in order to ensure that people live and work in an environment that is seen by society to be acceptably safe, where loss of assets is within tolerable limits, and where cost-effective and sustainable land usage is achieved.

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Development of dolomite land

Part 3:

Design and construction of buildings, structures and infrastructure

1 Scope

1.1 This part of SANS 1936 establishes requirements for the design and construction of permanent or temporary buildings, structures and infrastructure, including wet and dry engineering services, on dolomite land requiring precautionary measures to support sustainable development. It also applies to upgrading or maintenance of existing developments.

1.2 This part of SANS 1936 establishes requirements for sites designated as D2 or D3 dolomite areas in accordance with SANS 1936-1.

1.3 Development on sites designated as D4 dolomite areas require additional site-specific precautions over and above those specified in clause 10 of this part of SANS 1936.

NOTE 1 Maintenance and risk management requirements are established in SANS 1936-4.

NOTE 2 Design and construction requirements in this part of SANS 1936 are based on the premise that the risk management requirements of SANS 1936-4 will be implemented as long as the buildings, structures or infrastructure are in existence.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

ISO 9969, *Thermoplastics pipes – Determination of ring stiffness.*

SANS 32/EN 10240, *Internal and/or external protective coatings for steel tubes – Specification for hot dip galvanized coatings applied in automatic plants.*

SANS 62-1, *Steel pipes – Part 1: Pipes suitable for threading and of nominal size not exceeding 150 mm.*

SANS 62-2, *Steel pipes – Part 2: Screwed pieces and pipe fittings of nominal size not exceeding 150 mm.*

SANS 121/ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

SANS 370, *Steel mesh reinforced polyethylene (PE) pipes for water supply.*

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Edition 1

- SANS 460, *Plain-ended solid drawn copper tubes for potable water.*
- SANS 674, *Steel-reinforced spirally wound PE drainage and sewer pipes.*
- SANS 676, *Reinforced concrete pressure pipes.*
- SANS 677, *Concrete non-pressure pipes.*
- SANS 719, *Electric welded low carbon steel pipes for aqueous fluids (large bore).*
- SANS 791, *Unplasticized poly(vinyl chloride) (PVC-U) sewer and drain pipes and pipe fittings.*
- SANS 815-1, *Shoulder-ended and groove-ended piping systems – Part 1: Shoulder-ended steel pipes, fittings and couplings.*
- SANS 815-2, *Shoulder-ended and groove-ended pipe systems – Part 2: Groove-ended steel pipes, fittings and couplings.*
- SANS 966-1, *Components of pressure pipe systems – Part 1: Unplasticized poly(vinyl chloride) (PVC-U) pressure pipe systems.*
- SANS 966-2, *Components of pressure pipe systems – Part 2: Modified poly(vinyl chloride) (PVC-M) pressure pipe systems.*
- SANS 975, *Prestressed concrete pipes.*
- SANS 1067-1, *Copper-based fittings for copper tubes – Part 1: Compression fittings.*
- SANS 1067-2, *Copper-based fittings for copper tubes – Part 2: Capillary solder fittings.*
- SANS 1283, *Modified poly(vinyl chloride) (PVC-M) pressure pipe and couplings for cold water services in underground mining.*
- SANS 1601, *Structured wall pipes and fittings of unplasticized poly(vinyl chloride) (PVC-U) for buried drainage and sewerage systems.*
- SANS 1835, *Ductile iron pipes, fittings, accessories and their joints, for use in high and low pressure systems for potable and foul water.*
- SANS 1936-1:2012, *Development of dolomite land – Part 1: General principles and requirements.*
- SANS 1936-2, *Development of dolomite land – Part 2: Geotechnical investigations and determinations.*
- SANS 1936-4, *Development of dolomite land – Part 4: Risk management.*
- SANS 2001-CC1, *Construction works – Part CC1: Concrete works (structural).*
- SANS 2001-DP1, *Construction works – Part DP1: Earthworks for buried pipelines and prefabricated culverts.*
- SANS 2001-DP2, *Construction works – Part DP2: Medium pressure pipelines.*
- SANS 2001-DP3, *Construction works – Part DP3: Cable ducts.*
- SANS 2001-DP4, *Construction works – Part DP4: Sewers.*

SANS 2001-DP5, *Construction works – Part DP5: Stormwater drainage.*

SANS 2001-DP6, *Construction works – Part DP6: Below-ground water installations.*

SANS 2001-DP8, *Construction works – Part DP8: Pipe jacking.*

SANS 4427-1/ISO 4427-1, *Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 1: General.*

SANS 4427-2/ISO 4427-2, *Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 2: Pipes.*

SANS 4427-3/ISO 4427-3, *Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 3: Fittings.*

SANS 4427-5/ISO 4427-5, *Plastics piping systems – Polyethylene (PE) pipes and fittings for water supply – Part 5: Fitness for purpose of the system.*

SANS 8773, *Plastics piping systems for non-pressure underground drainage and sewerage – Polypropylene (PP).*

SANS 10268-1, *Welding of thermoplastics – Welding processes – Part 1: Heated-tool welding.*

SANS 10400-B, *The application of the National Building Regulations – Part B: Structural design.*

SANS 10400-H, *The application of the National Building Regulations – Part H: Foundations.*

SANS 10400-P, *The application of the National Building Regulations – Part P: Drainage.*

SANS 10400-Q, *The application of the National Building Regulations – Part Q: Non-water-borne means of sanitary disposal.*

SANS 10400-R, *The application of the National Building Regulations – Part R: Stormwater disposal.*

SANS 15874-1/ISO 15874-1, *Plastics piping systems for hot and cold water installations – Polypropylene (PP) – Part 1: General.*

SANS 15874-2/ISO 15874-2, *Plastics piping systems for hot and cold water installations – Polypropylene (PP) – Part 2: Pipes.*

SANS 15874-3/ISO 15874-3, *Plastics piping systems for hot and cold water installations – Polypropylene (PP) – Part 3: Fittings.*

SANS 15874-5/ISO 15874-5, *Plastics piping systems for hot and cold water installations – Polypropylene (PP) – Part 5: Fitness for purpose of the system.*

SANS 50545/EN 545, *Ductile iron pipes, fittings, accessories and their joints for water pipelines – Requirements and test methods.*

3 Definitions

For the purposes of this document, the following definitions apply.

3.1

borrow pit

excavation made, typically in soils or weathered rock, for the procurement of construction material

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3.2

building

includes

- a) any structure, whether of a temporary or permanent nature, and irrespective of the materials used in the erection thereof, erected or used in connection with
 - 1) the accommodation or convenience of human beings and animals;
 - 2) the manufacture, processing, storage, display or sale of goods;
 - 3) the rendering of a service;
 - 4) the destruction or treatment of refuse or other waste materials; and
 - 5) the cultivation or growing of plants or crops;
- b) any wall, swimming bath, swimming pool, reservoir or bridge or any structure connected therewith;
- c) any fuel pump or tank used in connection therewith;
- d) any part of a building, including a building as defined in (a), (b) or (c); and
- e) any facilities or system, or portion thereof, within or outside but incidental to a building, for the provision of a water supply, drainage, sewerage, stormwater disposal, electricity supply or other similar service in respect of the building

3.3

bulk pipeline

conveyance pipeline that has a nominal diameter of 300 mm or more

3.4

competent person (geo-professional)

person who is qualified by virtue of his experience, qualifications, training and in-depth contextual knowledge of development on dolomite land to

- a) plan and conduct geotechnical site investigations for the development of dolomite land, evaluate factual data, develop a geological model, establish interpretative data and formulate an opinion relating to the outcomes of such investigations;
- b) develop and inspect for compliance the necessary precautionary measures required on dolomite land to enable safe and sustainable developments to take place; or
- c) develop dolomite risk management strategies; or
- d) investigate the cause of an event and participate in the development of the remedial measures required.

NOTE See also 3.19.

3.5

competent person (engineer)

person who is qualified by virtue of his experience, qualifications, training and in-depth contextual knowledge of development on dolomite land to interpret the necessary precautionary measures required on dolomite land into appropriate engineering design, construction and maintenance strategies to ensure that the development of dolomite land is in accordance with SANS 1936

3.6

conservancy tank

watertight (impervious to liquid), pre-manufactured or on-site constructed tank used for the reception and temporary retention of sewage or other liquids (or both), and which requires emptying at intervals

3.7

design working life

intended service life of a building, structure or infrastructure or parts thereof, during which all performance requirements are complied with

3.8

de-watering

artificial lowering of the groundwater level beyond natural fluctuations

3.9

dolomite area designation

classification of dolomite areas in terms of the extent of mitigation required to achieve and maintain a tolerable hazard

NOTE A description of the dolomite area designations is given in table 1 of SANS 1936-1:2012.

3.10

dolomite land

land underlain by dolomite or limestone residuum or bedrock (or both), within the Malmani Subgroup and Campbell Rand Subgroup, typically at depths of no more than

- a) 60 m in areas where no de-watering has taken place and the local authority has jurisdiction, is monitoring and has control over the groundwater levels in the areas under consideration; or
- b) 100 m in areas where de-watering has taken place or where the local authority has no jurisdiction or control over groundwater levels

NOTE For more information on dolomite land in South Africa, see annex B of SANS 1936-1:2012.

3.11

dry engineering service

conveyance system for non-liquid substances, for example air, data or electricity, and may comprise cabling, sleeves, ducts, manholes and facility chambers complete with their supporting and conveyance elements

NOTE Dry engineering services exclude masts, communication towers, pylons and substations.

3.12

dwelling house

single dwelling unit and any garage and other domestic outbuildings thereto, situated on its own property

3.13

dwelling unit

unit containing one or more habitable rooms and provided with sanitation and cooking facilities

3.14

engineer

practitioner of the relevant engineering discipline who is a registered professional engineer in terms of the relevant national legislation (see foreword)

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3.15

engineering service

facilities including stormwater drainage systems, water supply systems, sewer systems, other pipelines and ducts for electrical or data systems

NOTE 1 Engineering service refers only to the constructed facilities and does not include the professional services rendered by engineers.

NOTE 2 Engineering services include wet and dry engineering services.

3.16

evapo-transpirative bed

effluent disposal system that comprises a shallow cohesionless sand-filled excavation covered with topsoil and planted over with suitable vegetation

3.17

event

occurrence of a sinkhole or subsidence

3.18

french drain

trench filled with suitable material which is used for the disposal of liquid effluent from a septic tank or waste water

3.19

geo-professional

practitioner of geotechnical engineering or engineering geology who is registered in any category of registration provided for in the relevant national legislation (see foreword)

3.20

groundwater level

GWL

level below which the subsurface profile is saturated with water, expressed in metres below ground surface or metres above mean sea level (or both)

3.21

hazard

source of potential harm

NOTE Hazard can be a risk source, i.e. an element which alone or in combination has the intrinsic potential to give rise to risk.

3.22

infrastructure

roads, railway lines, runways, liquid-retaining structures, stormwater systems, power lines, pipelines and associated structures, including water, sewer, fuel and gas lines, reservoirs, swimming pools, attenuation and retention ponds for stormwater management, dams, reservoirs, artificial lakes or similar constructed works

3.23

inspection

general inspection by a competent person (engineer or geo-professional depending on the inspection intent) of a system or measure or installation during the erection, construction or installation of a building, structure, infrastructure, or part thereof, at such intervals as might be necessary in accordance with accepted professional practice to enable such competent person to be satisfied that the design assumptions are valid, the design is being correctly interpreted and that the work is being executed generally in accordance with the specifications and designs, appropriate

construction techniques are being used in accordance with best practice engineering standards, but excludes detailed supervision and day-to-day inspections

3.24

interconnected complex

complex of multiple dwelling units, such as terraced or multi-storey complexes, or cluster or retirement-village-type developments, where management of common property is usually exercised by (but is not limited to) a management body (organization)

3.25

likelihood

description of the probability or frequency of occurrence

3.26

local authority

any institution, council or statutory body

3.27

maintenance

combination of all technical and associated administrative actions during the service life of an item to retain it in a state in which it can perform its required function

3.28

major stormwater system

stormwater system that is designed to cater for severe, infrequent storm events

3.29

minor stormwater system

stormwater system that is designed to cater for frequent storms of a minor nature

3.30

monitor

to check, supervise, observe critically and record the progress of an activity, action or system on a regular basis in order to identify change

NOTE The purpose of such monitoring is to pro-actively introduce intervention, if required.

3.31

original groundwater level

OWL

mean groundwater level in the dolomite aquifer, expressed as a depth below natural ground level or elevation above sea level (or both), about which the seasonal natural fluctuation occurs

3.32

owner

local authority (where engineering services are located in servitudes and road reserves), or the owner by virtue of registered title deeds, or the management body (in the case of interconnected complexes), or the owner (in case of a parcel of land) that is responsible for the maintenance of an engineering service

3.33

palaeo-structure

ancient karst feature of variable dimensions in-filled by younger material, especially Quaternary Period (1,65 Ma to 0,01 Ma) deposits, typically red and of sandy composition, and which might be a manifestation of an ancient sinkhole (palaeo-sinkhole) or subsidence (palaeo-subsidence)

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3.34

parcel of land

tract of land, comprising one or more farm portions or properties registered in a deeds registry, and identified for the purpose of development

3.35

performance

behaviour related to use

3.36

performance parameter

expression of quantitative performance requirements applicable to an engineering service

NOTE Performance parameters provide qualitative design criteria and, as such, establish constraints which impact on the solution that is adopted to comply with the performance requirements.

3.37

potential loss of support

potential removal of support below the foundation due to a nominal sinkhole or subsidence event

3.38

quarry

any excavation, irrespective of size, where rock is removed for construction or other purposes

NOTE Excavations for construction materials in soils and weathered rocks are generally referred to as "borrow pits".

3.39

record drawing

"as-built" drawing of construction works that, amongst other things, records information indicating all deviations from the construction drawings, and that carries the name of the competent person (geo-professional or engineer, as appropriate), his signature, professional registration number, contact particulars and date of signature

3.40

reliability

ability of an engineering service to fulfil the specified requirements for which it has been designed

3.41

recharging

artificial raising of the groundwater level

3.42

return period

recurrence interval

estimate of the average interval of time between events of a certain size

3.43

risk

effect of uncertainty on objectives

NOTE Risk is often expressed in terms of a combination of the consequences of an event and the associated likelihood of occurrence.

3.44

risk management

logical and systematic, iterative process of establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating risk associated with any activity, function or process in a way that will enable losses to be minimized and opportunities to be maximized

3.45
servitude
either

- a) the right by which an entire property, or any portion thereof, owned by one person or entity is subject to a specified use or enjoyment by another person or entity, or
- b) the property or portion thereof to which the rights in (a) apply

3.46
sinkhole
feature that occurs suddenly and manifests itself as a hole in the ground

3.47
structure
organized combination of connected parts designed to provide some measure of rigidity, or construction works that have such an arrangement

3.48
subsidence
shallow, enclosed depression

NOTE Most South African literature previously used the term “doline” when referring to a subsidence as defined above. The use of the term “subsidence” is in line with international literature and practice.

3.49
suitable
capable of fulfilling or having fulfilled the intended function, or fit for its intended purpose

3.50
temporary building
building that is so declared by the owner and that is being used or is to be used for a specified purpose for a specified limited period of time, but does not include a builder’s shed

3.51
tolerable hazard
where the number of events experienced is less than 0,1 events per hectare per 20 years (preferably tending to 0 per hectare), i.e. a return period of an event occurring on 1 ha of more than 200 years

NOTE Mitigating measures might need to be implemented in order to achieve a tolerable hazard.

3.52
user requirements
statement of needs to be fulfilled by an engineering service

NOTE User requirements are considered to be part of the design objectives.

3.53
wet service
engineered or constructed system that conveys fluids or gases from a point of bulk storage to an end user, or from a point of collection to a point of discharge into a natural watercourse, retention pond or sewerage treatment works, and that comprises equipment, pipes or channels and all related system elements, as well as their supporting structures

NOTE Wet services include water pipe networks, water-borne sewer pipe networks, stormwater conduits and channels, fuel pipelines and gas pipelines, and any other liquid conveyance system.

4 Requirements and precautionary measures on dolomite areas designated as D2 or D3

4.1 General

The requirements of competent persons (engineer and geo-professional) and the general requirements for the precautionary measures applicable to various elements of the development of buildings, structures and infrastructure and related wet and dry engineering services on dolomite land are given in 4.2. These requirements are extended with the specific precautionary measures given in clauses 5 to 9.

4.2 Design and construction requirements

4.2.1 General

4.2.1.1 Design and construction requirements in this part of SANS 1936 are based on the premise that all services are installed, inspected, maintained and repaired in accordance with the requirements of this part of SANS 1936, and that risk management procedures shall be implemented in accordance with SANS 1936-4.

4.2.1.2 The design and the associated inspection during construction of buildings, structures and infrastructure on parcels of D2 or D3 dolomite area designated land shall

- a) be undertaken by one or more competent persons (engineer assisted by geo-professional for elements of the work related to geotechnical site conditions);
- b) take account of the content and recommendations of the geotechnical site investigation report prepared in accordance with the requirements of SANS 1936-2; and
- c) take account of the content and recommendations of the post-development risk management programme compiled in accordance with the requirements of SANS 1936-4.

4.2.1.3 Extensions, additions and upgrading or maintenance works to existing buildings, structures and infrastructure on developed sites shall be subject to the same precautions as required for new construction works. No extensions, additions or upgrading shall be undertaken unless the resulting development complies with the permissible land use set out in SANS 1936-1.

4.2.2 Design methodology

The design of buildings, structures, infrastructure and related wet and dry engineering services, shall be carried out by a competent person (engineer). The design shall comply with the relevant compulsory specifications (see foreword) and the relevant national legislation (see foreword).

4.2.3 Status of planning, design, construction or record drawings

Competent persons (geo-professional and engineer) shall legibly affix their name, signature, professional registration number, contact particulars and date of signature to all drawings, design details and reports. The competent person shall ensure that as-built information indicating deviations (permitted by the competent person) from the construction drawings, design details and reports are recorded within 60 d of the works being completed. Drawings shall be clearly marked to indicate their intended purpose, e.g. planning, design, construction or as-built drawings.

4.2.4 Drawings of buildings, structures and infrastructure

4.2.4.1 Competent persons (geo-professional or engineer, as appropriate) shall specify on the drawings all the relevant design aspects/parameters that shall be implemented in accordance with this part of SANS 1936.

4.2.4.2 Drawings of buildings, structures, infrastructure and related wet and dry engineering services shall clearly indicate all elements of water, fire, sewer and stormwater drainage installations, as well as all other liquid-bearing infrastructure and dry engineering services. The drawings shall also indicate construction and material specifications. Where roads are to be used as the primary stormwater drainage system, layout drawings shall indicate the level of the lowest drainage point on the site, as well as the road level adjacent to such point.

4.2.5 Designs not compliant with this part of SANS 1936

Should there be any deviations or omissions from the requirements of this part of SANS 1936, the competent person (geo-professional or engineer, as appropriate) shall indicate all such deviations of the drawings and shall prepare a supporting document signed by the competent person, clearly indicating the reasons for the non-compliance.

4.3 Location of infrastructure

4.3.1 Bulk pipelines shall be located at least the following distances from the nearest residential, institutional or commercial property boundary, excluding buildings associated with the pipeline:

- a) dolomite area designation D2: 15 m;
- b) dolomite area designation D3: 25 m.

Where this is not practically achievable, the bulk service shall be laid in a duct or culvert that will intercept any leakage in a manner that is readily observable or an appropriate rational solution shall be provided by a competent person (engineer).

4.3.2 Dams, reservoirs, liquid-retaining structures, stormwater retention or attenuation ponds and sewer-retaining ponds shall be located at least the following distances from the nearest residential, institutional, industrial or commercial building site boundary, excluding buildings associated with such liquid-retaining facility:

- a) dolomite area designation D2: 20 m in all instances;
- b) dolomite area designation D3: 20 m for commercial and industrial developments and 30 m in other instances.

NOTE The location of waste and sewer disposal facilities is governed by prevailing legislation.

4.4 Stormwater drainage

4.4.1 Stormwater drainage systems shall discharge into a natural watercourse unless the land upon which it is discharged is

- a) not dolomite land; or
- b) dolomite land categorized as dolomite area designation D1 in accordance with SANS 1936-1.

4.4.2 Stormwater drainage shall be such that no surface water ponds other than in a natural watercourse, or in an appropriately designed attenuation pond. The retention period of attenuation ponds on dolomite land other than land designated as D1 shall not exceed 6 h.

4.4.3 Stormwater retention and attenuation structures shall be rendered impervious.

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4.4.4 The means for the control and disposal of stormwater around buildings shall be in accordance with the requirements of SANS 10400-R. All stormwater shall be controlled and shall drain away from such buildings.

4.5 Sanitation systems

4.5.1 Sanitation systems on dolomite land other than land designated as D1 shall not incorporate evapo-transpirative beds, soakaways or french drains. Conservancy tanks linked to a low flush system that complies with the requirements of SANS 10400-P may be used where municipal water-borne sewerage connections are not available.

4.5.2 If no alternative is available, pit toilets in accordance with the requirements of SANS 10400-Q may be utilized on sites designated as D1 and D2, provided that the design and implementation is approved by the competent persons (engineer and geo-professional) as well the local authority. Such toilets shall be constructed to prevent stormwater gaining access to the pit and shall be placed as far away as possible from any permanent buildings and structures.

NOTE 1 Suitable means of preventing stormwater from gaining access to the pit include the construction of a 0,5 m high earth berm around the upslope section of the pit toilet or construction of the floor slab 500 mm proud of natural ground level.

NOTE 2 Annual reconstruction of pit toilets on new locations is advisable.

NOTE 3 Redundant pits shall be allowed to dry and then be backfilled and compacted with suitable material to a density less permeable than the surrounding natural material.

4.5.3 Pit toilets shall not be provided on sites designated as D3 dolomite land.

4.6 De-watering and groundwater recharging

4.6.1 Before abstracting groundwater on dolomite land, the person or entity undertaking such abstraction shall obtain a water use licence from the relevant national authority (see foreword) in accordance with the relevant national legislation (see foreword). The application for such licence shall clearly state that the ground from which the water is to be abstracted is dolomite land.

4.6.2 Where abstraction or recharging of ground water could result in changes of more than 6 m in the original groundwater level, the person or entity undertaking such abstraction or recharging shall notify the relevant national authorities (see foreword).

4.7 Landscaping and gardens

4.7.1 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.

4.7.2 No automated irrigation systems shall be installed within a distance of 5 m from any structure or building on sites designated as D3 dolomite land.

4.7.3 All trees or shrubs should preferably be situated more than 5 m from any water-bearing service.

4.7.4 Large grassed areas, such as sports fields, shall have a fall to facilitate a free-draining surface.

NOTE A slope of less than 1:80 results in poor drainage characteristics.

4.7.5 Irrigation systems shall be designed in accordance with the requirements for wet engineering services by a competent person (engineer). The design shall ensure that the irrigation intensity and frequency is such that surface ponding of water does not occur.

4.7.6 All portions of the development, including reworked or landscaped areas, shall be free draining.

4.8 Construction

4.8.1 General

4.8.1.1 Measures shall be taken during construction activities to ensure that

- a) land which is not to be developed is not disturbed by construction activities or the construction equipment employed to the extent that it is compromised for future developments;
- b) water does not pond anywhere on the site;
- c) existing wet engineering services are maintained and any damage to such services is promptly repaired;
- d) any services that are to be abandoned are dealt with in accordance with the requirements of 4.9;
- e) surface water runoff does not interfere with or pose a threat to adjacent properties; and
- f) all excavations are backfilled in such a manner that the backfill is less permeable than the surrounding natural ground.

4.8.1.2 All stationary construction plant and facilities (tower cranes, batch plants, storage facilities, wash bays and temporary buildings) shall be designed and constructed in accordance with the requirements of this part of SANS 1936. Wet and dry engineering services to such plant and facilities shall comply with the requirements of this part of SANS 1936.

The provision of construction-related support functions, facilities and activities, including the provision of temporary accommodation, shall not increase the likelihood of subsidence events occurring.

4.8.1.3 Proactive measures shall be taken to mitigate the risk of

- a) ingress of water and or other liquids (irrespective of source) into trenches and excavations; and
- b) damage to existing wet and dry engineering services during construction.

4.8.1.4 Areas that require surface repairs, such as road layer works or pavements, shall be repaired in such a manner as to minimize the ponding of water on partially repaired surfaces, preferably in a single operation.

4.8.2 Quarries and borrow pits

4.8.2.1 Quarries and borrow pits on dolomite land shall be approved in terms of the required local, provincial and national legislation and shall be established, managed and operated under the direction of the competent person (engineer or geo-professional).

4.8.2.2 Any quarry or borrow pit on dolomite land shall be free draining for the full period of operation and shall, on completion, be rehabilitated to the design and standards specified by a competent person (engineer or geo-professional).

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4.8.2.3 The as-built drawings shall indicate and describe the nature of any quarry or borrow pit, including the method used to rehabilitate such quarry or borrow pit.

4.8.2.4 Quarries and borrow pits shall not be permitted on land already zoned (or provisionally allocated) for a specific land usage that does not specifically provide for the establishment of such quarries and borrow pits in the usage definition/description or conditions.

4.8.3 Excavations for infrastructure

4.8.3.1 The competent person (geo-professional) shall issue written instructions that the person responsible for the construction of below-ground infrastructure shall notify the competent person in the event of

- a) a sudden change in the colour of the soils;
- b) exposure of cavities or of weak or porous soils; and
- c) excavation of palaeo-structures.

4.8.3.2 The findings of the excavation inspection by the competent person (geo-professional) shall be fully documented in a concise report that contains

- a) details of the area of inspection;
- b) layout plans of the area;
- c) description of inspection routes;
- d) description of inspection findings;
- e) photographs to enhance report details;
- f) description of soil profile (in general, per chainage length);
- g) descriptions of changes in soil colour, density or type; and
- h) descriptions of the presence and location of any cavities and palaeo-structures.

4.8.3.3 The length of time excavations are left open or unattended, and the accumulation of water in such excavations shall be kept to a minimum to reduce the likelihood of subsidence. The length of trenches or extent of excavations opened up at any stage shall be limited to achieve this requirement. Backfilling of trenches shall take place as soon as possible after the services have been laid.

4.8.3.4 Backfilled areas shall be inspected at time intervals as specified by the competent person (engineer or geo-professional) for any signs of subsidence. Any subsidence that is found shall be attended to as directed by the competent person.

NOTE Typically, such inspections should, as a minimum, be before, during, and at the end of a rainy season, or as otherwise determined by the competent person.

4.8.4 Blasting operations

4.8.4.1 Uncontrolled blasting could trigger the formation of sinkholes or subsidences. Blasting shall be such that the inter-shot delay between rows is not less than 25 ms and the peak particle velocity

(PPV) at any building or buried service is not greater than 25 mm/s at a frequency of not less than 10 Hz unless a higher limit is approved by the competent person (engineer).

NOTE The Geotechnical Division of the South African Institution of Civil Engineers' Code of practice: *Lateral Support in surface excavations* provides guidance on the calculation of the maximum charge mass per relay in relation to a distance from a service.

4.8.4.2 Detonating relays shall have at least a 20 ms delay interval.

4.9 Demolition of buildings and services

4.9.1 Buildings shall be demolished (or deconstructed) under the direction of a competent person (engineer), observing minimum site precautions to ensure that

- a) water does not pond on the site,
- b) all wet engineering services to the building are disconnected before demolition commences,
- c) the risk of wet engineering services rupturing or leaking is controlled,
- d) wet engineering services are terminated completely upon completion of the works.

4.9.2 Disused pipes and ducts, including all associated structures, such as manholes and valve boxes, shall be removed and the trenches suitably backfilled and compacted such that the permeability of the trench is less than that of the in-situ soil. Where removal is impractical, or as an alternative to such removal, disused pipes and ducts shall be fully grouted using a suitably designed pumpable/flowable soil cement mixture. The same applies to all associated service structures, such as valve boxes and manholes, if they are not removed entirely.

4.9.3 Pipe replacement techniques that employ methods of deconstructing the in-situ pipe or duct and replacing it along the same route with the new pipe shall only be used if other methods of construction are not practical. Where used, such techniques shall include measures to ensure that no voids are left around the new pipe or duct after completion of the replacement. Typically a cement grout or a sand cement grout shall be injected to fill all voids between the new pipeline and the surrounding material.

NOTE This type of construction is not preferred in the dolomite environment due to the potential for creating a mini-french drain and thus concentrated drainage areas around the pipe.

4.10 Pipe jacking and horizontal drilling

4.10.1 Pipe jacking shall be in accordance with SANS 2001-DP8. The competent person (geoprofessional or engineer, as appropriate) shall specify or approve the proposed methodology and precautionary measures.

4.10.2 Water-jetting techniques shall not be used.

4.10.3 The design shall incorporate provisions that ensure that no voids are left around the pipe or duct after completion. A suitably designed, cement grout or sand cement grout shall be injected to fill all voids between the new pipeline and the surrounding material.

NOTE These methods of construction are not preferred (see the note to 4.9.3).

5 Requirements for design and construction of municipal township services and services in interconnected complexes

5.1 General

5.1.1 The design and construction of municipal township services and services in interconnected complexes shall

- a) comply with the requirements of all applicable Acts and Regulations and specific requirements of the local authority;
- b) satisfy the design objectives and performance requirements specified in table 1;
- c) perform to the specified performance parameters, if any, given in 5.2; and
- d) comply with the requirements given in clauses 4, 6 and 7.

5.1.2 Water mains shall be placed only in road reserves.

5.1.3 Roads that have a gradient flatter than 1:80 shall be surfaced or sealed.

5.1.4 Where roads provide stormwater drainage in a township, all roads serving as major stormwater collectors shall be surfaced.

5.1.5 Unsurfaced roads shall be designed to limit the 1 in 20 year stormwater runoff velocities to less than 1,5 m/s.

NOTE Erosion of surface materials increase the likelihood of ingress water due to the removal of blanketing materials which can act as aquitards, and might result in the creation of water ponding areas.

Table 1 — Design objectives and performance requirements

1	2	3
Service	Design objective or user requirements	Performance requirements
Stormwater management systems	The risks associated with flood hazards (which might affect the health, welfare and safety of the public, damage property or the environment) shall not exceed a level nominated by the local authority.	<p>Stormwater shall be controlled, safely routed and discharged from townships without unduly eroding land, unsurfaced roads or watercourses, contaminating water resources or compromising environmentally sensitive areas identified in an environmental impact assessment report. The degree of reliability shall be commensurate with the recurrence interval of the storm event and within established parameters.</p> <p>Stormwater structures shall, with an appropriate degree of reliability, perform within established parameters in terms of</p> <ul style="list-style-type: none"> a) design hydraulic load; b) maintenance (ease of access for cleaning and monitoring and be designed to ensure self-cleansing velocities); and c) watertightness.
Roads	Roads shall accommodate the safe travel of vehicles and pedestrians, and provide a means of draining stormwater from properties in a manner acceptable to the local authority	<p>Roads shall, with an appropriate degree of reliability and within established parameters,</p> <ul style="list-style-type: none"> a) provide access to stands; b) accommodate traffic; and c) convey stormwater to the major stormwater system.
Sewer mains	The sewer mains shall convey sewage from the water-borne sanitation system to the bulk sewer infrastructure in a manner acceptable to the local authority.	<p>The sewer mains shall, with an appropriate degree of reliability and within established parameters,</p> <ul style="list-style-type: none"> a) withstand all the loads and pressures to which they are likely to be subjected; b) be capable of receiving sewage from the water-borne sanitation system, carrying the design hydraulic load, and discharging into the local authority's bulk sewer infrastructure; c) be watertight; d) prevent rainwater from entering the system; and e) be accessible to clean, monitor and maintain.
Water supply system	The water supply system shall convey safe drinking water to a point within each stand, be compatible with the sanitation system that is provided, and shall serve the fire-fighting needs of the community in a manner acceptable to the local authority.	<p>The water supply system shall, with an appropriate degree of reliability and within established parameters,</p> <ul style="list-style-type: none"> a) withstand all the loads and pressures to which it is likely to be subjected; b) be capable of supplying water to stands; c) be watertight; and d) be easy to operate and maintain. e) be designed to allow efficient leakage testing of bulk supply lines at all sections on the supply network, such as at large buildings or building complexes and groups of residential properties.

5.2 Performance parameters

5.2.1 Stormwater drainage

5.2.1.1 Major and minor stormwater systems shall be designed for design flood frequencies not less frequent than

- a) major stormwater system: 50 years; and
- b) minor stormwater system: 2 years.

NOTE 1 Current legislation requires that flood lines for townships be determined for a 100-year recurrence interval. Flows emanating from such floods are typically 25 % greater than those for the 50-year flood. Major stormwater systems should be designed for a 50-year flood, provided that the certified 100-year flood lines remain unchanged.

NOTE 2 Overtopping of stormwater systems, particularly at the most frequently encountered floods (1-year and 2-year recurrence interval) could expose development to the same risk as any other leaking wet engineering service, due to the ingress of water and thereby compromise the stability of the system itself.

5.2.1.2 The stormwater management in townships shall be such that runoff is controlled to the extent that upstream, adjacent and downstream sites or watercourses are not adversely affected when the township is fully developed.

5.2.1.3 Terraces created for dwelling houses and dwelling units shall be capable of being drained by gravity. Road surfaces shall be located sufficiently lower than the surrounding land, permitting drainage from the stands onto the roads unless alternative drainage measures are provided.

5.2.1.4 Stormwater runoff shall not be concentrated so as to cause erosion.

5.2.1.5 In high-density residential developments (sites smaller than 500 m²), stormwater shall not be directed across more than two properties before discharging into a servitude, road or access court (see figure 1).

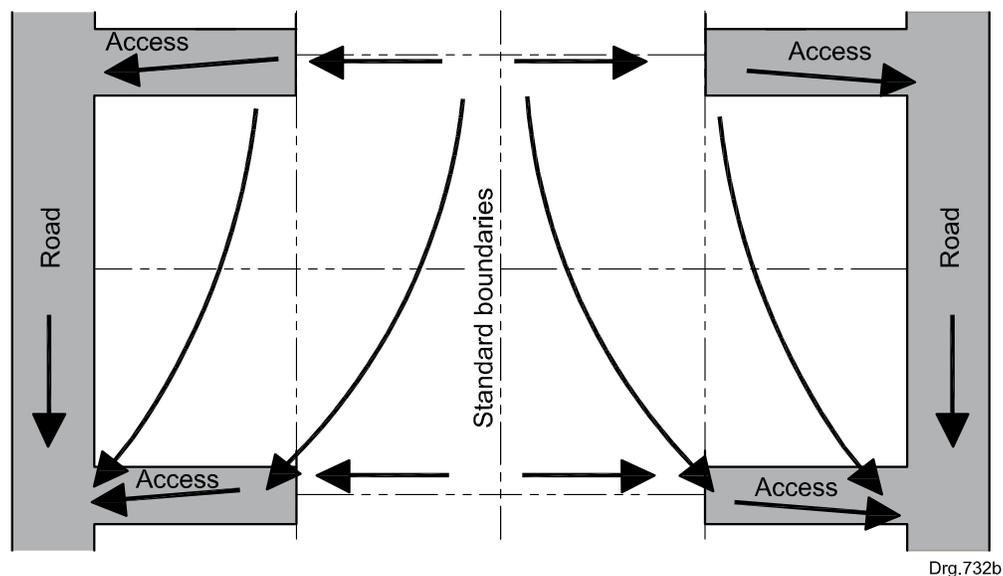


Figure 1 — Idealized flow directions for high-density housing developments

5.2.1.6 The maximum encroachment of runoff on roads during minor and major storms shall not exceed the provisions of table 2.

Table 2 — Maximum encroachment of stormwater runoff on roads

1	2	3
Storm type	Road classification	Maximum encroachment
Major	Local distributor or higher order road	The depth of water shall not exceed 150 mm to allow emergency vehicle access.
Minor	Residential and lower order roads	No kerb overtopping. Where no kerb exists, the encroachment shall not extend over property boundaries. Flow can spread to the crown of the road.
	Residential access collector	No kerb overtopping. Where no kerb exists, the encroachment shall not extend over property boundaries. Flow shall leave at least one traffic lane free of water.
	Local distributor	No kerb overtopping. Where no kerb exists, the encroachment shall not extend over property boundaries. Flow shall leave at least one traffic lane free of water in both directions.
	Higher order roads	No encroachment is allowed on any traffic lane.

5.2.1.7 The velocity of stormwater flow in the road edge channels associated with a minor storm shall not exceed

- a) 3 m/s in lined channels;
- b) 1,5 m/s in unlined channels comprising coarse non-colloidal gravel; and
- c) 1,1 m/s in unlined channels other than those comprising non-colloidal gravel.

5.2.1.8 Channels in dispersive soils shall be lined.

5.2.1.9 The slope of road edge channels shall not be flatter than 0,4 %.

5.2.1.10 The slope from the road crown should, on average, not be flatter than

- a) 2 % for surfaced roads; and
- b) 3 % for unsurfaced roads.

5.2.1.11 The diameter of stormwater pipes shall not be less than

- a) 300 mm in servitudes; and
- b) 400 mm in road reserves.

5.2.1.12 Stormwater structures shall be designed to have sufficient velocity to be self-cleansing and thus minimize maintenance. The minimum pipe gradients shall be in accordance with table 3.

Table 3 — Minimum stormwater pipe gradients

1	2	3
Pipe diameter mm	Minimum gradient m/m (1 in ...)	
	Desirable	Absolute
300	80	230
375	110	300
450	140	400
525	170	500
600	200	600
675	240	700
750	280	800
825	320	900
900	350	1 000
1 050	440	1 250
1 200	520	1 500

5.2.1.13 The distance between manholes shall be such that the owner/user/local authority responsible for monitoring and maintenance can effectively clean, and monitor the functioning of, the stormwater system.

5.2.2 Sewer mains and pump stations

5.2.2.1 The selection of materials for use in water-borne sanitation systems shall take cognizance of the local authority's or the complex's existing and future maintenance equipment and capacity, experience in maintaining specific pipe systems, and policy for keeping supplies of replacement pipes and components.

5.2.2.2 Manholes shall be located no further than 90 m apart. In interconnected complexes where no suitable cleaning equipment is available to deal with blockages between manholes at this spacing, access for cleaning purposes shall be provided at centres that do not exceed 25 m.

5.2.2.3 The nominal inside pipe diameter shall not be less than 100 mm.

5.2.2.4 All rodding eyes, junctions and bends, irrespective of the material used, shall be protected from mechanical damage caused by cleaning equipment by means of a suitably placed concrete encasement in accordance with SANS 2001-DP1.

5.2.2.5 Either a full-bore velocity of not less than 0,7 m/s shall be maintained or the minimum gradient established in table 4 shall be provided. The maximum pumping velocity in rising mains shall be 2,5 m/s.

Table 4 — Minimum gradients in sewer mains

1	2
Pipe diameter mm	Minimum gradient m/m (1 in ...)
100	120
150	200
200	300
225	350
250	400
300	500

5.2.2.6 The minimum emergency storage capacity in sumps for pump stations shall be equivalent to a 6 h flow at the average flow rate over and above the capacity available in the sump at normal top water level. Where this is impractical, an automatically activated back-up system shall be provided.

5.3 Water supply system

5.3.1 Separate meters shall be provided for each stand to which water is supplied. Water meters shall be easily accessible and any leakage shall be readily detectable.

5.3.2 The number of high and low points shall be kept to a minimum. Pipes should preferably be laid to gradients greater than

- a) 0,3 % for pipes that have an internal diameter equal to or less than 200 mm; and
- b) 0,2 % for pipes that have an internal diameter in excess of 200 mm.

5.3.3 A suitable means of scouring and venting pipes shall be provided at low and high points, respectively, on all bulk water pipelines.

5.3.4 Water supply systems to townships or interconnected complexes should be designed to allow for detection of leakages in sections that do not exceed flows of 2 000 m³ per month.

6 Requirements for wet and dry engineering services

6.1 General

6.1.1 Underground wet and dry engineering services shall

- a) be designed and constructed so as to minimize maintenance requirements and to circumvent any potential leakages into or from the services at joints or other potential leakage points;
- b) as far as possible, be designed to avoid possible disturbance of the underground environment, and where the underground environment is disturbed, the soil shall be compacted to a density not less than the surrounding soil and the backfilled excavations shall be shaped so as to avoid the ponding of water.

6.1.2 The backfilling to service trenches shall, except in rock, be less permeable than the surrounding material.

6.1.3 The number of joints in a pipeline shall be kept to a minimum by using the longest available lengths of pipes.

6.1.4 Wherever feasible, planning for the provisions of future connections to all wet engineering services should be made in order to minimize cutting into pipes at a later stage.

6.1.5 High concentrations of subsurface wet and dry engineering services near buildings shall be avoided. Where unavoidable

- a) an engineered soil mattress in accordance with the requirements of SANS 10400-H shall be provided along a 3 m wide corridor within which the services are laid to reduce the permeability of the subsurface and to improve founding conditions; or

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b) services shall be placed in watertight sleeves culverts with inspection chambers adjacent to the building and at distances as determined by the competent person (engineer) away from the building. Such sleeves shall slope away from buildings.

6.1.6 The fall (slope/gradient) of the bottom of trenches shall, as far as is practicable, be away from the buildings.

6.1.7 All access chambers, inlet structures, manholes, valve chambers, pump stations, etc. shall be watertight. Where necessary, such structures shall be fitted with a suitable sump pump or drainage pipe that discharges into a suitable discharge system.

6.1.8 Wet and dry engineering services shall be designed and constructed to be watertight (zero leakage) in accordance with the relevant requirements of SANS 2001-DP1, SANS 2001-DP2, SANS 2001-DP3, SANS 2001-DP4, SANS 2001-DP5, SANS 2001-DP6 and SANS 2001-DP8, in addition to any requirements specified in this part of SANS 1936.

6.1.9 The selection of pipes and fittings, as well as their associated attributes, shall take cognizance of factors such as

- a) resistance to internal and external environmental agents, including freezing, corrosion and, if relevant, ultraviolet radiation, over its design working life;
- b) ability to reliably withstand all direct and indirect actions (forces), including those relating to potential loss of support, to which the system is likely to be subjected over its design working life without losing functionality;
- c) ability to withstand differential movements and remain watertight;
- d) ability to withstand mechanical damage before and during installation and the implications of any such damage on the performance of the system once in use;
- e) design working life;
- f) long term reliability of jointing systems even if lateral/vertical movement takes place;
- g) workmanship quality assurance requirements and the availability of suitably skilled artisans to execute work in terms of the design specifications and install all components of a service in accordance with the manufacturer's and the competent person's (engineer) specifications;
- h) means by which quality and manufacturing consistency can be assured;
- i) vulnerability and resistance to damage during normal use and maintenance activities;
- j) method and ease of repair, maintenance and inspection procedures; and
- k) measures which might be required to extend the design working life, should this be necessary.

6.2 Wet engineering services

6.2.1 General

6.2.1.1 Wet engineering services, excluding stormwater systems, shall be capable of spanning the projected notional sinkhole diameter (2 m, 5 m or 15 m, as determined by the geo-professional), 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.

6.2.1.2 The pipe conveyance system (e.g. water supply, stormwater drainage and sewerage systems) shall incorporate measures to ensure watertightness (zero leakage) of the system and all other related components. Provision shall be made in all water-bearing services to accommodate differential movements that can reasonably be expected for the given soil conditions without causing the pipeline or joints to leak.

6.2.1.3 Pipes and associated fittings shall be selected on the basis of their design working life, resistance to damage, workmanship required to produce the required quality of installation and jointing, ease of repair, flexibility and any deterioration (e.g. corrosion) that will inhibit resistance to internal and external agents. The pipe fittings used in pipelines under pressure shall be of the self-anchoring type, i.e. not reliant on thrust blocks (i.e. mechanical anchoring) or friction for anchorage.

6.2.1.4 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).

6.2.1.5 The number of different wet engineering service types and connections to a building shall be minimized.

6.2.1.6 Pipes through walls at entry points to buildings shall be sleeved to permit the anticipated relative movement as prescribed by the competent person (geo-professional or engineer). The annulus shall be sealed with a suitable (including rodent-resistant) compressible material. The arrangement of service connections shall allow for movement of the building or surrounding soil without resulting in tension or compression forces that might impact on the performance of the service.

6.2.1.7 Wet engineering service systems may only be placed beneath the footprint of a building where such services are placed in a sealed sleeve, watertight duct or drainage channel which drains towards a point where any leakage of the wet engineering service can be readily detected. Sleeves shall comply with the requirements for sewer design in dolomite area designation D3 sites.

6.2.1.8 Wet engineering service pipes (medium pressure pipe types) shall be subjected to hydraulic pipeline testing after installation, as specified in SANS 2001-DP2 for the selected pipe type, irrespective of application.

6.2.2 Water supply

6.2.2.1 Water supply networks shall be fitted with water meters at suitable locations to allow for the auditing of water losses and the detection of leaks.

6.2.2.2 Underground valves, inline strainers, reflux valves, water meters or any other fitting other than pipe joints shall be placed in watertight chambers. All associated fittings, such as flange adaptors and reducers, shall be within the watertight chamber.

6.2.2.3 Valves and water meters shall be provided at all stand connections. For testing purposes, such connections shall be provided with either a pressure gauge or a connection point for such a gauge on the stand side of the valve. Such point shall be clearly marked and placed to ensure accessibility to maintenance crews without entering the premises.

6.2.2.4 Buried piping shall have a nominal working pressure rating (unless the design/working pressure exceeds the value below) at between 20 °C and 25 °C, of

a) municipal mains: 800 kPa;

b) connections to buildings: 1 200 kPa;

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c) irrigation systems that have a cover of 600 mm or less: 1 200 kPa; or

d) irrigation pipes that have a cover of more than 600 mm: 800 kPa.

6.2.2.5 Buried piping from the water mains reticulation to a building shall, as far as possible, be free of joints (other than butt-fusion joints) or other fittings between the water mains and the building. Essential fittings, including any water meters or testing points, shall be installed in watertight chambers. All connections between flexible and rigid pipes shall be provided with flexible, self-anchoring joints. Such connections shall be either within watertight structures or above ground level and not be restrained from movement under conditions of subsidence.

6.2.2.6 Joints between buried and above-ground piping shall be made not less than 100 mm above ground or paving level. A 500 mm x 500 mm concrete slab, not less than 75 mm thick, shall be cast around the exit point from the ground to protect the pipe if this area is not paved.

6.2.2.7 Buried water pipes shall have a minimum soil cover of 600 mm.

6.2.2.8 All external water taps mounted on a wall shall be installed above a gulley which is connected to the drainage system. Free-standing taps shall be provided with a 1,0 m square slab at least 75 mm thick with uniform falls to all sides, centred underneath the tap, and the surrounding area, shaped to prevent ponding of water in the vicinity of the tap.

6.2.2.9 Water pipe entry into buildings shall be designed to allow differential movement (see figure 2.)

6.2.2.10 The type, size and pressure rating of the pipe to be used shall be specified by the competent person (engineer). The preferred pipe types and other requirements for subsurface water reticulation systems are given in table 5.

6.2.2.11 Exposed above-ground pipe installations may be made using any of the following systems:

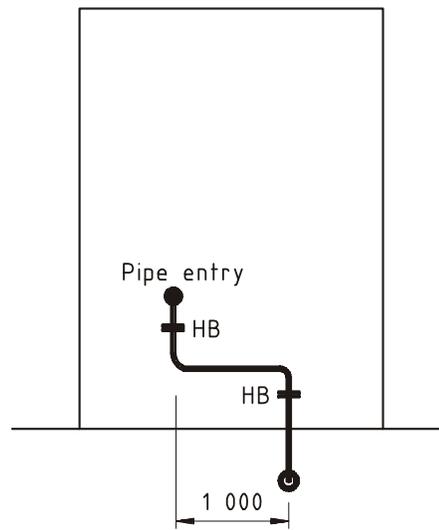
a) hot dipped galvanized steel pipes and fittings manufactured in accordance with the requirements of SANS 62-1, SANS 32 and SANS 121;

b) copper pipes and fittings that comply with SANS 460, SANS 1067-1 and SANS 1067-2;

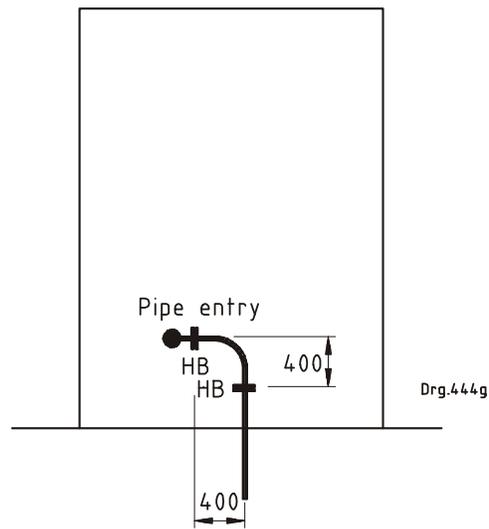
c) polypropylene pipes and fittings that comply with SANS 15874.

6.2.2.12 The overflow from any water storage tanks in a building, including the overflow from toilet cisterns and the discharge from any pressure regulators, shall be piped and discharged into a gulley that is connected to the drainage system.

Dimensions in millimetres



Rigid / semi flexible pipe



Flexible piping

HB = holder bat

Figure 2 — Water pipe entries to buildings

Table 5 — Preferred pipe types for use on sites designated as D2 or D3 dolomite land

1	2	3	4	5	6
Application	Pipe type and material classification	Minimum pressure rating or ring stiffness	Applicable standards	Pipe joint requirements	Additional requirements and comments
Water supply (see 6.2.2.10)					
Bulk supply: OD ≥ 300 mm	Steel pipes	In accordance with design requirements	SANS 719 or SANS 1835	Continuous butt, sleeve or socket welds. Mechanical jointing devices (including flanges) shall be used only in manholes. Screwed joints shall not be used.	Pipes shall be protected against corrosion by means of galvanizing or coatings and, where required, by cathodic protection.
	High density polyethylene (HDPE): PE 100	PN 8 ^{a, b}	SANS 4427	Butt welded, in accordance with SANS 10268-1. Mechanical jointing devices (including flanges) shall be used only in manholes.	Number of joints shall be kept to a minimum.
OD 75 mm to 300 mm	High density polyethylene (HDPE): PE 100	PN 12.5 ^{a, b}	SANS 4427	Butt welded, in accordance with SANS 10268-1. Mechanical jointing devices (including flanges and compression fittings) shall be used only in manholes.	Number of joints shall be kept to a minimum. 75 mm and 90 mm diameter pipes should preferably be supplied in 100 m rolls. 110 mm diameter pipes should be supplied in 50 m rolls.
	Modified poly(vinyl chloride) (PVC-M)	Class 12 ^{a, b}	SANS 966-2	Mechanical devices consisting of sealing rings or grooves (or both) and clamps. Use stainless steel only for metal fittings.	Pipes supplied in 6 m or 9 m lengths.
	Modified poly(vinyl chloride) (PVC-M)	Class 16 ^{a, b}	SANS 1283	Pressed on SG iron victaulic shoulders.	Pipes supplied in 6 m or 9 m lengths.
OD < 75 mm	High density polyethylene (HDPE): PE 100	PN 12.5 ^{a, b, c}	SANS 4427	Electro-fusion or butt-fusion ^d Mechanical jointing devices (including flanges and compression fittings) shall be used only in manholes.	Number of joints shall be kept to a minimum. Pipes supplied in 100 m rolls
^a The minimum pressure rating shall be as stated or in accordance with design requirements, whichever is higher. The design of the pipe shall make allowance for the design pressure and potential loss of support as required in 6.2.1.1. ^b On sites designated as D3 dolomite land, the nominal pressure rating shall be one pipe designation or class higher than that which complies with the above requirement (see 6.4(d)). ^c On residential land, the pressure rating shall not be lower than PN 16 as the applicable pipe sizes are prone to damage by gardening activities. ^d Small diameter HDPE pipes preferably jointed by electro-fusion instead of butt-fusion.					

Table 5 (concluded)

1	2	3	4	5	6
Application	Pipe type and material classification	Minimum pressure rating or ring stiffness	Applicable standards	Pipe joint requirements	Additional requirements and comments
Sewers (see 6.2.3.5)					
All diameters	High density polyethylene (HDPE): PE 100	PN 10 SDR 17 ^{a, b}	SANS 4427	Butt-fusion, electro-fusion or hot gas extrusion welds, in accordance with SANS 10268-1.	Pipes shall be supplied in minimum lengths of 12 m.
	Polypropylene (PP): PPH 100	PN 10 SDR 17 ^{a, b}	SANS 8773	Butt-fusion, flanges or electro-welded sockets, in accordance with SANS 10268-1 ^e .	Pipes shall be supplied in minimum lengths of 12 m.
	Unplasticized poly(vinyl chloride) (PVC-U)	Class 34 ^{a, b}	SANS 791	Mechanical devices consisting of sealing rings or grooves (or both) and clamps. Use stainless steel only for metal fittings.	Pipes supplied in 6 m or 9 m lengths.
Stormwater drainage (see 6.2.4.11)					
Minimum diameter 300 mm	Solid wall high density polyethylene (HDPE): PE 100	PN 10 SDR 17	SANS 4427	Butt-fusion or electro-fusion fittings or hot gas extrusion welding, in accordance with SANS 10268-1.	Pipes shall be supplied in minimum lengths of 12 m.
	Structured wall high density polyethylene (HDPE): PE 100	Class 8 kN/m ²	SANS 4427	Butt-fusion or electro-fusion fittings or hot gas extrusion welding, in accordance with SANS 10268-1.	Pipes shall be supplied in minimum lengths of 12 m.
	Polypropylene (PP): PPH 100	PN 10 SDR 17	SANS 8773	Butt-fusion, flanges or electro-welded sockets, in accordance with SANS 10268-1.	Pipes shall be supplied in minimum lengths of 12 m.
	Unplasticized poly(vinyl chloride) (PVC-U)	Class 34	SANS 791	Mechanical devices consisting of sealing rings or grooves (or both) and clamps. Use stainless steel only for metal fittings. Rubber joints that comply with SANS 9661 or SANS 9662.	Pipes supplied in 6 m lengths.
	Concrete	Non-pressure Type SC	SANS 677	Spigot and socket with rolling rubber rings or spigot and socket with sliding rubber joints.	Bedding conditions shall ensure that the deflection tolerances are not exceeded as a result of consolidation settlement.
^a The minimum pressure rating shall be as stated or in accordance with design requirements, whichever is higher. The design of the pipe shall make allowance for the design pressure and potential loss of support as required in 6.2.1.1. ^b On sites designated as D3 dolomite land, the nominal pressure rating shall be one pipe designation or class higher than that which complies with the above requirement (see 6.4(d)). ^c On residential land, the pressure rating shall not be lower than PN 16 as the applicable pipe sizes are prone to damage by gardening activities. ^d Small diameter HDPE pipes shall preferably be jointed by electro-fusion instead of butt-fusion. ^e Welding of polypropylene pipes can be problematic. Careful inspection and testing shall be undertaken to confirm integrity of welds.					

6.2.3 Sewers and gravity drainage systems

6.2.3.1 All manholes shall be watertight and shall be tested for watertightness (zero leakage) during construction.

6.2.3.2 Sewers and gravity drainage systems, inclusive of pipes, sleeves or conduits shall be subjected to hydraulic pipeline testing, after installation, in accordance with SANS 2001-DP2 for the selected pipe type, irrespective of application.

6.2.3.3 Connections from multiple adjoining toilets or washbasins shall be made above ground and shall feed into a single downpipe draining into the subsurface system.

6.2.3.4 Toilet pans shall be provided with an external flexible connection at the junction point to the subsurface sewer system.

6.2.3.5 The type, size and pressure rating of the pipe to be used shall be specified by the competent person (geo-professional or engineer). The preferred pipe types and other requirements for subsurface sewers and gravity drainage systems are given in table 5.

6.2.4 Stormwater drainage

6.2.4.1 Channels and canals which are constructed to reroute water from natural drainage paths shall be lined. Any joints in such channels shall be suitably sealed to be watertight.

6.2.4.2 Unlined stormwater cut-off or diversion trenches shall be avoided as far as possible.

6.2.4.3 All concentrated stormwater entering any parcel of land shall be diverted away from any building and structures by means of concrete-lined channels. Where necessary, earth berms and contouring shall be used to enhance site drainage.

6.2.4.4 Stormwater drainage systems shall incorporate measures to ensure watertightness (zero leakage) of conveyance systems, culverts and other compartments, including the sealing of all joints, and shall be designed to minimize the effects of settlement. All manholes, junction boxes and conveyance systems shall be tested for watertightness during construction. Reinforced concrete manholes shall be designed as liquid-retaining structures.

6.2.4.5 Stormwater drainage conveyance systems shall be designed to gradients which are self-cleansing. Such systems shall have an internal diameter equal to or greater than 300 mm.

6.2.4.6 For drainage purposes, surfaced roadways and parking areas should be constructed at a level below the surrounding buildings, developed or landscaped areas and gardens.

6.2.4.7 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.

6.2.4.8 Small diameter stormwater drainage pipes shall not be placed parallel to buildings unless they are at least 5 m (if stand size allows) from the structure. If this is not practical, a rational design shall be performed by a competent person (engineer).

6.2.4.9 Buildings and structures without gutters shall be provided with impervious paving not less than 1,5 m wide with a minimum slope of 1:20 all around. Joints between such paving and the building or structure, as well as any joints to control shrinkage/expansion, shall be suitably sealed. The ground surface shall be shaped to fall away from the building at a minimum slope of 1:20 for a further 1 m from the edge of the slab and shall thereafter fall continuously towards the closest drainage point.

6.2.4.10 Water shall not be permitted to accumulate against boundary walls. Suitable drainage ports shall be incorporated in boundary walls, particularly at the lowest point of the site, to permit the passage of surface runoff water. Such ports shall be provided (on both the inlet and outlet sides of the wall or fence) with a concrete slab 1,0 m wide, 100 mm thick, and extending 400 mm beyond the edges of the drainage port along the fence. The concrete slab shall have a minimum fall of 1:15 to ensure self-cleaning drainage characteristics. Any security outlet grids that are provided shall not impede the flow of water through the port.

6.2.4.11 The type, size and pressure rating of the pipe to be used shall be specified by the competent person (engineer). The preferred pipe types and other requirements for subsurface stormwater drainage systems are given in table 5.

6.3 Dry engineering services

6.3.1 Buried dry engineering services or dry engineering service sleeves shall, in all respects, comply with the requirements of the installation of a sewer system.

6.3.2 Sleeve and draw box systems for electrical and communication cables shall be watertight, flexible and comply with the requirements of a sewer system in accordance with this part of SANS 1936. No water shall enter or drain from the dry service system.

6.3.3 Dry engineering services pipes, sleeves or conduits (medium pressure pipe types) shall be subjected to hydraulic pipeline testing, after installation, in accordance with SANS 2001-DP2 for the selected pipe type, irrespective of application.

6.3.4 Cable ducts shall be constructed from the same materials specified for sewer systems, i.e. in accordance with SANS 2001-DP2 and table 5.

NOTE Requirements for excavation and backfilling of dry engineering service trenches are described in 4.8.3 and 6.1.2.

6.4 Additional precautionary measures in dolomite area designation D3 sites

Wet engineering services in dolomite area designation D3 sites shall comply with the following requirements, in addition to those established in 6.1 and 6.2:

- a) 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 parts 1, 2, 3 and 5 of SANS 4427, with a material designation of PE 100 and that are supplied in straight lengths of 12 m, or rolls of 50 m or 100 m with joints made by means of butt-fusion or electrofusion fittings.
- b) Structured wall polyethylene (PE) pipes or steel-reinforced spirally wound PE drainage and sewer pipes shall be made from PE 100 material in accordance with SANS 4427-1. Steel-reinforced spirally wound PE pipes shall comply with SANS 674. Specified ring stiffness shall be tested in accordance with ISO 9969.
- c) Manholes and inspection chambers should preferably be manufactured from structured or solid wall polyethylene (PE) or steel reinforced spirally wound pipes that comply with the requirements of SANS 4427-1 or SANS 674, as appropriate, with a material designation of PE 100 (or higher), with inlets and outlets that can be joined to compatible pipe systems by means of butt-fusion or electro-fusion fittings.
- d) The nominal pressure rating of plastic pipes shall be one pipe designation or class higher than that which complies with the design requirements for a dolomite area designation D2 site.

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- e) Wet and dry engineering services pipes (medium pressure pipe types) shall be subjected to hydraulic pipeline testing, after installation, in accordance with SANS 2001-DP2 for the selected pipe type, irrespective of application. The test pressure applied over any section of pipeline, taking any differences in elevation along the pipeline into account, shall be such that the pressure at any point along the section is not less than $1,25 \times$ the designated working pressure or 0,4 MPa, whichever is the greater, and not more than $1,5 \times$ the designated working pressure at these points. The field test pressure shall not exceed the appropriate values given in table 6.

NOTE Increasing the nominal pressure rating increases the safety factor and the design life of the pipe and reduces the risk of rupture due to localized stresses or damage.

- f) Wet engineering services shall not be placed beneath the footprint of a building or structure.
- g) 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.
- h) Water supply for domestic use and fire-fighting inside the building can be combined, provided that there is a distinct, and clearly marked split above ground (mounted on the outside of building) of the two systems. The point of split shall include a shut-off valve for the domestic supply, but no shut-off valve on the fire-fighting supply side.
- i) Within 15 m of any building other than a dwelling house, the water supply and other pressurized liquid-bearing service connections shall be placed
- 1) in a flexible, watertight sleeve if underground;
 - 2) above ground; or
 - 3) in watertight (zero leakage) open ducts.
- j) Distribution of water within a building or structure should preferably make use of above-ground piping mounted on walls, in the roof or in above-floor-level service shafts. Service shafts shall be watertight (zero leakage) at ground floor level, have drainage ports that drain visibly into the stormwater system, and shall be supplied with easy access inspection hatches.
- k) Sewers and drains shall comply with the following minimum requirements:
- 1) within 15 m of the footprint of a building, buried pipelines shall not be provided with joints other than specified butt welded joints; and
 - 2) suitable prefabricated small diameter ($< 1,0$ m) watertight manholes shall be used in place of rodding and cleaning eyes;
- l) Stormwater drainage systems shall comply with the following requirements:
- NOTE The use of the word "should" in this subclause indicates best practice to be applied where practical.
- 1) roadways with a gradient flatter than 1:80 should be surfaced or be sealed;
 - 2) no piped stormwater systems should be permitted within 15 m of a building or structure, other than those serving the building or structure in question;
 - 3) natural ponds and watercourses located within 10 m of any structure and within 30 m of a building should either be rendered impervious or diverted so that their location is not within these distances of the structure or building;

- 4) lined surface canals should be located at least 15 m from buildings;
 - 5) open culverts with grated covering material should be used to traverse any trafficked area within 15 m of buildings or structures;
 - 6) all stormwater from downpipes and gutters from buildings and structures shall discharge into impervious lined channels which, in turn, should discharge the water at least 15 m away from such buildings and structures onto areas that permit free surface drainage;
 - 7) pipelines shall be pressure-tested during construction using the pressure test procedures prescribed in SANS 2001-DP2;
 - 8) manholes shall be tested for watertightness (zero leakage) using the test procedure in SANS 2001-CC1;
 - 9) impervious paved areas or apron slabs shall be provided within 3 m (or greater if deemed appropriate by the competent person (engineer)) of structures and buildings, runoff from which shall drain into lined stormwater channels feeding into the a designed stormwater system or shall be spread as sheet flow away from the buildings or structures; and
 - 10) all areas shall be graded to slopes that permit free drainage of water away from structures and buildings.
- m) The area immediately below above-ground installed wet engineering services shall be free draining to ensure drainage away from buildings and structures in the event of a burst or leaking pipe.
 - n) All sleeves or ducts shall be laid to grades that will facilitate drainage away from buildings and structures into designated watertight inspection chambers.
 - o) Engineered masonry and concrete manholes shall be designed as water-retaining structures and tested for watertightness (zero leakage) using the test procedure in SANS 2001-CC1;
 - p) Gas pipelines within 15 m of buildings shall be provided with welded joints.
 - q) Fuel reticulations shall, as far as is practicable, be above ground.

Table 6 — Maximum field test pressures

1	2	3
Type of pipe	Applicable materials standard	Maximum field pressure at any point in the pipeline
Steel	SANS 62-1, SANS 62-2, SANS 719, SANS 815-1 or SANS 815-2	50 % of the hydraulic test pressure
Ductile iron	SANS 50545	Allowable site test pressure (PEA)
Reinforced concrete	SANS 676	75 % of the hydraulic test pressure
Prestressed concrete	SANS 975	75 % of the hydraulic test pressure
Polyethylene	SANS 4427-2 and SANS 4427-3	100 % of the hydrostatic pressure
Steel mesh reinforced polyethylene	SANS 370	1,6 times the nominal pressure
Polypropylene	SANS 15874-2 and SANS 15874-3	75 % of the hydrostatic pressure
PVC-U	SANS 966-1	75 % of the hydrostatic pressure
PVC-M	SANS 966-2 or SANS 1283	75 % of the hydrostatic pressure

7 Requirements for design and construction of infrastructure

7.1 General

The design and construction of infrastructure on dolomite area designation D3 sites shall, to the extent reasonably practicable, ensure that, in the event of a sinkhole or subsidence with the notional diameter indicated in the geotechnical report occurring,

- a) the safety or environmental hazard from the time of the occurrence of such an event to the time that the surrounding area can be secured and made safe is minimized; and
- b) the risk of rupture of or leakage from wet services is minimized.

NOTE 1 Consideration should be given to supporting infrastructure or elements thereof on foundations or piles if the infrastructure is not inherently able to span the sinkhole or subsidence.

NOTE 2 Suitably designed ground improvement techniques may be considered, including

- a) excavation and compaction of areas below services or pavement layer work to improve soil stability; or
- b) the creation of structural arching by means of soil mattresses; or
- c) improving subsurface conditions by means of dynamic compaction or subsurface grouting.

NOTE 3 Consideration may be given to the use of geosynthetic reinforcement to retard the propagation of localized subterranean voids to surface thereby increasing the likelihood that the event will be detected before it develops into a sinkhole.

7.2 Aircraft runways

7.2.1 General

7.2.1.1 The concentrated ingress of water on the verges of surfaced runways shall be avoided by suitably reducing the permeability of the gravel shoulder for at least 10 m beyond the edge of the surfaced area.

7.2.1.2 Wet and dry engineering services under runways shall be placed in a watertight sleeve or ducts extending 50 m beyond the edges of the runway. Such sleeves and ducts shall drain away from the runway to specific points or manholes (which may, if necessary, incorporate drainage pumps) that are linked to a suitable stormwater system.

7.2.2 Additional precautionary measures for runways on dolomite area designation D3 sites

7.2.2.1 The subgrade (all earthworks below the sub-base, base and surfacing) of runways and taxiways and associated hardstands for the purpose of aviation and related traffic shall be excavated and replaced with engineered backfill to improve soil stability or to create structural arching by means of soil mattresses. Alternatively, subsurface conditions could be improved by means of dynamic compaction or grouting.

7.2.2.2 No wet engineering services shall be placed under or within a distance of 50 m from the edge of aircraft trafficking areas, unless continuously watertight sleeved or provided for in an enclosed watertight (zero leakage) culvert, which daylight at the distance noted.

7.2.2.3 The gravel shoulder of the runways on dolomite area designation D3 sites shall slope away from the runway, for a distance of at least 5 m at a gradient steeper than the runway cross-fall, and shall be sealed with a suitable bituminous sealant to prevent ingress of stormwater.

8 Requirements for design and construction of buildings and structures on dolomite area designation D2 and D3 sites

8.1 General

8.1.1 All buildings and structures shall be designed and constructed in accordance with

- a) SANS 10400-B and SANS 10400-H, to the extent that these standards are applicable;
- b) relevant national or international standards; or
- c) relevant codes of practice.

8.1.2 The earthworks immediately against buildings shall be shaped to fall in excess of 3 % over the first 3 m beyond the perimeter of buildings or structures, from where it should drain freely away. Apron slabs, where provided, should have the same fall.

8.1.3 Courtyards that require sub-floor level drainage systems should be avoided. All courtyards or spaces less than 4 m between buildings and structures shall be paved and appropriately drained.

8.2 Additional precautionary measures for design and construction of buildings and structures on dolomite area designation D3 sites

8.2.1 Buildings on dolomite area designation D3 sites in which people congregate, work or sleep shall be designed and constructed in such a manner that

- a) a sinkhole or subsidence that has a high likelihood of occurring and that has the notional diameter of surface manifestation indicated in the geotechnical report within or adjacent to the footprint of such building, shall not result in the toppling or sliding failure of the building or a portion thereof into such a sinkhole or subsidence; and
- b) there is sufficient period of structural stability to allow occupants to escape from such buildings after the occurrence of a sinkhole or subsidence within or adjacent to the footprint of the building;

NOTE 1 SANS 10400-H establishes requirements for the design of foundations for single-storey and double-storey domestic residences and dwelling houses.

NOTE 2 An engineered soil mattress (appropriately selected and graded material compacted to specified standards) should be used in areas of shallow dolomite bedrock due to the highly susceptible nature of the subsurface profile to erosion. This mattress has the dual purpose of improving founding conditions (negating differential movement) and reducing the permeability of the subsurface profile. The construction of the mattress involves the removal and replacement of unsuitable soil beneath and for 3 m beyond the periphery of buildings. The precise specification for the soil mattress as designed by the competent person(s) (geo-professional or engineer) will be dependent on bedrock depth and the nature of the local soil materials (see also SANS 10400-H).

8.2.2 The design of all buildings and structures shall be such that the occurrence of a sinkhole or subsidence with a high likelihood of occurring and that has the notional diameter of a sinkhole and the maximum diameter indicated in the geotechnical report within or adjacent to the footprint of such structure, does not present a safety or environmental hazard from the time of the occurrence of such an event to the time that the surrounding area can be secured and made safe.

8.2.3 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

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located below the drip line or the periphery of the building or structure that is subject to draining rainwater.

8.2.4 Stormwater upstream of buildings and structures shall be diverted away from the building or structure in such a manner that concentration of stormwater is minimized or the water is led into a designed stormwater drainage system.

8.2.5 Stormwater shall be controlled and disposed of using suitable means (e.g. by means of contouring and shaping) within 50 m of any element of any bridge or viaduct. All concentrated stormwater should be controlled and disposed of in suitable open stormwater channels.

8.2.6 No wet engineering service shall be constructed underground within 40 m of the foundation piers of any bridge or viaduct unless installed in welded polyethylene or polypropylene sleeves that allow for detection of leakage.

8.2.7 No liquid-retaining structures (excluding elevated storage facilities) shall be constructed within 40 m of the foundation piers of any bridge or viaduct.

8.2.8 Piles, where provided, shall be

- a) proof-drilled for a minimum of 6 m of solid rock in order to confirm that the piles are socketed into pinnacles or bedrock, as opposed to floaters, and
- b) capable of providing the necessary support despite the frictional drag and loss of lateral support within a sinkhole of the notional diameter given in the geotechnical report.

9 Requirements for swimming pools and liquid-retaining structures

9.1 General

9.1.1 Domestic swimming pools and 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.

9.1.2 Public swimming pools and other liquid-retaining structures shall be watertight (zero leakage) and should not be placed closer than 30 m from a building. The design of such structures shall be such that the joints

- a) can readily be inspected for leakage;
- b) remain watertight with a high degree of reliability; and
- c) are able to accommodate all likely differential movements between the wall and floor panels without the joints losing their watertightness.

9.1.3 Backwash and other water from swimming pools shall discharge into drainage systems in a manner acceptable to the local authority.

9.1.4 No subsurface drainage, other than for leakage detection or prevention of floatation, shall be installed beneath swimming pools or liquid-retaining structures. If installed for leakage detection purposes, the liquid shall be capable of draining freely and without the need for pumping from the collector, which shall have a watertight floor installed.

9.1.5 Public swimming pools and liquid-retaining structures, shall be surrounded by a sloped, impervious paving, the width of which shall be specified by the competent person (engineer). All waste or drainpipes should release water in the stormwater system or, alternatively, 30 m from the structure on the topographical down slope.

9.1.6 Earthworks around the perimeter of public swimming pools and liquid-retaining structures shall be sloped and compacted to a slope not flatter than 1:30 for a distance of not less than 15 m from the outer perimeter of such structures.

NOTE For the purposes of this subclause, the perimeter of a swimming pool includes any surfaced area which returns water to the pool.

9.2 Additional precautionary measures on dolomite area designation D3 sites

9.2.1 Swimming pools and liquid-retaining structures shall be designed so that any leakage that might occur during their lifetime can readily be detected or remedied.

9.2.2 Other liquid-retaining structures, including public swimming pools, shall not be placed within 50 m of residential buildings and 30 m of non-residential structures.

NOTE An impervious lining might be necessary to prevent leakage in attenuation and retention ponds for stormwater management, artificial lakes, slimes dams and waste disposal facilities.

10 Requirements and precautionary measures on dolomite area designation D4 sites

10.1 Development on dolomite area designation D4 sites requires site-specific precautions additional to those contained in this part of SANS 1936. These precautions shall be determined and reviewed by the competent persons (geo-professional and engineer) as laid down in SANS 1936-1 for the development of such land.

10.2 The design of the foundations, structure and associated infrastructure, including the precautionary measures and dolomite risk management plan, shall specifically address and effectively mitigate the dolomite risks present on the site.

10.3 Unless the risks posed by the development of D4 dolomite land are effectively mitigated by alternative means, the precautionary measures adopted shall comply with or exceed the relevant requirements of this part of SANS 1936 for developments of D3 dolomite land.

10.4 Extensions, additions and upgrading or maintenance works to existing buildings, structures and infrastructure on developed sites which are dolomite area designation D4 sites in terms of SANS 1936-1 and SANS 1936-2, shall be subject to the same precautions as required for new construction works.

Bibliography

Savage, P.F., South African Institution of Civil Engineers Geotechnical Division. *Lateral Support in surface excavations*. Code of practice edition 2 1989.