DOLOMITE STABILITY REPORT FOR THE CONSTRUCTION OF A STORMWATER ATTENUATION DAM FOR THE TOWNSHIP FULCRUM EXTENSION 10, SITUATED ON THE REMAINDER OF THE FARM RIETFONTEIN 128-IR, EKURHULENI METROPOLITAN MUNICIPALITY, GAUTENG

PREPARED FOR:

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REPORT NR. 2014/01 ***DATE: FEBRUARY 2014***

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1. BACKGROUND

According to the SANS 1936-1-4 documents a number of standards must be adhered to when constructing an attenuation dam on dolomitic ground. The area on which the attenuation dam for Fulcrum Extension 10 is to be constructed is situated on dolomitic ground as boreholes around the site show that even though the area is underlain by Karoo Supergroup sediments, the contact with dolomite is often present within 60 m from surface. Some of the holes show the dolomite contact to be deeper than 60 m.

J P Venter Consulting Services (JPV) was instructed by Dijalo Property Services (Pty) Ltd. to compile a dolomitic stability report for the attenuation dam.

2. PURPOSE OF THE INVESTIGATION

The purpose of the investigation was to determine the dolomite stability of the area underlying the attenuation dam and to make recommendations regarding the precautionary measures that should be applied.

3. METHOD OF INVESTIGATION

As a number of boreholes have already been drilled in the area surrounding the dam, the results from these boreholes were used to determine the dolomite stability of the area. This information has also been used in the adjacent proposed Fulcrum Extension 10 investigation and a large volume of the information is therefore repeated, in this report instead of constantly referring to the proposed Fulcrum X10 report. It would have been much more efficient to include the attenuation dam report in the Fulcrum X10 township report.

4. SITE LOCATION, DESCRIPTION AND TOPOGRAPHY

The location of the site is shown on Figures 1, 2 and 3. The purpose of the dam is to attenuate the stormwater flow from the proposed township of Fulcrum X10 which is situated to the east and to the south of the dam (Figures 3 and 4). The attenuation dam is situated against the southeastern boundary of Areas B and A as shown on Figures 2, 3 and 4. An old backfilled clay quarry is situated on Area B while a properly designed and backfilled waste disposal site (also situated on another old quarry) is situated on Area A. A large rock dump from gold mining is present on the southeastern boundary of Areas A and B (Figures 2 and 3). The eastern part of the attenuation dam footprint is situated on the rock dump and the rock will therefore have to be removed. The other part of the dam is situated on disturbed ground to the west of the rock dump. The topsoil and sand in the area to the south and east of the dam have been excavated to a shallow depth and water from the surrounding areas therefore drains to this area as is shown by the elevation contours on Figure 3. The outlet of the attenuation dam should be constructed in such a way that the water can follow a natural course across undisturbed ground across the natural fall of the larger area to the northeast towards the Klein Blesbok Spruit.

Even though the underlying dolomite is protected by thick deposits of Karoo Supergroup rocks, ponding and infiltration of water in dolomitic areas cannot be allowed and the township and surrounding areas must be drained properly.

5. GEOLOGY

The geology of the area is shown on the 1:250000 map (Figure 5) and in more detail on the 1:50000 map (Figure 6). The site is underlain by sedimentary rocks (mainly mudstone and shale) of the Vryheid Formation of the Ecca Group, Karoo Supergroup and these are mined at present in Area E for brickmaking purposes. The Vryheid Formation is underlain by the glacial deposits of the Dwyka Group. The Dwyka Group is the lowermost formation of the Karoo Supergroup and was deposited on an uneven topography of the dolomite of the Chuniespoort Group, Transvaal Supergroup. The surface was probably an unweathered and unevenly scoured glaciated rock surface. The following is an extract from a report by Meyer (CSIR, 1997) "*Through exploration boreholes in search of the presence of the gold deposits associated with the Central and West Rand Groups of the Witwatersrand Supergroup, extensive deep drilling has occurred in the area around the Rietfontein*

Site. These boreholes indicated that to the northwest of the site (Portion 81) the Karoo sedimentary succession is directly underlain by conglomerate reefs of the Witwatersrand Supergroup. Closer to Portion 81 the Karoo rocks are underlain by >100 m of dolomite which increases in thickness towards the east. The dolomite is underlain by the Black Reef Formation which in turn is followed by the quartzites of the Witwatersrand. None of the available borehole records indicated the presence of rocks of the Ventersdorp Supergroup." The existence of mine dumps (now reclaimed) on portions of the farm Rietfontein originating from the gold mining in close proximity to Rietfontein are proof of active gold mining in the region. According to Mr Peter Kelly of the Department of Mineral Resources (e-mail dated 16 August 2012) the area is shallowly underlain by the Black Reef Formation but that reef has not been mined. The Kimberley Reef is at about 800 m and has also not been mined. The only Reef that has been mined in the area is the Main Reef which is in excess of 1000 m deep.

The boreholes and the results of the geophysical surveys confirm the presence of a prominent dyke striking at about 150 degrees west of the Rand Water Servitude. The approximate location of the dyke is indicated on Figure 2 and boreholes and boreholes drilled to the east confirm the southerly continuation of the dyke by intersecting fairly thick dolerite sills or part of the dyke.

It is unknown whether intrusions of different ages are present but intrusions into the Karoo sediments show that some or all of the intrusions are post Karoo. In the report all the intrusions are considered to be post-Karoo dolerite intrusions.

6. GEOHYDROLOGY OF THE LARGER AREA

An extensive geohydrological study of Portion 81 was carried out by R Meyer and is reported on in the report "An assessment of the geohydrological conditions at the proposed Tonk Meter road landfill site, Springs, Mpumulanga" (Report No.014/2012 dated December 2012).

It is concluded that two distinctly different ground water level situations are present

i) a shallow perhaps perched water level associated with the mudstone and carbonaceous shale of the Vryheid Formation and dolerite intrusions; and

ii) a deeper water level associated with the tillite and dolomite of the Dwyka and Malmani Groups respectively. Water levels in the Vryheid Formation range between approximately 2 and 39 m below ground surface (1580 and 1616 mamsl). In terms of groundwater movement the contour map indicates a flow towards the central and western part of Portion 81 (i.e Area D and the northern part of Area G) from the north, east and south (the Fulcrum X10 area).

The north-south directed dolerite intrusion is not considered to act as a barrier as no indication to that effect is displayed by the individual water level measurements. As a general observation it should, however, be stated that the water levels to the east of the dolerite intrusion are generally above 1600 mamsl, whereas those on the western side are below 1600 mamsl.

Water level depths in the Dwyka Malmani Group rocks range between approximately 10 m and 67 m below ground surface i.e. between approximately 1550 and 1600 mamsl. Water levels recorded in the tillite and dolomite rocks are in general approximately 20 – 30 m below those present in the Vryheid Formation.

The information on all the boreholes (83 boreholes drilled on Areas A to G) was used to do an aquifer classification. From the available information 75 per cent are classified as having a sustainable yield of $\geq$ 0,1 ℓ/s. In terms of groundwater significance and based on the borehole yield information, the aquifers associated with the Vryheid Formation and Dwyka and Malmani Groups are considered to be "non-aquifers" It is clear that the overall aquifer classification for the Portion 81 area is one of low potential sustainable yield and poor to good groundwater quality depending on the historical impact of mining and possible future impact from waste disposal activities.

The boreholes close to the attenuation pond shows variable conditions as far as water tables are concerned. Some boreholes are dry to the depth of 60 m drilled. In the area of the attenuation pond a borehole drilled into the waste body in Area B (Borehole WS-1) shows an elevated water table at 7,4 m in the waste while a hole drilled to 28 m depth just outside the waste body (Borehole BS-1) is dry to the depth drilled (28 m) (Figure 8). This shows the low permeability of the Karoo sediments. Some water tables are shallow , probably because of water collecting in the excavated area south of the dam location (i.e holes 19/17 and V11). Other water

tables vary from 24,5 m to 47,3 m. Because of the nature of the materials in Karoo sediments and the Karoo/dolomite contact it is highly unlikely that changes in the water table levels will influence the stability in the area of the attenuation dam.

7. AVAILABLE INFORMATION

As mentioned before large parts of Portion 81 have been investigated in detail. Information of these studies is used to evaluate the stability conditions underlying the attenuation dam. Some of the more important reports (in which other studies done in the area are also listed) are given below.

Information on other studies done in adjacent areas was requested from the CGS. The study areas are shown on Figure 7 received from the CGS.

- The investigation of Areas A and C for the waste disposal permitting of these areas. This report includes dolomite stability investigations i.e. geophysical surveys on traverse lines and percussion drilling.

  BKS (Pty) Ltd 1997
  Verref Rietfontein Springs Waste Disposal Site: Feasibility study report Volumes 1, 2A and 2B
  Report No. I08/570 to Eastern Gauteng Services Council Project No.P539131 dated May 1997

- The investigation of Area B (the Rand Scrap Landfill area) to determine the extent, nature and recommended rehabilitation methods for the landfill

  BKS (Pty) Ltd. 2003
  Geotechnical and geohydrological investigation of the Verref – Rietfontein Area B waste landfill site – Springs
  Report No. I08/800 to Rand Scrap Iron , Project No. H169701 dated October 2003

- The dolomite stability investigation of Areas D, E and F for waste disposal landfill permitting. A gravity survey was done over the whole remainder Portion 81 area. The existing waste sites on Areas A, B and C was excluded but area G and the area of the proposed Fulcrum Extension 10 were included in the gravity survey.

The gravity survey was followed by percussion drilling on anomalies and to provide good cover. The report was submitted to the CGS for comments.

Dr J P Venter Consulting Services 2011
Dolomite stability investigation of part of portion 81 of the farm Rietfontein 128-IR for the development of waste disposal facilities
Report No 2011/02 dated July 2011

- Comments by CGS on the abovementioned report
  Council for Geoscience (CGS) 2011
  Comment letter: Waste disposal site: Remainder of Portion 81, Rietfontein 128-IR
  Reference No: F3849 Rem of Portion 81, Rietfontein 128-IR dated 12 August 2011.

- An investigation of Area G was started in 2013. Whereas no poor conditions were found during the 1997 and 2011 studies of the waste disposal areas, limited poorish conditions were found at depth at or near the contact with the dolomite below the thick Karoo Supergroup deposits. Such conditions were found in three holes in Area G ie. holes 15/13 and 19/17 in the south and hole 33/33 west of Area D towards Kwa Thema. As this could influence the waste disposal facility, further investigations were done in the area west of Area D and on the proposed waste disposal areas D and E. Following the investigations an Addendum Report was compiled. It was concluded that the localised soft or looses zones were present in the lower part of the deeper Dwyka deposits. The additional holes on Area D and E did not show conditions which would adversely influence the waste disposal operation. The report was submitted to the CGS for comments and positive comments were received.

  JP Venter Consulting Services and J D Geotechnical Services CC, 2013
  Dolomite stability investigation of parts of portion 81 of the farm Rietfontein 128-IR for the development of waste disposal facilities.
  Addendum report
  Report No. 2013/03 dated May 2013

- Comments by the CGS on the abovementioned report
  Council for Geoscience (CGS) 2013
  Comment letter: Waste disposal facilities: Parts of Portion 81, Rietfontein 128-IR
  Reference: F3849.2 Parts of Portion 81, Rietfontein 128-IR dated 23 May 2013

- A Dolomite stability investigation of the Fulcrum Extension 10 area situated on the southern and eastern side of the attenuation dam have been carried out. Apart from boreholes drilled at the end of 2012 an additional three boreholes were drilled in November 2013. All the boreholes show Karoo Supergroup (Vryheid Formation) sediments overlying Dwyka Group sediments. The sediments were deposited on a glaciated dolomite surface and most of the holes penetrated into the dolomite. In one hole the dolomite was deeper than the 60 m depth at which the hole was stopped in the Dwyka. The area was classified as Inherent Hazard Class I with a Dolomite Area Designation D2.

  Dr J P Venter Consulting Services, 2013
  Dolomite stability investigation of the proposed Fulcrum Extension 10, situated on the remainder of Portion 81 of the farm Rietfontein 128-IR, Ekurhuleni Metropolitan Municipality, Gauteng, for the development of a shopping centre, other commercial buildings, a filling station and a taxi rank
  Reference: 2013/06, dated November 2013

- Comments by CGS on the abovementioned report
  Council for Geoscience (CGS) 2013
  Comment letter: Fulcrum Extension 10: Proposed development of a shopping centre, other commercial buildings, a filling station and a taxi rank.
  Reference No. F3849.3, Fulcrum Ext.10, Rem of Portion 81, Rietfontein 128-IR, dated 9 December 2013

- Relly Dr B H 1974
  A geological report on the proposed township of Selcourt No.3
  Report dated December 1974

  The area indicated as F2247 is shown on Figure 6. It includes the large area east of Tonk Meter road including a part of the existing Selcourt township

protruding into the area. The report deals with a 79 ha area to the west of the existing Selcourt. A gravity survey on a 30 m grid was done and five boreholes were drilled. It is concluded that "although dolomite is present, it is overlain by a continuous cover of Karoo System (Supergroup) sediments and (in parts) by a diabase sill that together everywhere, exceed 30 m in thickness. Consequently the potential for sinkholes is extremely remote. The two boreholes which intersect the dolomite subsurface encountered no wad, and the remainder continued to 45 m without encountering wad or dolomite. It therefore seems very unlikely that the ordinary lowering of the water table could affect the stability of the area."

The profile of borehole S3-B7/13 (indicated on the CGS plan as 7/13) shows carbonaceous siltstone and shale, grey shale, coal and carbonaceous shale and medium grey siltstone/ sandstone (i.e Vryheid Formation sediment) to 45 m (EOH). Hole 14/34 drilled further to the east also show non-dolomitic material down to 45 m (EOH). Dolomite was encountered at a more shallow depth (32 m) in borehole A33/22 (S3-A33/22) further to the north opposite Corobrik.

- Soilcraft CC 2009
  Report on the dolomite stability conditions for the proposed establishment of Selcourt Extension ten, Springs
  Report 2009/J071B/FIR to First Trading and Invest 4 (Pty) Ltd dated 2009

  The area is shown with reference F3750 on Figure 6. A geophysical survey was carried out followed by the drilling of 23 holes and later another four holes. It was found that the Vryheid Formation underlies the whole site with dolomite at depth. During initial investigations the site was divided into two zones i.e Inherent Risk (hazard) class (IHC) 2 and class IHC 2/4(b). The second class could not be classified as IHC 2 due to the fact that drilling did not proceed to a depth of 60 m. Afterwards it was, however, decided to drill near the 2/4(b) boreholes in an attempt to class them as class 2. The four additional holes were drilled and rezoned as class 2. Only one zone (IHC2) therefore applied to the site. The shallowest depth at which Chuniespoort rocks (dolomite) occurred underneath the Vryheid Formation may be 35 m but in many boreholes Vryheid Formation rocks occur down to the 60 m depth drilled. Water levels were measured from 2,5 m to 36,0 m.

In a CGS letter dated 8 December 2009 it is stated that Soilcraft has classified the area as IHC 2 but requested that the entire site must be considered IHC 1 with an NHBRC classification of D2. The CGS did not object to this request.

- Geo-logic Hydro Geological Consultants CC 2009
  Geohydrological assessment study for the proposed establishment of Selcourt Extension 10, Springs
  Report No.: G2009/110 to First Trade and Invest 4 (Pty) Ltd dated December 2009

  The report was done on the same area as the Soilkraft report and is shown as F3750 on Figure 6.

  In the report it was concluded that:

  - "The Vryheid Formation and Chuniespoort Group are both low yielding aquifers with limited groundwater movement
  - No signs of abnormal groundwater abstraction or dewatering of the aquifers could be detected;
  - An assessment was made based on possible groundwater movement. No areas of high probability of groundwater movement can be delineated;
  - Low probability of groundwater movement was interpreted for the total area based on depths ranging from 37 to more than 60 metres to hard rock dolomite, slow groundwater velocity and low groundwater abstraction figures in the region;
  - Fluctuation in groundwater levels is not expected;
  - The probability of sinkhole forming is rated to be very limited"

- Occurrences of sinkholes and subsidences in the area
  A request to the CGS about sinkholes and subsidences being present within 3 km from the site received a negative response. There are no known instability features within 3 km from the site. Large portions of the area surrounding the site have been developed for a long time.

8. INVESTIGATION PROCEDURES

8.1 Background

As mentioned before holes have already been drilled in the attenuation dam area. The results from these holes from different investigations were used to evaluate the stability conditions surrounding and underlying the attenuation dam area.

8.2 Geophysical surveys

An extensive gravity survey was carried out to cover all the areas apart from the existing waste disposal sites (Areas A, B and C). The geophysical report by R Day (EEGS) for Fulcrum Extension 10 (JPV, 2013) shows gravimetric conditions similar to the area around borehole 19/17 underlying the attenuation dam area.

8.3 Rotary percussion drilling

The boreholes drilled during previous investigations were used to evaluate the stability of the attenuation dam area. Nine holes were drilled within about 200 m or slightly more from the dam and the profiles of these holes were used for the stability evaluation. Boreholes WS1 and BS1 were drilled during an investigation of the backfilled quarry in Area B. The holes were therefore only drilled through the waste or the Vryheid Formation sediment and stopped when the Dwyka tillite was reached at depths of 26 and 28 m respectively. The profiles of the holes are given in Appendix A and summaries of the profiles are shown on Figure 8. The nature of the materials and drilling results are summarized in Table 8.1.

9. STABILITY EVALUATION

9.1 Nature of the blanketing layer and mobilisation potential

As mentioned before and in the previous reports the dolomite in the area is overlain by rocks of the Vryheid Formation underlain by tillite of the Dwyka Group. A dolerite dyke and probably some irregularly shaped sills are also present on the eastern side of the township area. The approximate location of the dyke is shown on Figure 2.

The typical profile is a transported sandy silt of 1 to 1,5 m thickness followed by ferrugenised silty clay. The ferrugenised silty clay is the top of the residual Vryheid mudrock and usually extends to depths of about 5 to 5,5 m. The level of ferrugenisation decreases with depth and is followed by thick residual mudrock (silty clay) – the so-called "yellow clay" which is used for brickmaking. The "yellow clay" extends to depths typically from 20 to 25 m. Below the yellow clay the profile is more variable with carbonaceous shale and coal being present in various thicknesses. These deposits are lens-like and are not present in all the profiles. The so-called plastic clay layers and fire clay layers are also present below the "yellow clay" and occur above and below the coal deposits. These deposits are part of the Vryheid Formation of the Ecca Group and are underlain by tillite of the Dwyka Group. The tillite is almost invariably chert-rich but clayey layers with some chert were also observed at depth eg. from 34 m depth in borehole 15/13.

As found in the investigations on the larger area there are substantial variations in the depth to dolomite rock. In the holes surrounding the attenuation pond sample loss occurred in two southern holes – probably in the Dwyka tillite just above the dolomite contact - i.e. in holes 19/17 and V11 at 48,5 m and 37 m respectively. In the other holes to the south and east depths to dolomite are 53 m, 37 m and >60 m. In a hole to the northeast (N6/18 - which was not profiled in detail) Karoo sediments and dolerite overlies dolomite to a depth of 41 m. As mentioned before a dolerite dyke is present to the east and a number of boreholes in the area intersected dolerite, either the dyke or sills probably starting at the dyke. In a hole drilled to the north (BKS-6/18) Karoo sediment and Dwyka tillite overlie dolomite at 28 m. As mentioned before two holes were drilled to the northwest and to the west of the dam into Dwyka tillite and stopped within 2 m after entering the tillite. The dolomite contact is therefore deeper than 26 m and 28 m, the depths at which these holes were stopped.

All indications are therefore that the cover of Vryheid Formation mudrocks and the Dwyka Group tillite are close to or more likely to exceed 30 m in the area underlying the attenuation dam. The overburden or blanketing layer materials also have a low permeability and erosion down to the level of the dolomite is extremely unlikely.

9.2 Receptacle development

A number of boreholes in the larger Portion 81 area were drilled to extensive depths into the dolomite rock. No cavities were encountered in the dolomite in the holes apart from a small cavity which may be present in one of the SRK boreholes to the north (RSI). It is, however, assumed that receptacles are present in the dolomite bedrock. Some small receptacles may be present sporadically in the lower part of the Dwyka tillite but these conditions are very sporadic and limited and are protected by thick mainly very low permeability materials.

9.3 Potential Development Space (PDS)

According to SANS 1936-2 the PDS is a function of the thickness and properties of the blanketing material. The properties of the blanketing material indicate a low hazard for any size of sinkhole.

9.4 Mobilising agencies

As the development type is an attenuation dam, the potential mobilising agencies will be the leakage of water from the dam. Attenuation dams, however, are designed to store water for very limited periods during heavy rainfall events and the periods for potential leakage are therefore short i.e hours.

9.5 Sinkhole and subsidence hazard

Sinkhole hazard:

Low

Main reasons: Thick cover of low permeability and low mobilisation potential cover of Karoo sediments.

Absence or very sporadic occurrence of small receptacles at depth.

Absence of signs of extensive leaching on the Dwyka/dolomite interface.

Subsidence hazard:

Low

Ingress water: Almost complete absence of compressible materials and cover of low permeability materials.

Groundwater drawdown: Almost complete absence of compressible materials.

9.6 Inherent hazard class

The information indicates a low hazard for the formation of any size sinkhole. During discussions with the CGS on 26 November 2013 it was confirmed that the present guideline for IHC 1 areas requires a cover of more than 30 m of non-dolomitic material. The available information indicates a thickness of close to 30 m or more of Vryheid Formation sediments and Dwyka Group tillite. The Inherent hazard class for the area is therefore IHC1.

9.7 Dolomite Area Designation

D2 according to SANS 1936-1 for 1N2 type developments.

10. CONCLUSIONS

Nine holes were drilled within about 200 m or slightly more of the proposed attenuation dam. The area is covered by sediments and rocks of the Vryheid Formation of the Ecca Group and of the Dwyka Group overlying dolomite of the Malmani Group. The conditions at the Dwyka/dolomite contact were generally found to be very good. Occasional soft zones of limited extent were found near the contact, probably in the lower parts of the Dwyka sediments, in a very limited number of the boreholes drilled. These zones are, however, overlain by a minimum of about 30 m of competent Karoo sediments and Dwyka Group tillite. The area is therefore considered to have a low hazard for sinkholes and subsidence of any size i.e. Inherent Hazard Class 1 with a Dolomite Area Designation of D2.

11. RECOMMENDATIONS

The area is considered suitable for the construction of the attenuation dam. Footprint drilling is, however, usually required. In discussion with the CGS on 26 November 2013 they expressed the view that because of the thick cover of Karoo and Dwyka sediments footprint drilling will not be necessary if the dam is supplied with a proper liner eg. a geosynthetic clay liner, which has a very low permeability and will basically

seal the dam during the short periods during which the dam stores water. They will, however, require footprint drilling if the dam is not constructed with a proper liner.

Regarding precautionary measures the competent person must study the requirements contained in the SANS 1936 (2012) documents, especially SANS 1936-3. The design must be approved by the relevant authorities including the Ekurhuleni Metropolitan Municipality (EMM). A Risk Management Plan (RMP) must be compiled and submitted to the CGS and the Geo-informatics section of the EMM for their approval. A competent person must also inspect the excavation during construction and submit a construction report to the CGS and EMM.