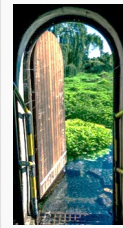




URBAN HYDROLOGY: WATER IN THE CITY OF TSHWANE
High Performance Centre, University of Pretoria
23 – 24 January 2014

KARST SUBSIDENCE AND ASSOCIATED RISK

THARINA OOSTHUIZEN
COUNCIL FOR GEOSCIENCE



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



Adopt
Moreletaspruit



CITY OF
TSHWANE



SANBI
SOUTH AFRICAN NATIONAL
BIODIVERSITY INSTITUTE



SAGPA
SOUTH AFRICAN
GEOSCIENCE PROFESSIONAL
ASSOCIATION



SAIWS
SOUTH AFRICAN
INSTITUTE OF WATER
SCIENCE AND TECHNOLOGY



WHAT IS DOLOMITE

- A carbonate rock type (2,3 billion years old), which dissolves (very slowly) to form cavities which leads to sinkhole formation
- Highly variable over short distances



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DISSOLUTION OF DOLOMITE

- Dolomite is soluble, i.e. dissolves in water.
- The dissolution of the dolomite has given rise to **cave systems** and **voids** in the rock. Soils covering the rock can collapse into these caves or voids resulting in catastrophic ground movement on the surface such as sinkholes or subsidences.
- Results in **wad**: a highly compressible and erodible material immediately above bedrock surface



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IMPLICATIONS OF DOLOMITE



Pretorius Avenue - 2013



The Pines (Jean Avenue) - 2013



Lyttelton Manor - 2008



Pretorius Avenue - 2012



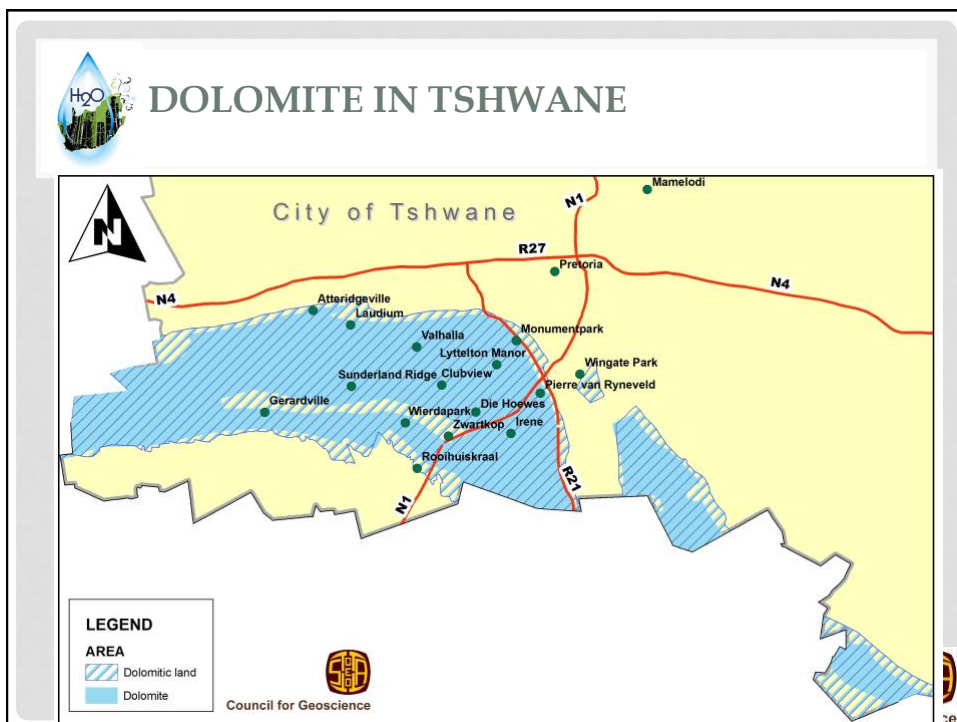
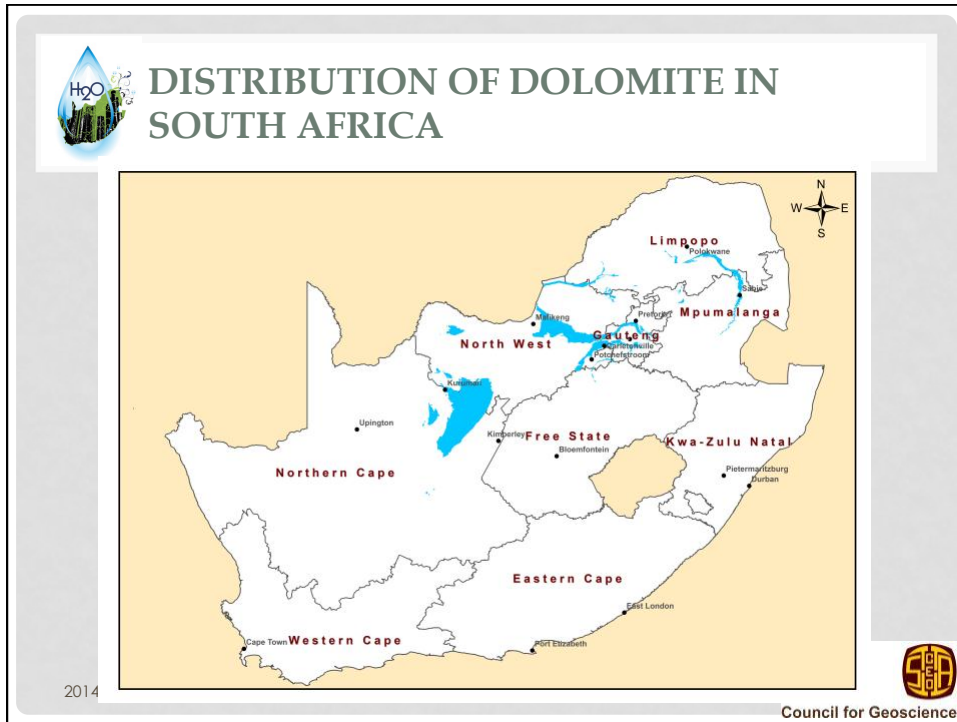
Alto Complex (Baden Street) - 2008




Jean Avenue - 2011


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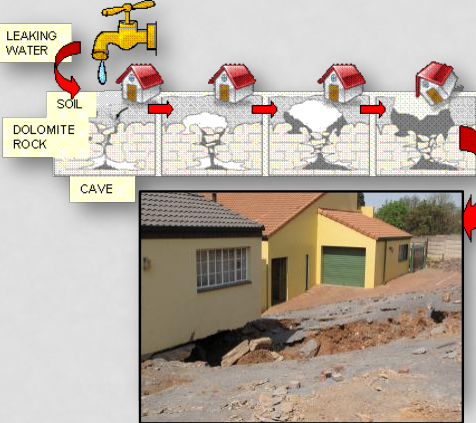




SINKHOLE FORMATION




Karst landscape



LEAKING WATER
SOIL
DOLOMITE ROCK
CAVE

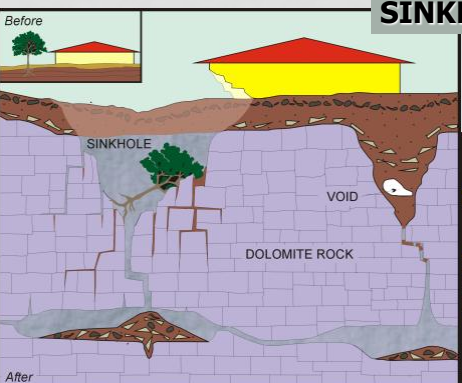
2 Main Triggering Mechanisms:

- Ingress water (leaking services, poor stormwater management, etc.)
- Lowering of the groundwater level



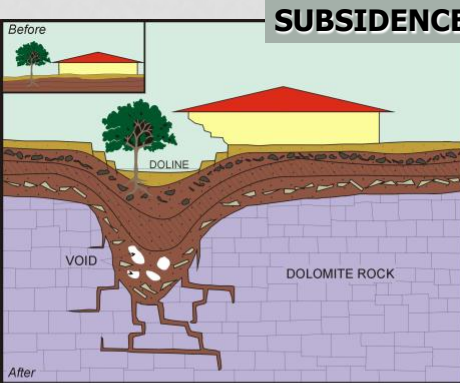
HOW DO THEY FORM?

SINKHOLE



Before
SINKHOLE
VOID
DOLOMITE ROCK
After


SUBSIDENCE

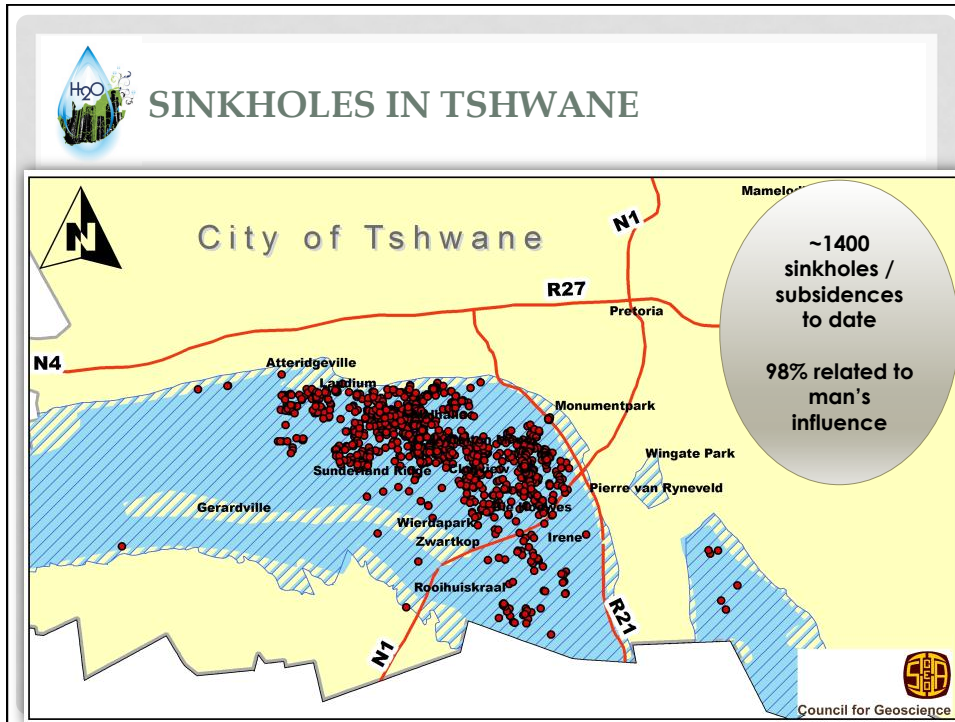


Before
DOLINE
VOID
DOLOMITE ROCK
After

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SINKHOLES ARE:

- **CATASTROPHIC !**
- **Circular**
- **1 - 100 m in diameter**
- **1 - 100 m deep**
- **Mainly Caused by leaking services**
- **MAY CAUSE LOSS OF LIFE/DAMAGE TO PROPERTY**

The figure shows a photograph of a sinkhole in a residential area. The sinkhole is a large, circular depression in the ground, approximately 1-100 meters in diameter and 1-100 meters deep. It is surrounded by a concrete wall and some vegetation. The text on the right side of the image lists characteristics of sinkholes: they are catastrophic, circular, 1-100 m in diameter, 1-100 m deep, mainly caused by leaking services, and may cause loss of life or damage to property.



INCREASED SINKHOLES ARE RELATED TO INCREASED DEVELOPMENT



Smallholdings -1950's




Townhouses-1990's






Multi storey - >2010's?

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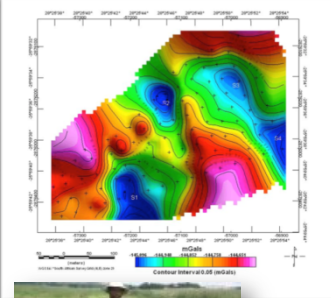
SINKHOLE STATISTICS


- **3 people** have died as a result of sinkholes (during remediation thereof)
- >60% of the sinkholes are sized between **2 m and 15 m** in diameter
- >60% of the sinkholes are **less than 5 m** deep
- Average of 7,58 events per km²
- **0,13 sinkholes / km² / year**
- 8 residential dwellings demolished in central Centurion area
- No sinkholes have formed as a result of dewatering






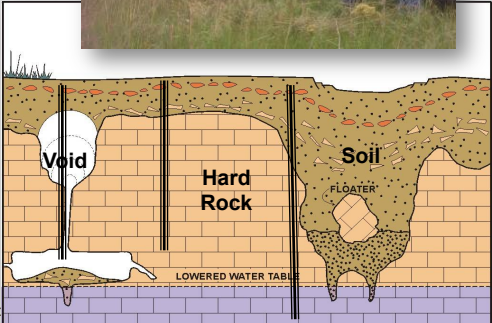
HOW DO WE INVESTIGATE?












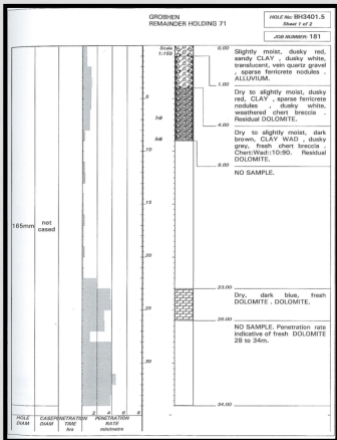
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CLASSIFICATION OF DOLOMITIC LAND




CLASSIFICATION OF DOLOMITIC LAND


- Using the Method of Scenario Supposition (Buttrick et al., 2001)
 - Based on the properties of the overburden
 - General assumption – the deeper the dolomite bedrock, the larger the expected sinkhole
- Classify a site for both ingress and a dewatering scenario
- 8 Inherent Hazard Classes (IHC)



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IHC TABLE

Inherent Hazard Class (IHC)	Small sinkhole (<2m)	Medium sinkhole (2-5m)	Large sinkhole (5-15m)	Very large sinkhole (>15m)	Subsidence Formation	Recommended development types
1	Low	Low	Low	Low	Low	All types of residential (limited density). RN1-RN3, RL1-RL2, RH2-RH3 D2
2	Medium	Low	Low	Low	Medium	All types of residential (limited density). RN1-RN3, RL1-RL2, RH3 D2/D3
3	Medium	Medium	Low	Low	Medium	Selected residential development (limited density). RN2-RN3, RL2, RH3 D3
4	Medium	Medium	Medium	Low	Medium	Selected residential development (limited density). RN2-RN3, RL2, RH3 D3
5	High	Medium	Low	Low	High	Certain selected residential may be considered. RN3, RL2, RH3 D3
6	High	High	Medium	Low	High	No residential development. D4 ROUTE
7	High	High	High	Medium	High	No residential development.
8	High	High	High	High	High	No development.

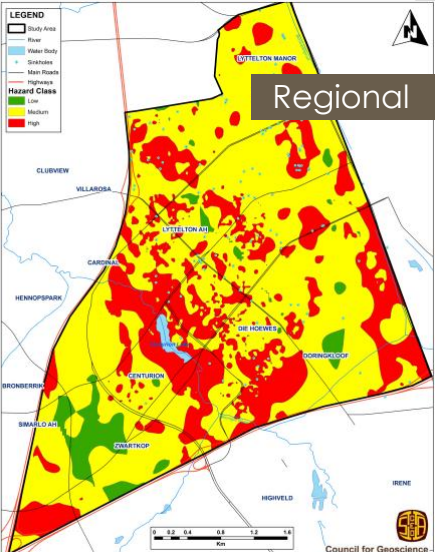
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CLASSIFICATION



Site specific



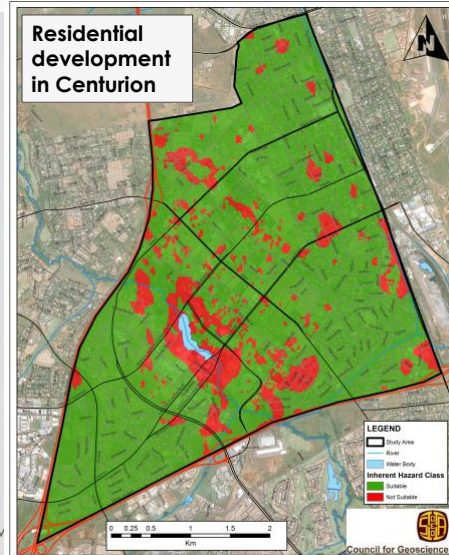
Regional

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APPROPRIATE LAND USE

- Based on the SANS 1936-1 (2012) documents
- Dolomite Area Designation (D-designation) assigned to each site, which specifies the required precautionary measures



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PRECAUTIONARY MEASURES

- Although there is always a risk in dolomitic areas, the **risk can be managed by the implementation of appropriate precautionary measures.**



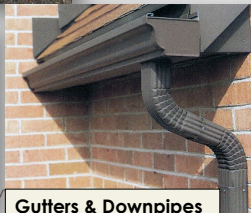
Raff Foundations



Concrete aprons



Storm water management



Gutters & Downpipes



HDPE Pipes



CONCLUSION

- In Tshwane, all sinkholes are caused by water ingress
- Generally a low hazard in terms of a dewatering scenario
 - Groundwater relatively deep, and mostly within dolomite bedrock
 - Only limited areas where a high hazard in a dewatering scenario has been identified

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THANK YOU

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