The assessment of mine rebound and decanting in deeper coal mines

Presented
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Overview

- Introduction
- Problems with mine closure
- Geology
- Hydrogeology
- Regional conceptual model
- Validation with numerical models
- Conclusion of results

Introduction

- South Africa
  - Fourth largest producer of coal – new coalfields open up currently
  - Numerous impacts on groundwater systems
  - Must manage and protect as SA is a water scarce country.

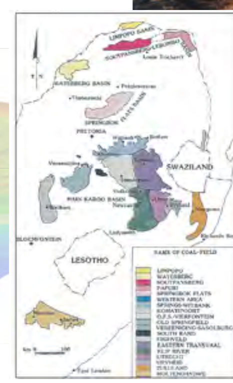
INTRODUCTION TO COAL MINING

Coal mining for more than a century (1870).

Initially, all the mines were in the shallower areas around Witbank.

Once the economically mineable coal has been removed, mines close down and are left to fill up with water. Most of them will eventually decant and/or seep into the adjacent strata and environment, thus polluting aquifers and rivers.

Coal mining thus alters the geohydrology.



Problems with mine closure

- Mine closure
  - Government requires long-term monitoring and management plans
  - Concerns about pollution
    - Surface water and groundwater
    - Volumes and quality of decanting water
    - Impacts on the environment
      - Discard dumps, return water dams, decanting etc
    - Impacts of on humans
      - Basic human needs
      - Health

Mining methods

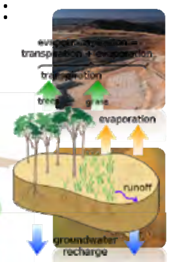
- Bord-and-pillar
  - Lower recharge
- Total extraction
  - Higher recharge due to fracturing and collapse of over burden

Recharge into Collieries: Conclusions

Before mining 1- 3% of the annual rainfall

According to mining type

- Shallow Bord-and-pillar typically **3 - 8%**
- Deep bord-and-pillar with no subsidence – **1 to 4%** of the rainfall.
- Stooping **5 - 9%**
- Longwall/Shortwall **8 - 12%**
- Rehabilitated Opencast **12 - 20%**

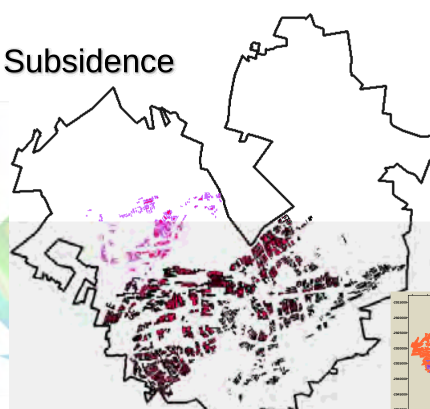


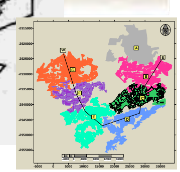
$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[K(\psi)\left(\frac{\partial \psi}{\partial z} + 1\right)\right]$$

K is the hydraulic co
ψ is the pressure head
z is the elevation ab
θ is the water content, and
t is time

Subsidence and recharge enhancement

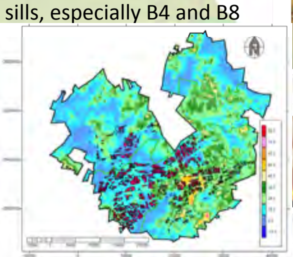
Subsidence



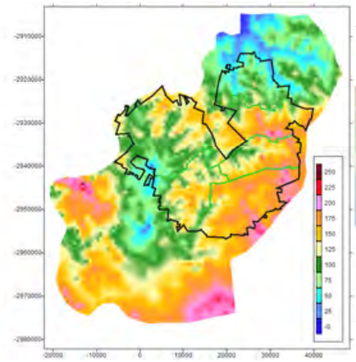


Geology

- Sandstone, shale, siltstone, mudstone and coal
- Dolerite
  - Dykes and sills, especially B4 and B8 sills

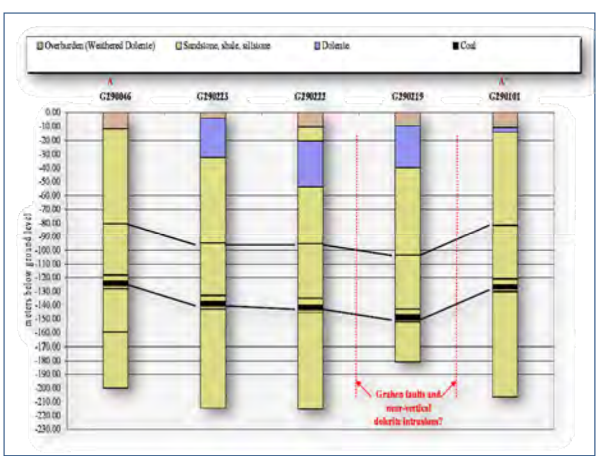


Overburden thickness

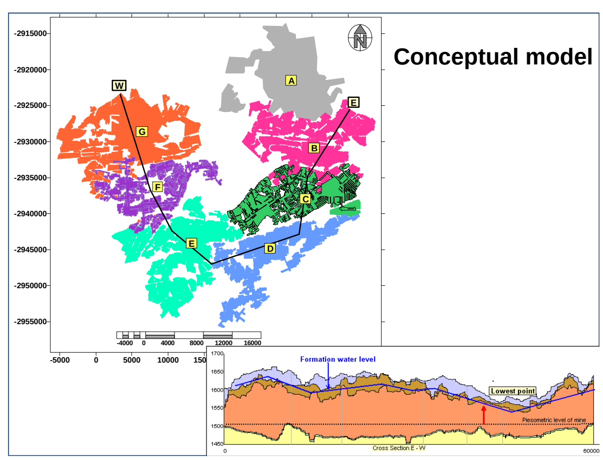


Hydrogeology

- Weathered aquifer
  - 5 – 15 m (soil & weathered rock)
  - Thick dolerite sill
  - Fountains
  - Low yielding boreholes (0.1 l/s)
- Lower fractured rock aquifer
  - Groundwater movement mostly in fractures and faults
  - Low yielding boreholes (1 l/s)

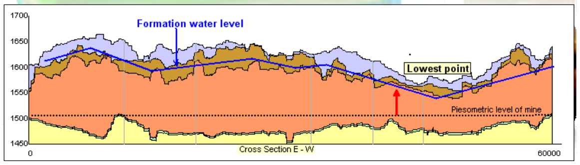


Conceptual model

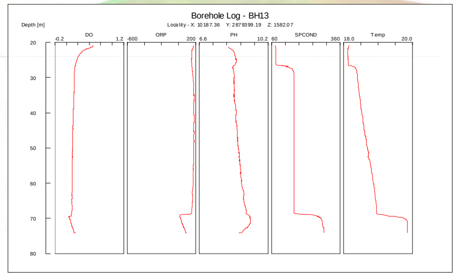


Conceptual model (cont)

- Once the mine has filled up with water, the piesometric level of the mine will rise with the storage coefficient value of the mine (and not the specific yield) as conditions have changed from unconfined to confined. The flux from the overlying aquifers into the mine aquifer will decrease as the two water levels approach each other (as pressure gradient decreases).



Example of stratification in deeper mining



Groundwater flow model

- A model is a simplification of reality

Users must always understand the implications of simplifying assumptions
Groundwater systems are complicated beyond our ability to evaluate them in detail

Recharge

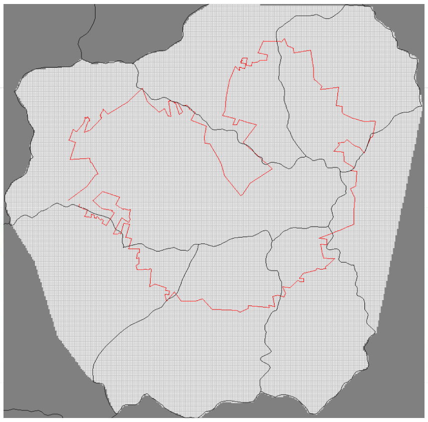
- Sill important
- Recharge
  - 7 – 15 % subsidence
  - 1 – 3 % no subsidence
  - 16 % backfilled opencast
  - < 1 % where the sill is a couple of metres thick
  - Shafts high recharge

Model setup

- PMWIN
  - Modflow
  - Not ideal
  - Large area (62.5 x 65 km)
    - Cells 200 x 200 m
    - Borders – topographic highs
  - Included 3 layers
    - Weathered upper aquifer
    - Dolerite dyke
    - Fractured rock aquifer

Aquifer parameters

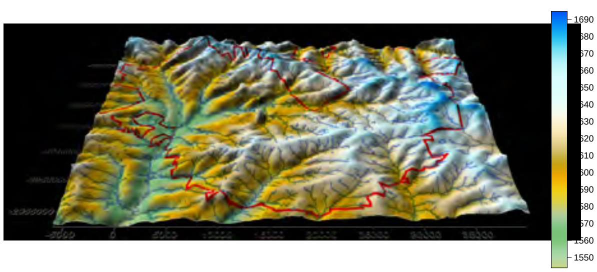
Geology	Transmissivity (m²/d)	Vertical hydraulic conductivity (m/d)
Weathered	0.1	1.0×10^{-4}
Dolerite	1.0×10^{-3}	1.0×10^{-5}
Fractured rock	1	1.0×10^{-4}



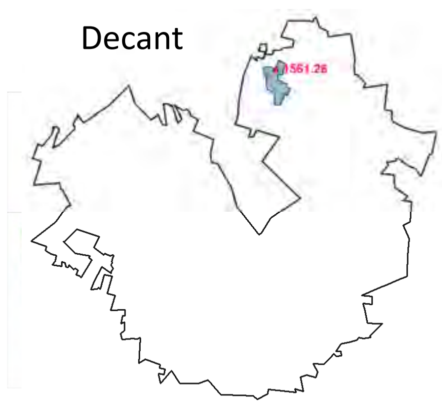
Groundwater levels

- Initial water levels
  - Base of mine
- Weathered aquifer
  - Steady state water level

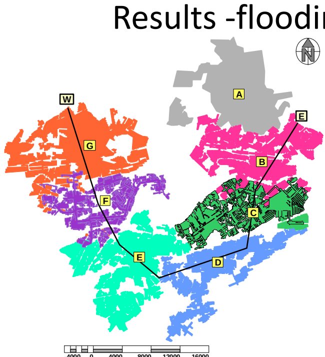
Water levels



Decant



Results -flooding



Mines	Time to reach steady state (years)
A	60
B & C	145
D	49
E	51
F & G	80

Results

- Water levels will rise with storage coefficient
- Aquifer return to normal pre-mining conditions in approximately 150 yrs
- **No decant** except at opencast
  - Lowest point
  - Decant rate approximate 2.5 Ml/d
- High sulphates & calcium
- Relatively high pH
- Potential for AMD medium to low

Should we always cry foul?

Source: www.nicholsoncartoons.com.au

My favorite slogan!!!!

Please analyze data scientifically as very emotional statements can sometimes cause more harm

(Courtesy of Anglo Coal Environmental)

Any Questions ?