The Water Balance of South African Coal Mines Pit Lakes

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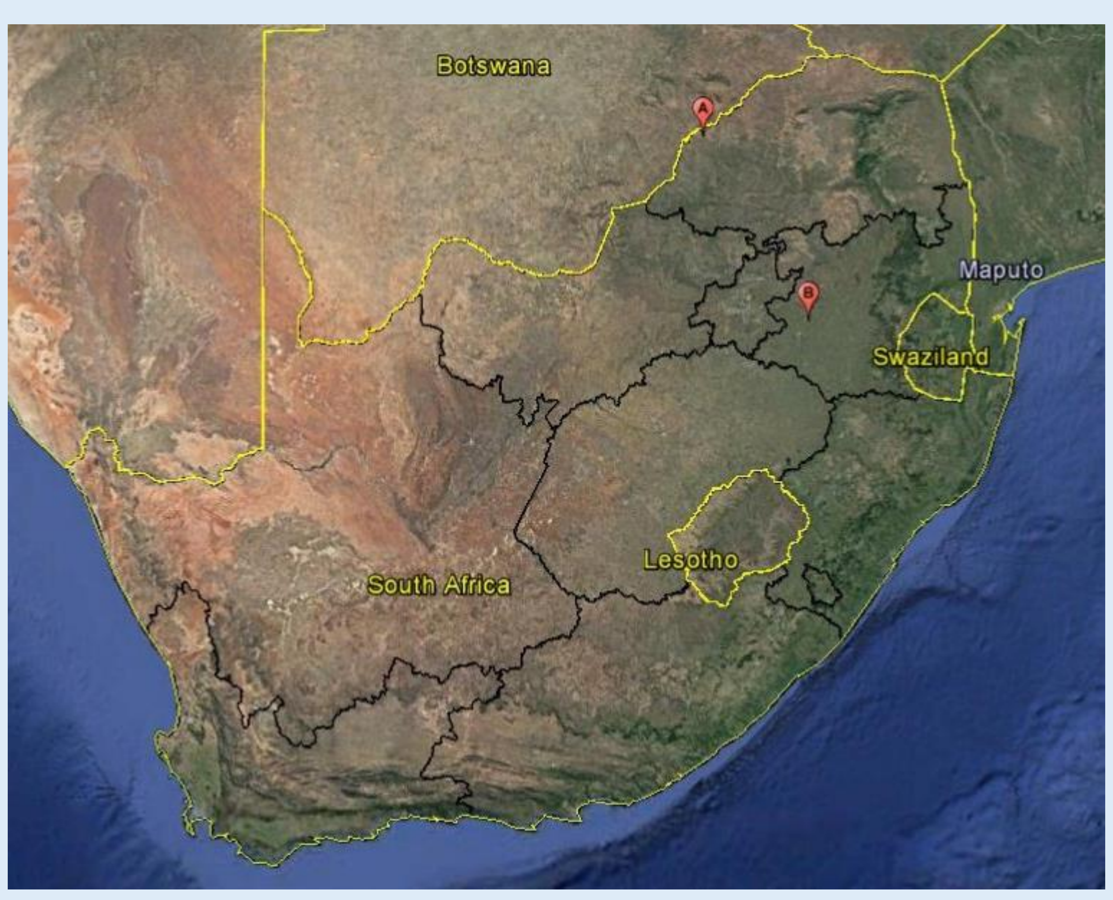
INTRODUCTION

- Pit lakes form in inactive mine pits which extended below the groundwater table.
- Mine pit lakes are usually associated with environmental problems and backfilling has been a preferred closure option.
- McCullough & Lund (2006) have however reported on the potential benefits pit lakes may have on the environment and communities.
- The aim of the study is to develop water balance models.
- The overall project objective is to determine if pit lakes are an environmentally viable solution for south African open pit coal mines.
- Two case studies of pit lakes will be discussed;



1. Pit Lake A is a standalone pit lake in the Waterberg Coalfield approximately 90 m in depth.

2. Pit Lake B is located in the Highveld Coalfield and consists of a series of 7 pit lakes of which only 4 are investigated. Some portions of the mine have been rehabilitated. The pit lakes vary in sizes.

METHODS

- Water balance models were developed with the use of Goldsim Academic Program to account for the volume of water in the pit lakes

Data Collection

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Construction of Conceptual Models

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Construction of Water Balance Models

- *Water balance models were constructed with consideration to the below components: Groundwater + Rainfall + Runoff = Evaporation ± ∆Storage*
- Site specific rainfall data was used for Pit Lake A
- Runoff percentages suggested by Hodgson and Krantz (1998) were applied
- Lake evaporation factors applicable to S-Pan as provided by Midgely et al. (1994) were applied to the MAE
- Groundwater inflow into Pit Lake A was calculated using the Marinelli & Niccoli (2000) approach which is as follows:

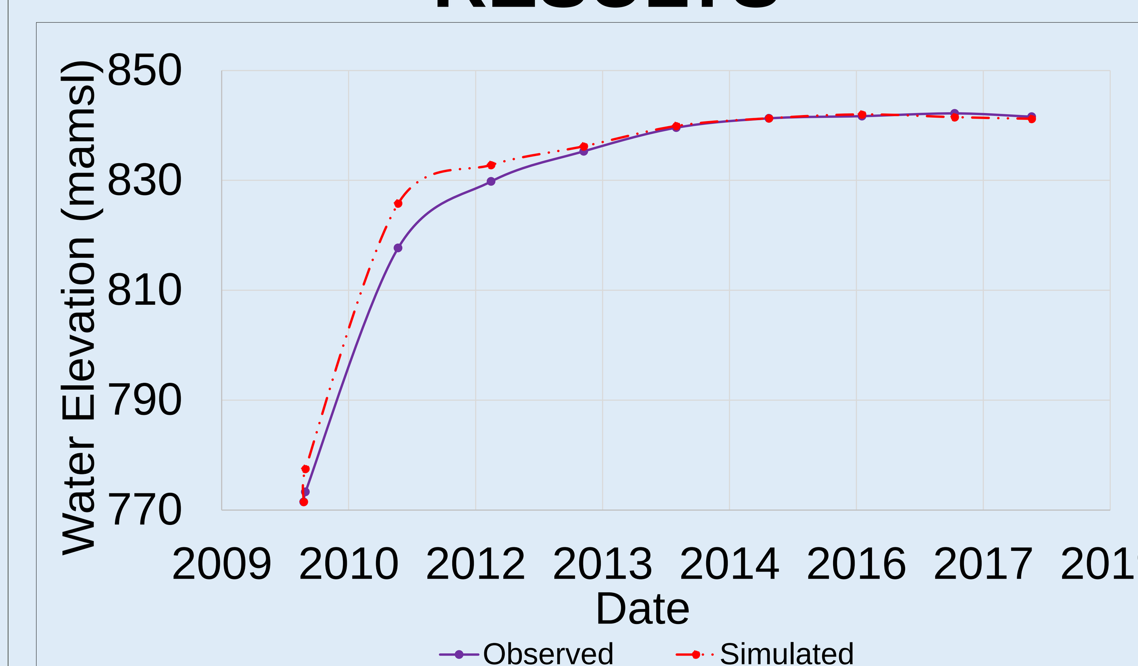
$$Q_1 = W\pi(r_0^2 - r_p^2)$$

$$Q_2 = 4 \times r_p \times \left(\frac{K_{h2}}{m_2}\right) \times (h_0 - d)$$

- The conditions of the Dupuit-Forchheimer analytical solution were more applicable to calculate groundwater inflow into Pit Lake B:

$$Q = \frac{\pi \times K \times (h_0^2 - h_w^2)}{\ln(\frac{r_0}{r_w})}$$

RESULTS



Runoff (m^3)	Rainfall (m^3)	Groundwater Inflow (m^3)	Evaporation (m^3)	Volume achieved (m^3)	% Filled
140 66	588 96	644 384	218 087	499 259	49

- Pit Lake A reached equilibrium 5 years post closure.
- The water balance summary shows that groundwater and evaporation play an important role in managing the pit lake water elevation

Pit Name	Groundwater Inflow (m^3)	Rainfall (m^3)	Runoff (m^3)	Evaporation (m^3)	Volume achieved (m3)	% Filled
44a	110 800 0	110 000 0	245 795	219 800 0	255 713	60
44b	222 846	344 601	187 817	687 884	673 79	70
44c	250 828	236 866	146 460	472 094	162 060	80
R42	564 644	400 940	864 77	724 813	327 268	92

- No pit in filling data were available for Pit Lake B but LiDAR data from 2013 to present were used to calibrate the models.
- Each pit lake was modeled individually
- Water balance summary presented for Pit Lake B is the cumulative volumes for 13 years.
- Rest water elevation of the pit lakes is 1536 mamsl.
- This is also assumed to be the water elevation in the backfilled area.
- Using a porosity of 25%, the volume of water contained within the pores of the backfilled material is estimated to be $1.65 \times 10^6\ m^3$.
- The ratio of the volume of water in the pit lakes versus the volume of water in the backfilled area is $\frac{1}{2}:1$.

CONCLUSION

- Pit lakes of both study areas are classified as terminal sinks.
- Increased permeability created during the backfilling process in Pit Lake B, increases the rate of pit filling compared to Pit Lake A.
- Surface area of pit lakes may be increased in order to manage pit lake water levels.
- Both pit lakes have the potential to be utilized for farm fishing and recreational activities.
- For improved results, monitoring of site specific data is recommended.

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