Groundwater Rebound in the South Yorkshire Coalfield: A review of initial modelling

[1] S. P. Burke, [1] H. A.B. Potter and [2] A. Jarvis

[1] Environment Agency: Science Group, Olton Court, Olton ,Solihull UK
[2] Institute for Research on the Environment and Sustainability, University of Newcastle, UK.
E-Mail: s.burke@environment-agency.gov.uk

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ABSTRACT

The closures of the majority of the deep coal mines in South Yorkshire and the associated cessation of dewatering has raised questions on the timing of likely impact on groundwater and surface water resources in this area. The Major Aquifers, the Permian Limestone and Triassic Sandstone are a major source of drinking water supply in the area that may be impacted by the recovery of mine water. In light of available mine water recovery data for this area this paper intends to review the modelling undertaken by Burke and Younger (2000), where an assessment of the current and future situation was made by applying the computer model GRAM (Groundwater Rebound in Abandoned Mineworkings) to predict possible recovery rates.

INTRODUCTION

It is now generally accepted that groundwater rebound due to the cessation of dewatering in coal mine areas often results in a deterioration of water quality within the worked strata as sulphate minerals formed by pyrite oxidation are rapidly taken into solution (Younger, 1997, 1998). Once rebound is complete or recovery is at such a level that surface discharges are taking place, pollution of surrounding water bodies (either overlying aquifers or surface watercourses) often occurs to a varying degree dependent on the nature of the discharge (Younger, 1994). Major ecological impacts (Jarvis and Younger, 1997) persisting over many decades or even centuries can occur (Younger, 1997). The cessation of pumping in the majority of the South Yorkshire Coalfield and subsequent recovery of mine water has led to concerns over the future quality of surface and groundwater resources. At present only two collieries are operational (Maltby and Rossington) and one pumping station (Car House), which assist in controlling mine water levels in the area. Burke and Younger (2000) considered mine water recovery at three selected deep mine collieries in the Rotherham area (South Yorkshire) Treeton, Thurcroft and Silverwood. An assessment of the recovery was carried out by using the recently-developed, semi-distributed computer model GRAM (Groundwater Rebound in Abandoned Mineworkings). The area of mine workings were considered along with subsurface connections to adjacent collieries, this evidence was gained from mine plans and discussed with former underground workers, to assess their hydrogeological significance. However, there was no recovery data to assist in model development and recharge and therefore subsequent recovery rates were based on pumping rates from the mines when they were in operation and expected mine void open to inflow. The rate of recovery and the timing of future surface discharges were then predicted by GRAM. The simulations predicted by GRAM suggested that 'major surface discharges were to be expected no sooner than the year 2005, and will eventually amount to around 3.9 $Ml.d^{-1}$. It is also predicted that around 0.4 $Ml.d^{-1}$ of water will flow from the abandoned mine-workings into nearby workings of Maltby Colliery'. Likely water quality was expected to be poor.

Figure 1 - Map of the Rotherham area, showing principal settlements and rivers, the locations of major and minor collieries mentioned in the text, and major geological boundaries (the latter after Eden *et al*, 1957) (Burke and Younger, 2000)

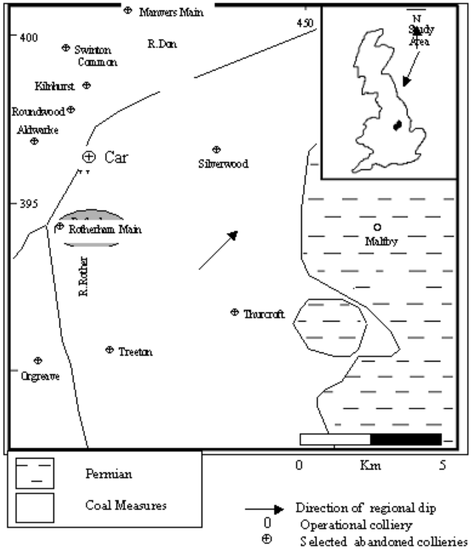
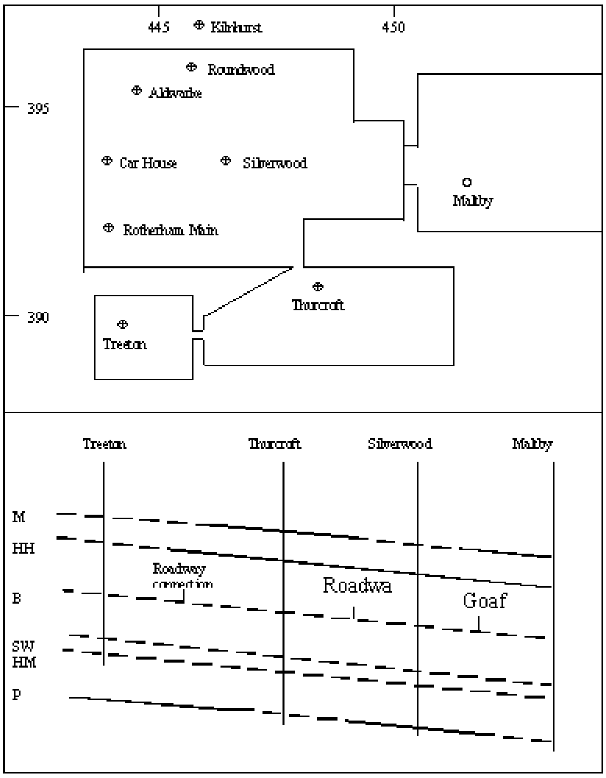


Figure 2 - Schematic layout of the three abandoned "ponds" at the elevation of the Barnsley Seam with the connection to Maltby Colliery (active workings) in the Rotherham area and a cross-section, showing the relevant coal seams.



M, Meltonfield; HH, High Hazel; B, Barnsley; SW, Swallow Wood; HM, Haigh Moor; P, Parkgate
Dashed lines on seams indicate seams worked by individual collieries, connections only in Barnsley Seam.

BACKGROUND

The geological, hydrogeological and mining setting is presented in detail in Burke and Younger (2000) and Eden et al, 1957, but is briefly discussed below for completeness.

The study area (Figure 1) is directly underlain by Upper Carboniferous (Westphalian) strata of the Upper and Middle Coal Measures Groups. The Permian "Magnesian Limestone" Series (Figure 1) overlies the Coal Measures. These are overlain by the Triassic Sandstones which are a Major Aquifer and extremely important for potable water supply. A cyclothemic sequence of mudstones, coals and sandstones (Eden *et al*, 1957) dominates the Upper and Middle Coal Measures with folding gentle and dipping to the north-east 5^{o} to 15^{o}. Several of the sandstone units have a thickness greater than 8 metres (e.g. Mexborough Rock) and supply economic quantities of water to shallow boreholes for private and commercial use. Sandstones that have fractures above mineworkings contribute to significant "feeders" (ie underground springs) of water which will begin to flow into the workings. This occurred during the sinking of Treeton Drift when a large fracture was encountered in the Mexborough Rock (M.Mcintyre *PersComm*). Saul (1948) has argued that the effective rainfall infiltrating the outcrops of these sandstones can account for virtually all of the water encountered in the deep mines of South Yorkshire.

The study area (Figure 1) consisted of three abandoned coal mines which are connected underground to an operational colliery Treeton, Thurcroft, Silverwood and Maltby respectively. The collieries are divided into ponds which is a discrete network of isolated workings. The general layout of these ponds (determined from mine plans) is shown on Figure 2.

Burke and Younger (2000) predicted that Treeton pond would start to fill immediately with the cessation of pumping at that particular colliery in 1991. There would then be a recovery in water levels at the Thurcroft pond followed by a similar recovery at the Silverwood pond with the cessation of pumping from the individual collieries in 1992 and 1995 respectively (Figure 3). Burke and Younger (2000) suggested that the geometry of the pond systems is 'fairly well known from mine plans and direct underground observations by the first author' (see Figure 2). However, there was an underground connection between the Silverwood pond and the operation mine of Maltby. This permeability of this connection was unknown and could have ranged from impermeable to highly permeable. Consequently, in making predictions, GRAM was used in "what if mode" to examine the implications of three alternative scenarios for the functioning of this goaf connection:

- **Scenario One:** the goaf is totally impermeable so that water from Silverwood Pond is never allowed to migrate to the Maltby Pond. (Unlikely)
- **Scenario Two:** the goaf is moderately permeable, so that limited flows to Maltby can occur under appropriate head conditions. (Most Likely)
- **Scenario Three:** the goaf connection is just as transmissive as the roadway connection from Thurcroft to Silverwood. (Unlikely)

REVIEW OF REBOUND PREDICTIONS

Burke and Younger (2000) considered that the most likely rebound profile would resemble a point between scenario 2 and 3. Data supplied by the UK Coal Authority for the measured recovery at the Thurcroft Pond is shown on Figure 3 for Scenario 2 and 3 and highlights the success of the modelling. Drilling at Silverwood colliery through the shaft cap took place in 2000 within the Silverwood Pond to establish mine water levels in this area. It was discovered that partial shaft collapse had occurred at a depth of -242 mOD which prevented monitoring below this level. However, no water was encountered at this depth indicating that mine water has not yet recovered to this level. This confirms the modelling predictions by Burke and Younger (2000) and supports their conclusion that the rebound profile is between scenarios 2 and 3 (Fig 3). The data also suggests that while Maltby colliery is operational there is no immediate threat to surface water resources at the present time.

The likely water entering Maltby Colliery workings were also predicted at being in the range of 15-130 m^3 hr^{-1-1}. At the present time it is thought Maltby Colliery is pumping water out within this range This suggests that the model was also successful in predicting likely water make in Maltby Colliery.

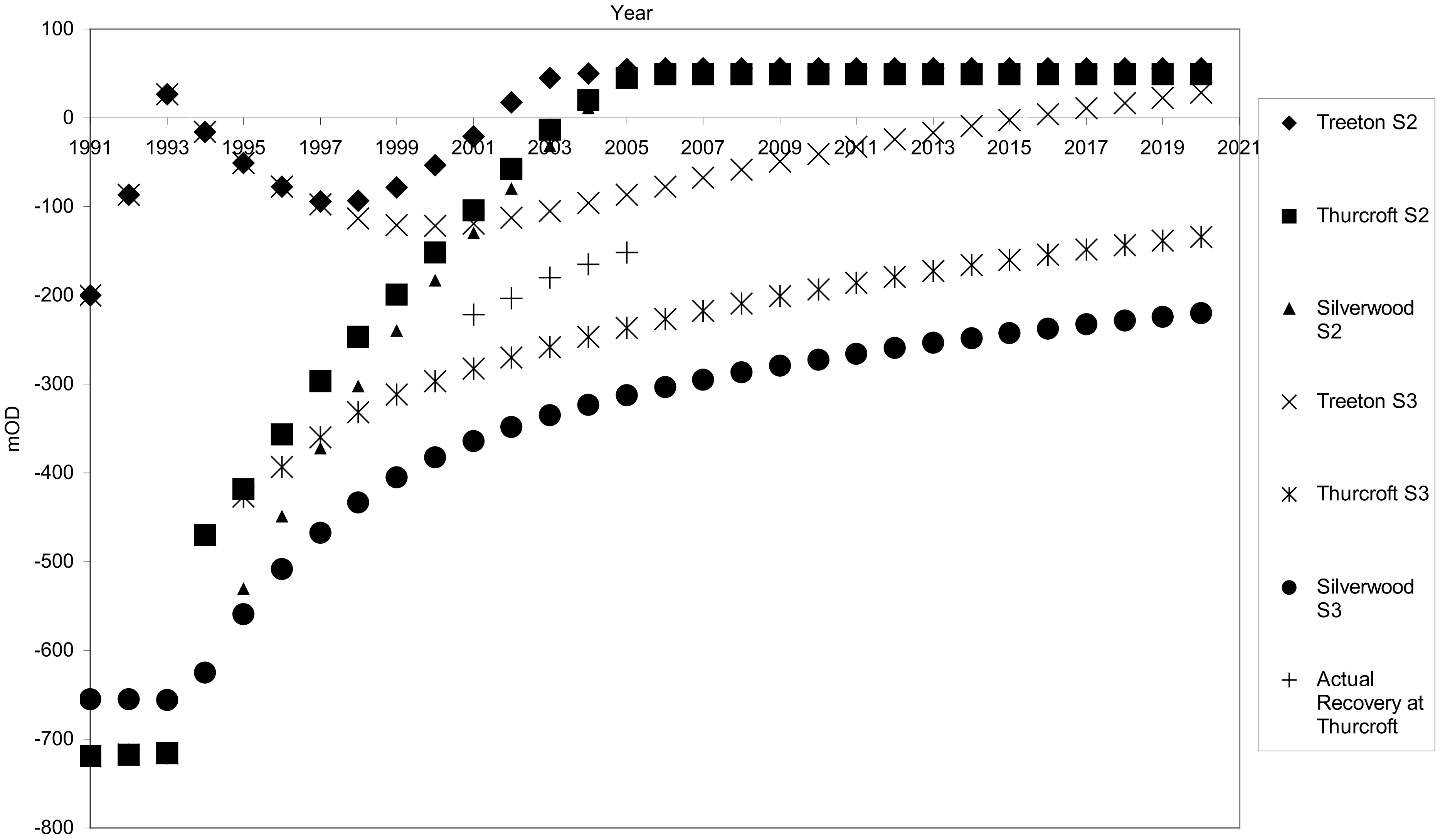


Figure 3 modelled and actual recovery in the three ponds

CONCLUSIONS

This study has briefly reviewed the work undertaken by Burke and Younger (2000). It has compared existing mine water recovery data against predicted recovery levels. It highlights the fact that initial estimates of mine water recovery can be made from a basic understanding of the system. It is expected that the connections between existing operational and closed collieries have a significant influence on the rate of minewater recovery and subsequent pathways. It is also suggested that further modelling is carried out to examine the effects of the cessation of dewatering from Maltby colliery.

DISCLAIMER

The views expressed in this document are not necessarily those of the Environment Agency.

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