15 years of mine water analysis and developments in monitoring of abandoned coal mines in the United Kingdom

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Abstract Since their formation in 1994, The Coal Authority manage the liabilities resulting from abandoned coal mines which include issues resulting from rebound of mine water within abanonded mines. To enable the Authority to perform their duties, meet environmental regulations; and aid predictions a substantial monitoring network of over 750 sites (over 1500 individual points) throughout the UK has been established. The Authority has continually assessed their monitoring and sampling requirements with improvements evident such as changes in mine water analyses to further aid the industry, make improvements in site management and performance along with various ongoing research projects.

Key Words Monitoring, mine water analysis, sampling, data management, coalfield management

Introduction

The management of liabilities, sites and data relating to abandoned coal mines on a national scale within the UK has been a progressive approach adapting to current and future requirements. Management of mine water from abandoned coal mines since 1994/95 has resulted in adjustments to monitoring networks along with type of information taken at these sites. This paper highlights how The Coal Authority have evolved their mine water management issues through an adaptive system of monitoring, sampling, testing, data management, data analysis and modelling. The paper also shows how improvements to monitoring and data collation have been used to make improvements to treatment schemes, predicting remediation and preventative options and ongoing research projects.

Monitoring network

The initial monitoring network throughout the UK comprised of 82 sites with various purposes (see figure 1). These sites were inherited from British Coal of which the majority comprised open mine shafts primarily for venting mine gas. During the earlier years it became evident that a much larger network of monitoring, remediation and venting was required to adequately assess and control the issues relating from coal mine abandonment. Figure 1 shows the trend in the growth of the monitoring network and the breakdown of the monitoring sites split in to various site types. Throughout the late 1990's there was a rapid increase in monitoring sites, this is followed by a slower rate of rise resulting in 759 by the end of 2009 of which approximately a third are related to mine gasses and the majority of the remainder are water related. This increase in number of monitoring sites was due to active searches for appropriate mine entries (i.e. shafts and drifts) and existing mine water discharges. In circumstances where adequate sites could not be found then new boreholes were located, currently boreholes account for approximately a third of the monitoring sites.

Monitoring methods and testing

Initial parameters measured were restricted to gas

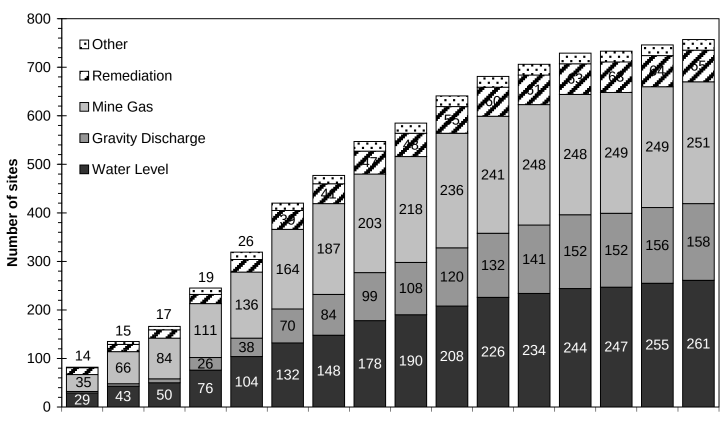

Figure 1 *Growth pattern of monitoring network from*

Figure 2 Examples of changes to monitoring requirements (left is a rectangular weir with a datalogger, top right is a digital titrator, bottom right are some on-site testing equipment).

measurements (generally CH_4 and O_2), water levels, pumping data, chemistry data (the majority taken at pumping stations) and limited flow measurements (mainly ad-hoc estimates). Alterations to monitoring came gradually with the introduction of increased water level monitoring and additional gasses including CO_2 which in turn were succeeded by the addition of data-logging equipment and standard weir structures (see figure 2) for accurate flow measuring. Alongside additional flow monitoring regular and routine water samples were taken for laboratory analysis. More recent developments in the understanding of the importance of alkalinity / acidity measurements (McAllan, 2009) resulted in a more wide spread regime of regular on site measurements. In particular on site measurements of pH, Alkalinity, Acidity, Iron and Dissolved Oxygen throughout pumping tests (Sapsford & Watson, 2011) have proven essential for scheme designs. The latest changes to monitoring have generally been in response to research projects and now includes on site temperature and data-logger temperature measurements.

Data management and analysis

Increasing the size of the monitoring network along with number and type of parameters measured results in large amounts of data being acquired. To manage the bulk of the sites (i.e. non data-logged) with manual readings and chemistry analyses is currently undertaken using in-house designed Microsoft© Access databases and Excel spreadsheets. However, with large amounts of data-logged data (i.e. generally at 30 minute intervals) it is difficult to manage using these software packages. Thus, bespoke software for data management enables improvements to analyses, predictions and modelling of the data. Analysis of good data allowing for better predictions has allowed the Authority to predict rising mine water events (see figure 3) such as potential outbursts and appropriate control strategies (see figure 4) including pumping, engineered gravity discharges (Watson et al, 2007) and appropriate site locations. Furthermore, more detailed analysis throughout operational treatment schemes has allowed for a better understanding processes involved. This in turn along with pumping test analysis (Bailey et

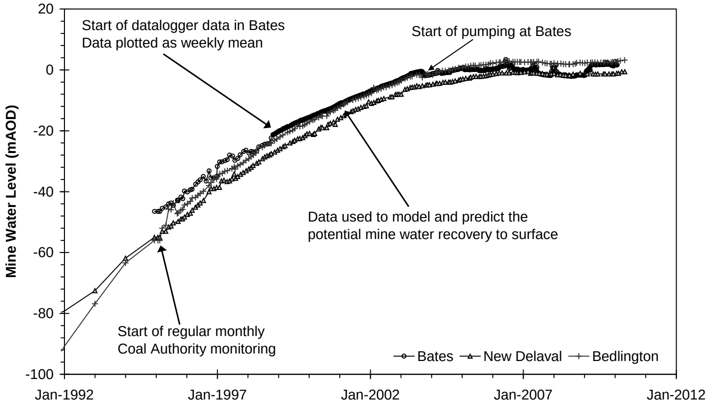

Figure 3 Mine water recovery and changes to monitoring for a strategy for mine water pumping.

Figure 4 Engineered gravity discharge pipe at Page Bank

al, 2011) aids design and management stages of treatment schemes.

Lessons learned and Conclusions

The first lesson learnt relates to the type of data being collected from these sites, this lesson developed as increasing amount of knowledge was required to progress schemes; to control; and assess each coalfield. This lesson over the years has been the most dynamic and adaptive with changes made to types of parameters monitored (i.e. additional gasses and on-site chemistry), frequency of data monitoring (i.e. data-logged) and types of analysis (i.e. mine water recovery and gas reserves) performed on new data. The changes to types of data collected is now evident with the addition of chemistry analysis to assist research on projects such as treatment scheme performance (i.e. cascade, settlement lagoons) and collection of temperature measurements (on-site and data-logged) to aid geothermal potential projects.

Analysis of the sites themselves along with the specific data (i.e. mine water responses and trends) from these sites has helped to build knowledge about appropriate locations (i.e. target seams and types of mine workings) for new boreholes. This analysis also leads to defining appropriate areas for remediation options (i.e. pumped and gravity discharges) for existing and potential mine water discharges. Approximately 10% of the monitoring sites are of discharges from gravity mine water drainage adits. There are a number of these adits which have potential risks of and or regular 'blow-outs' of mine water. As part of the Coal Authority's risk management a number of these adits are monitored for water levels to ascertain any build up of mine water upstream of the discharge points. In later years where appropriate shafts can not be located boreholes have been sunk to assess these risks.

In addition to the lessons above there has also been lessons learned due to the lack of monitor-

Figure 5 Netherleys Pit discharge in 2010 and post remedial works in 2011.

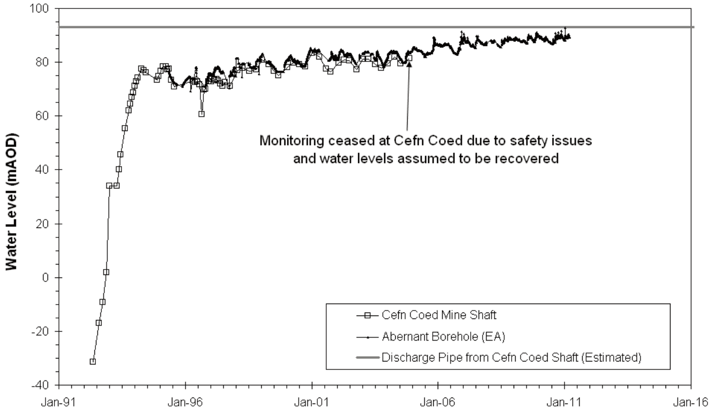

***Figure 6** – Mine water recovery at Cefn Coed*

ing. In 2007 inadequate monitoring of recovering mine water levels following changes to mine gas emission trends resulted in unexpectedly high mine water levels within the South Derbyshire Coalfield. Without the correct amount of time and without a good understanding of the current mine water regime two uncontrolled discharges of mine water occurred. One in to a local watercourse in 2008 and another in 2010 to a small fishing pond forming part of a local nature reserve (see figure 5). Subsequently to these issues in South Derbyshire a separate potential risk for uncontrolled discharges of mine water have occurred at Cefn Coed, South Wales. Initially mine water levels were monitored at Cefn Coed up to 2004 when safety issues resulted in the site no longer being monitored; thus after assuming mine water recovery was complete no further monitoring was undertaken. Following recent data obtained from the Environment Agency (see figure 6) it became evident the mine water in the area was still recovering and is believed to be close to surface. Both of these events highlight the importance of continued monitoring which have lead to rapid investigations with changes to the Coal Authority mine water remediation programme.

Post 1994 there have been a number of issues and lesson learned from the management of liabilities relating to coalfield abandonment on a national scale. One of the first and one of the most obvious is the original lack of adequate and appropriate monitoring network to assess water and gas regimes within whole coalfields. The original number of 82 sites was clearly not enough for all the major coalfields and generally each major coalfield has an average of approximately 70 sites.

Continuing assessment of the monitoring network and types of data monitored is necessary to adapt to any changes in mine water regimes; improvements within designs and operations of remediation schemes; changes in risk characterisation and management; and changes to third party requirements such as new environmental regulations.

References

Bailey M, Watson, I, Wyatt L, Davies T, (2011) Applications of pumping tests in the development of mine water management strategies and remediation scheme. Proceedings of the International Mine Water Association Congress, Aachen, Germany, 4 – 11 September 2011

McAllan, J, Banks, D, Beyer, N, Watson, I. (2009) Alkalinity, temporary (CO2) and permanent acidity: an empirical assessment of the significane of field and laboratory determinations on mine waters. Geochemistry: Exploration, Environment, Analysis 9: 299—312

Sapsford D.J., Watson I (2011) A process-orientated design and performance assessment methodology for passive mine water treatment systems. Ecological Engineering 37: 770—975

Watson, I (2007) Managing minewater abandoned coalfield using engineered gravity discharges. Proceedings of the International Mine Water Association Symposium, Cagliari, Italy, 27 – 31 May 2007: 355—359