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MINE DRAINAGE AND WATER RESOURCES

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The Environment Agency: The Environment Agency is responsible for the management of water resources in England and Wales. Management involves the conservation, redistribution, augmentation and securing the proper use of water, and requires a combination of formal regulation and less formal persuasion and liaison.

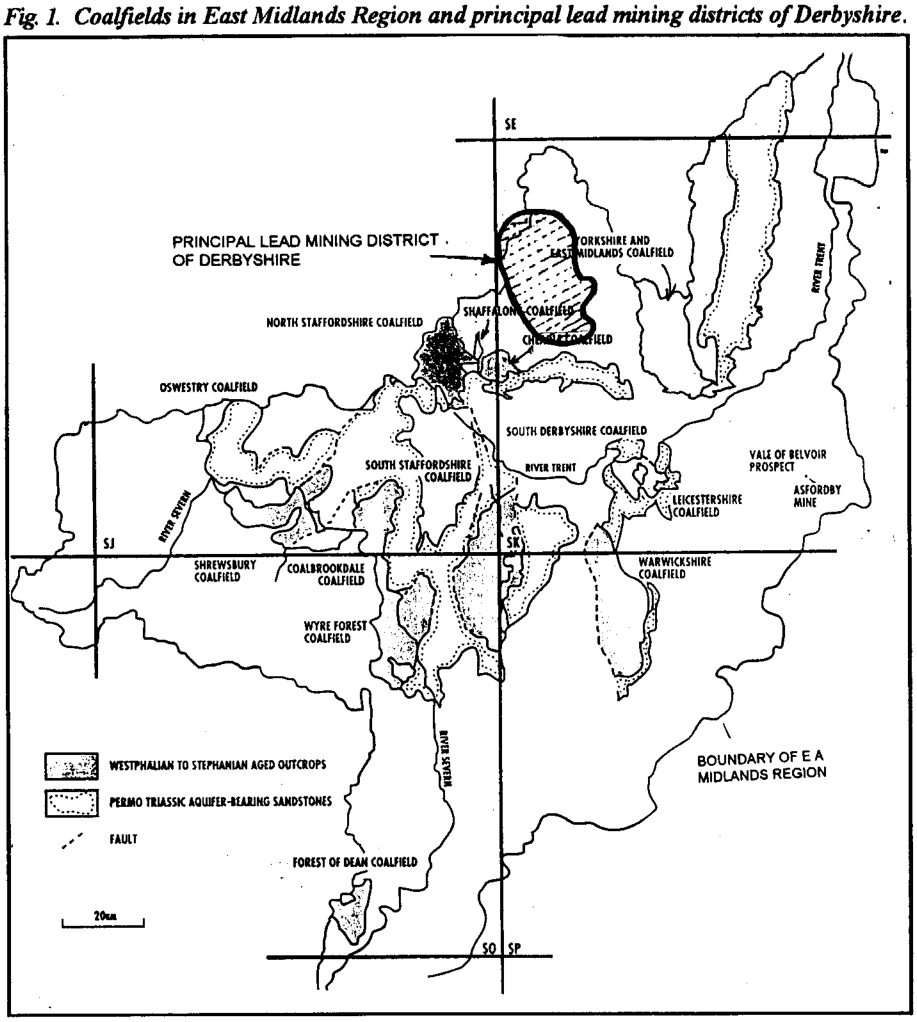
The Agency has eight Regions comprising twenty six operational Areas in total. The Lower Trent Area of the Midlands Region covers the River Trent catchment downstream of its confluence with the River Dove near Burton upon Trent. The area coincides approximately with Derbyshire, Leicestershire, and Nottinghamshire.

MINING IN LOWER TRENT

The two main types of mining which impact on water resources in Lower Trent Area are deep coal mining and lead mining (Fig. 1). The Agency is concerned about the impact of mine drainage on both the quantity and quality of water resources.

This paper discusses first the Agency's involvement in the general effects of mine drainage, and then concentrates on the lead mines in Derbyshire's River Derwent catchment.

Fig. 1. Coalfields in East Midlands Region and principal lead mining districts of Derbyshire.



COAL MINES AS A SOURCE OF WATER

Most deep mines required some degree of dewatering to allow safe and efficient mining operation. In some cases the dewatering added a fairly constant flow to a receiving river such that the mine water became to be regarded as part of the baseflow in the river. A limited number of mines were positively developed to provide water for other purposes outside the mine.

Manton Colliery at Worksop in Nottinghamshire is a good example. When the shafts were sunk through the Sherwood Sandstones and Lower Magnesian Limestone to reach the Coal Measures, rather than installing an impermeable lining to seal the aquifers, the mines built troughs, adits and pump houses to collect the water and raise it to the surface. Up to 20 million litres per day (Ml/d) can be abstracted for public water supply, with a variable part of that amount being discharged to the River Ryton nearby. This water augments the flow in the river, especially in dry weather, so that there is sufficient flow for dilution of effluent, and for other in-river uses.

COAL MINE DRAINAGE

Sophistication in mining techniques and advances in geological knowledge allowed the exploitation of seams at depths of more than 1000 metres, and at many kilometres from their outcrop at the surface where mining began. Progressive working and reworking of coal seams led to complex interlinking of workings within a coalfield and ready paths for water movement. Frequently a network of pumping stations is needed, using old shafts and boreholes in otherwise abandoned mines, to protect working collieries from flooding (Fig. 2).

Paper presented at the meeting of the National Association of Mining History Organisations at Darley Dale, Derbyshire on 12 July 1997.

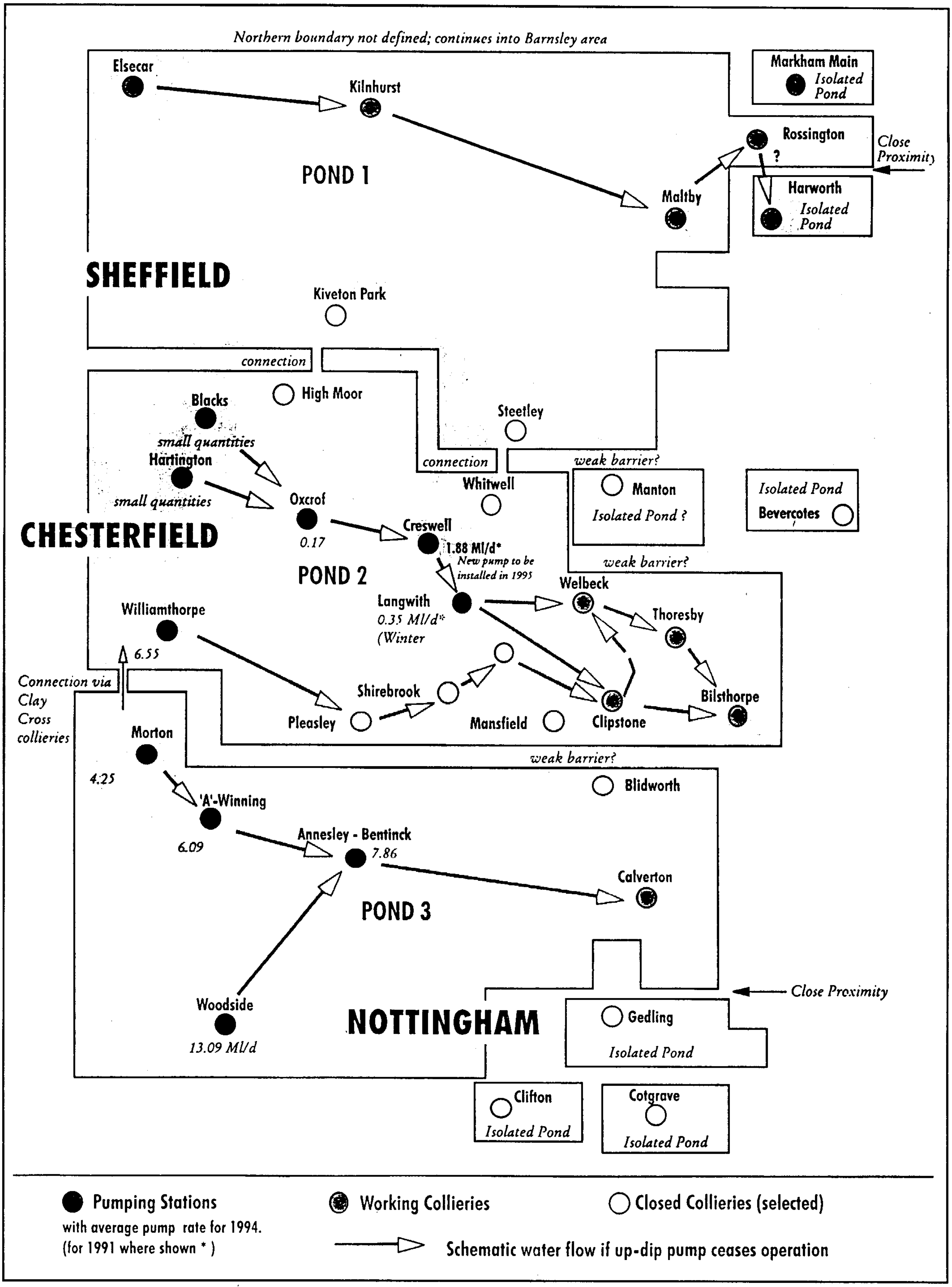


Fig. 2. South Yorkshire/Derbyshire/Nottinghamshire Coalfield: schematic pumping arrangements (as at February 1995).

Water within the mine workings comes from two main sources: water entrapped within the sediments that formed the rock strata 300 million years ago, known as connate water, and water originating as rainfall, and which has infiltrated from the surface through the overlying rock. The volume of connate water present in coal seams and the surrounding strata is usually not great. In comparison water which infiltrates from the surface can, depending on the geological conditions, produce significant water for pumping out. This can be an important factor on exposed coalfields such as Durham and South Wales and cause environmental concern. However in the Midlands the Coal Measures are generally confined beneath younger rocks with less infiltration. Hence the time scales for the flooding of local mines are much longer.

WATER RESOURCES PROBLEMS DURING MINE OPERATION

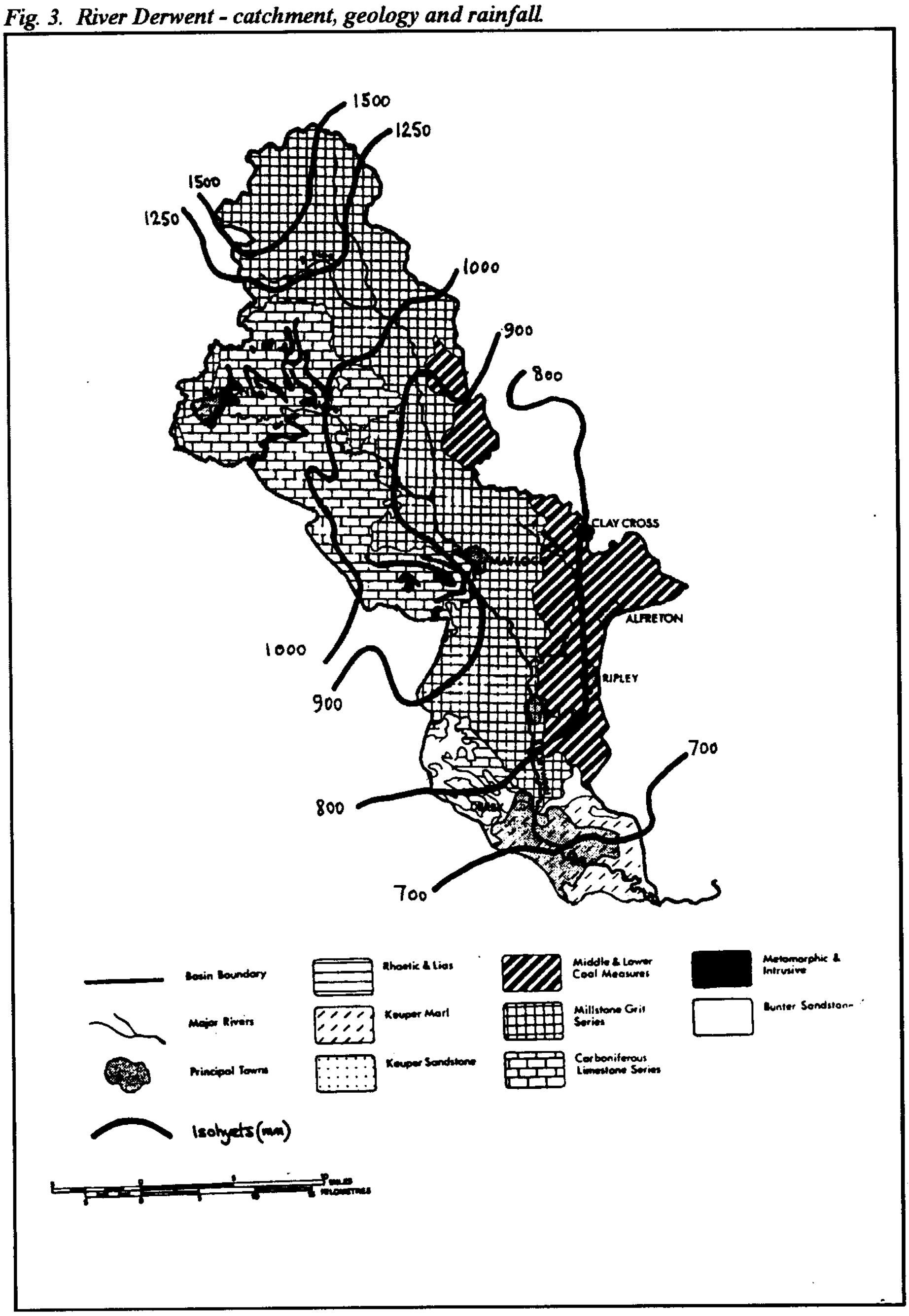
Connate water from the Coal Measures is often rich in the minerals which were present in the seas when the coal was formed. In the Midlands, chloride concentrations in some mine waters can be greater than those found in sea water today. In working collieries the saline water is pumped to the surface, mixed with process water, and discharged to watercourses, giving unnaturally high salinity levels. In Nottinghamshire for example, the saline water has re-infiltrated and contaminated the shallower groundwater used for public supply. This occurs where groundwater levels are depressed by abstraction and boreholes are close to rivers. Salinity can be detrimental to crops such as potatoes when the water is used for spray irrigation.

PROBLEMS OF MINE CLOSURE

The wholesale closure of deep coal mines in recent years has created many actual and potential problems of rebound of the groundwater. After a mine is abandoned and pumping ceases, the water table will rise through the workings and the fractured overburden. The mining process exposes sulphide materials such as iron pyrites which become oxidised and dissolve in the mine water. If the mine water reaches the surface, it results in an ochreous, bright orange discharge. Such discharges can have a major impact on aquatic habitats by affecting stream chemistry, and by physically blinding the stream bed with iron rich deposits.

The closure of mines can also have an impact on the quantity of flow in the watercourses which no longer receive the minewater. Although there are benefits such as reduction of salinity, the loss of flow can be a handicap to other river uses and users. This is noticeable where baseflow from groundwater is already reduced by abstraction of groundwater for public water supply. A reduction in flow can reduce dilution of sewage works effluent discharges, which in turn can lead the Agency to impose a more restrictive discharge consent on the works in order to preserve river water quality. Reduced flows will also restrict the availability of surface water in summer for spray irrigation, since the farmers' licences normally have a flow threshold below which abstraction is prohibited.

Fig. 3. River Derwent - catchment, geology and rainfall.



THE AGENCY'S PROGRAMME OF MINEWATER REMEDIATION

Discharges from abandoned mines, of all types, have been exempt under previous pollution control legislation. The Environment Act 1995 ends this exemption, but only for mines abandoned after 1999. Then it will be possible to require mine owners to undertake remedial schemes to mitigate pollution. Where there is significant pollution now, the Agency can take preventive action at its own expense.

The Agency has worked very closely with the Coal Authority on all of the problems associated with discharges from abandoned coal mines. Both organisations have been looking for a way to tackle those discharges which have the greatest impact on the water environment. A priority listing of 35 discharges has been drawn up, and the top ten examined in more detail. Memoranda of Agreement have been signed by the Agency and the principal mine operators to allow continuation of pumping or its controlled cessation.

In some locations, the Agency has had to step in and provide expensive treatment facilities to remove iron and other metals. The best known example is Wheal Jane tin mine near Falmouth, but there are treatment schemes in the Agency's Welsh, North West and North East Regions.

LEAD MINE DRAINAGE

The problems with deep coal mining relate to the east and south parts of Lower Trent Area. In the west we have the remains of the Derbyshire lead mines, and a different set of problems for water resources.

The water resources value of the Derbyshire Derwent catchment is related to its rainfall and its geology. Rainfall averages between 1600 mm. per year in the northern moors, to just under 700 mm. per year in the south around the Trent/Derwent confluence. The River Derwent largely has a hard bed on grits and shales, and the baseflow support from groundwater is very limited (Fig. 3). Its tributary the River Wye, however, flows

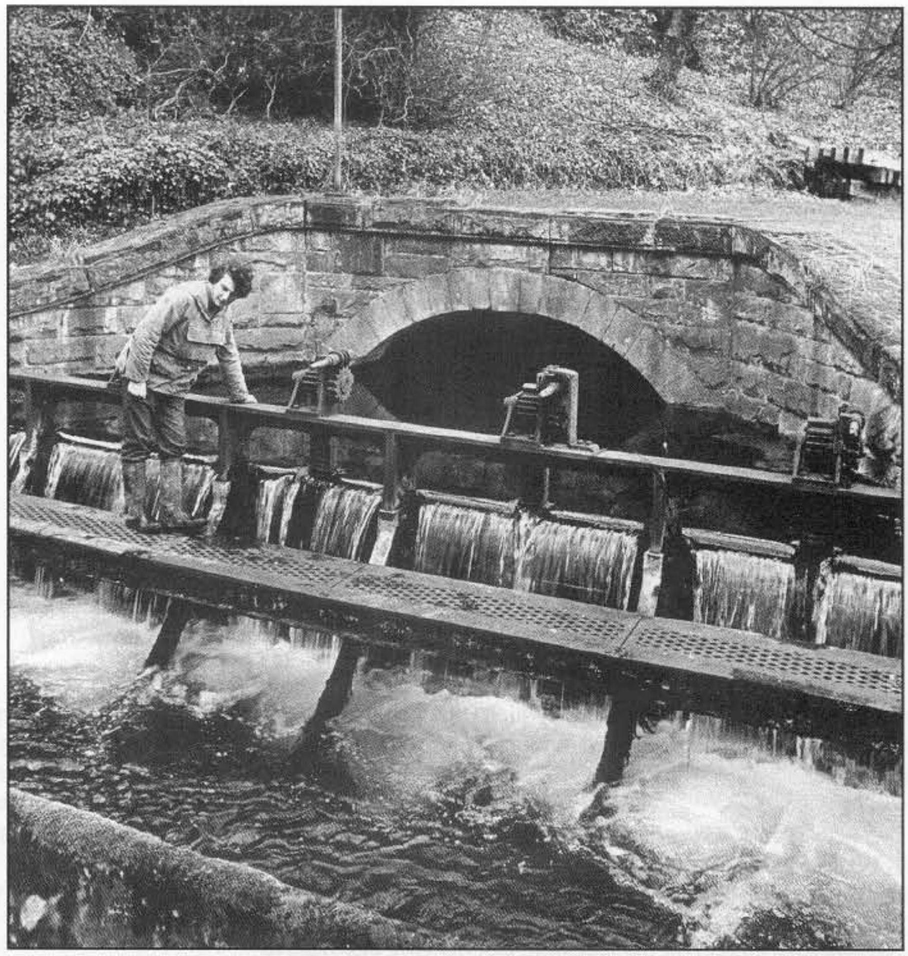
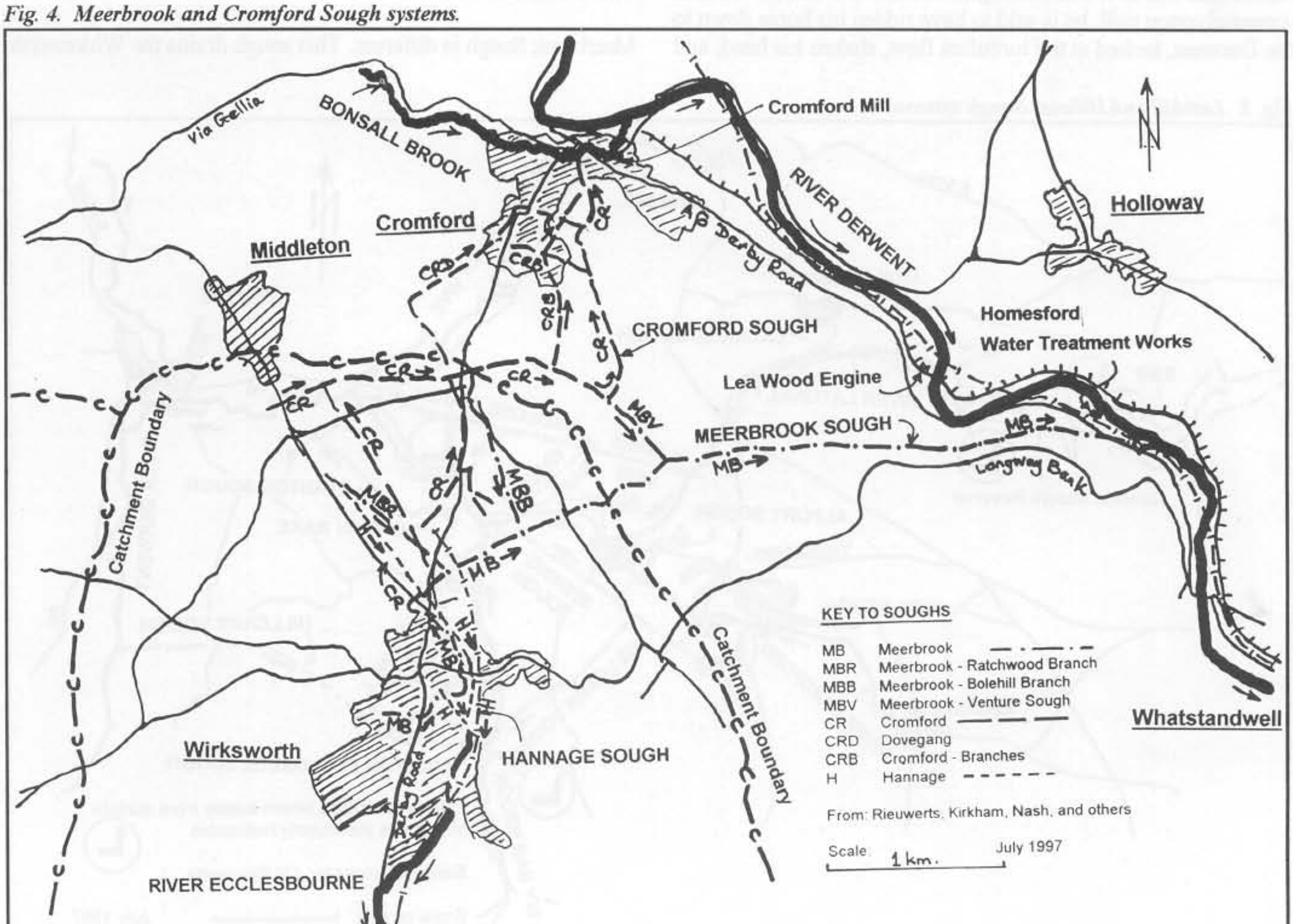


Plate 1. Meerbrook Sough outfall in 1974. *Photo: H.M. Parker.*

Fig. 4. Meerbrook and Cromford Sough systems.



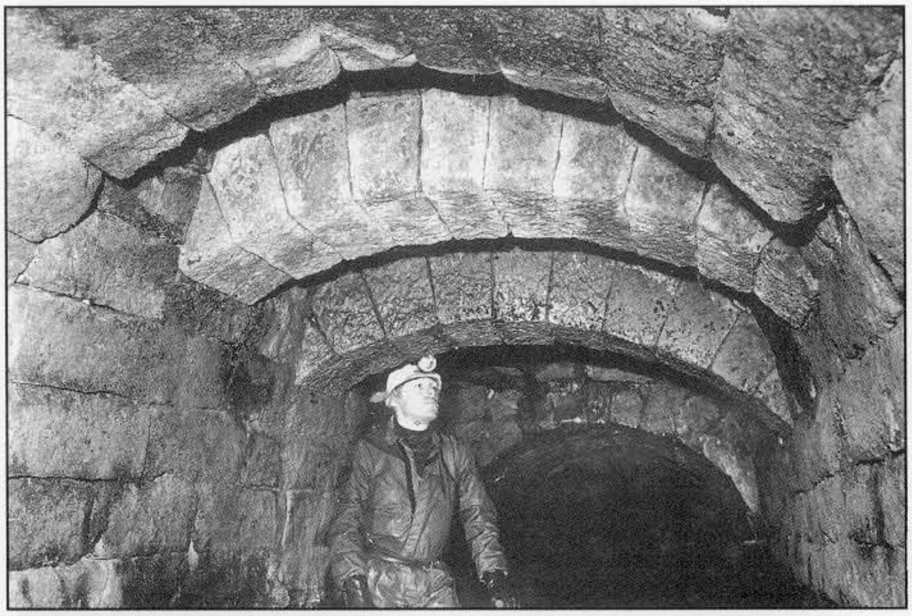


Plate 2. Hillcarr Sough, c. 1970. *Photo: Lawrence Hurt.*

ridden sadly away to arrange to use the Cromford Sough and Bonsall Brook as his water supplies. How he was to regret that decision.

Drainage of the lead mines was essential to reach the ore below the water table. Initially horse gins and water wheels were used and, later, steam and water pressure engines were brought introduced. But gravity drainage was preferred on cost and safety grounds. Soughs, near horizontal tunnels and channels, were driven from low points in river valleys to drain distant mines, often passing from one catchment to another. More than 200 soughs are known to have been driven in Derbyshire. The combined effect of these soughs is to divert much of the base flow of the rivers which cross the limestone into underground flow direct to the Derwent. As well as lowering the water table by often tens of metres, the soughs drain the limestone aquifer to the rivers much more quickly than would occur naturally. This makes the rivers more "flashy", and reduces the reservoir storage effect normally provided within the aquifer. In the Derwent catchment, the losses of natural storage are more than compensated for by the massive storage reservoirs in the Upper Derwent Valley and at Carsington. So the impact of the soughs on public water supply, at the strategic scale, is quite limited.

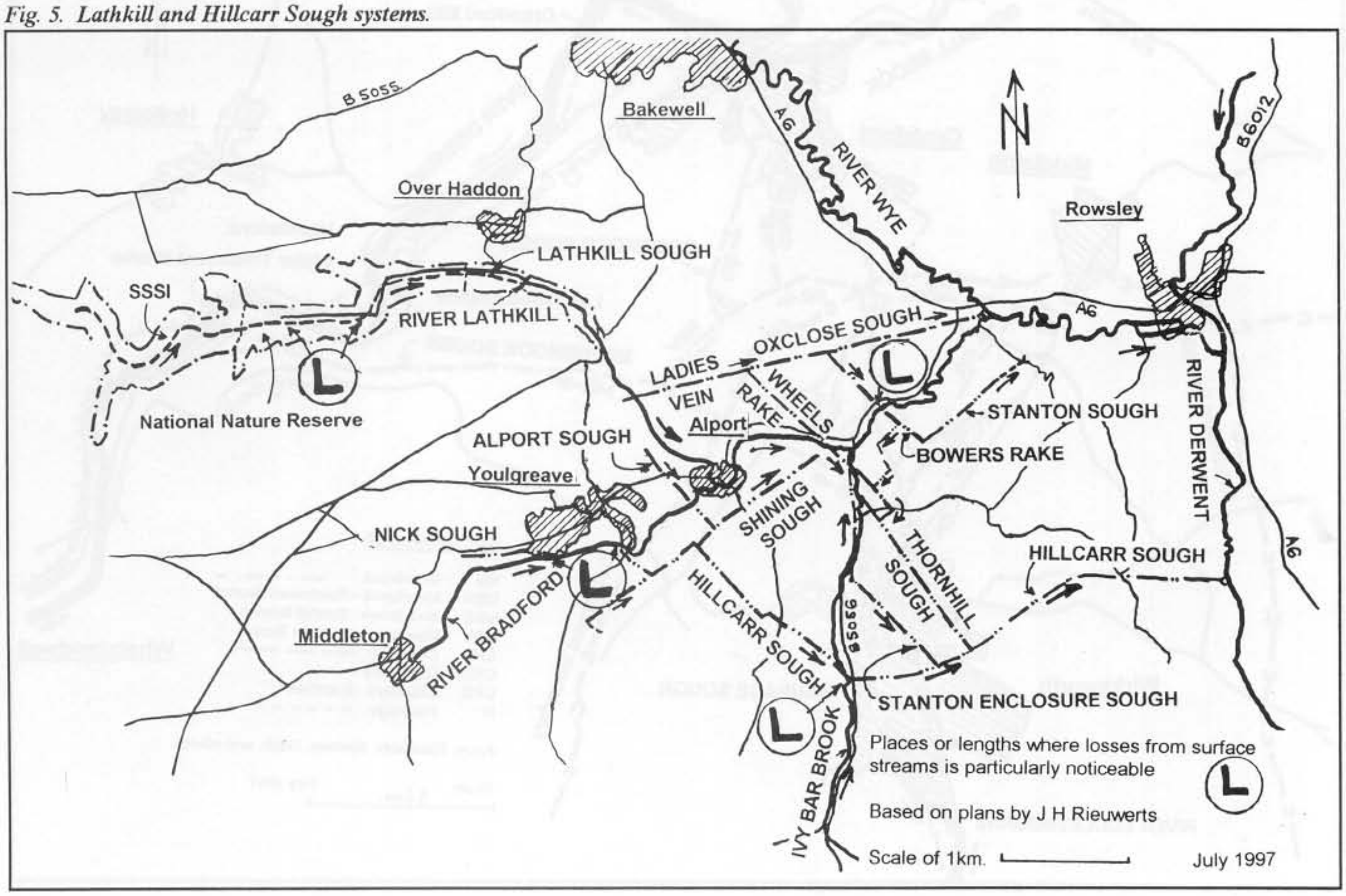
over the Carboniferous Limestones which provide a significant baseflow. It is in the limestone area that the lead mines are located.

Exploitation of the Derwent for public water supply has changed the character of the river from "a fury of a river" described by Daniel Defoe in the 1720s. The large impounding and regulating reservoirs have lopped off the very high and the very low rates of flow, possibly making the river less interesting. When Richard Arkwright was first considering Cromford as a site for a water -powered cotton mill, he is said to have ridden his horse down to the Derwent, looked at the turbulent flow, shaken his head, and

MEERBROOK SOUGH

Meerbrook Sough is different. This sough drains the Wirksworth

Fig. 5. Lathkill and Hillcarr Sough systems.



lead mines to the Derwent at Homesford. Immediately upstream of the sough tail Severn Trent Water Ltd. abstract, from an average total flow of about 75 million litres per day (Ml/d), 40 to 50 Ml/d for public water supply.

Meerbrook Sough was started in 1772 by a company of adventurers, the principal proprietor of the Meerbrook Sough Company being Francis Hurt of nearby Alderwasley Hall. The inscription on the arch keystone at the sough tail is "FH 1772". Francis Hurt owned many of the Wirksworth lead mines where many of the rich veins were submerged. It took the soughers until 1845 to reach Bolehill only two miles away from the sough tail, and construction continued on the main drive and branches until the 1880s. The eventual length of soughs draining to Homesford was about 8 kilometres (Fig. 4).

Meerbrook Sough reduced the flow in the River Ecclesbourne which naturally drains Wirksworth, and even took water from the River Dove catchment to the west. The sough drastically reduced the flow in the Cromford Sough on which Richard Arkwright was dependent to power his mills, and to supply water to Cromford Canal which had been built to transport finished goods to the buyers. After a bitter lawsuit between Arkwright and the Sough Company, two mills were abandoned and the Leawood pumping engine built to lift water from the River Derwent up to the canal.

After the end of lead mining the sough was purchased by the Ilkeston and Heanor Joint Water Board in 1903 as a reliable source of high quality water requiring little treatment. Ownership passed through South Derbyshire Water Board to Severn Trent Water.

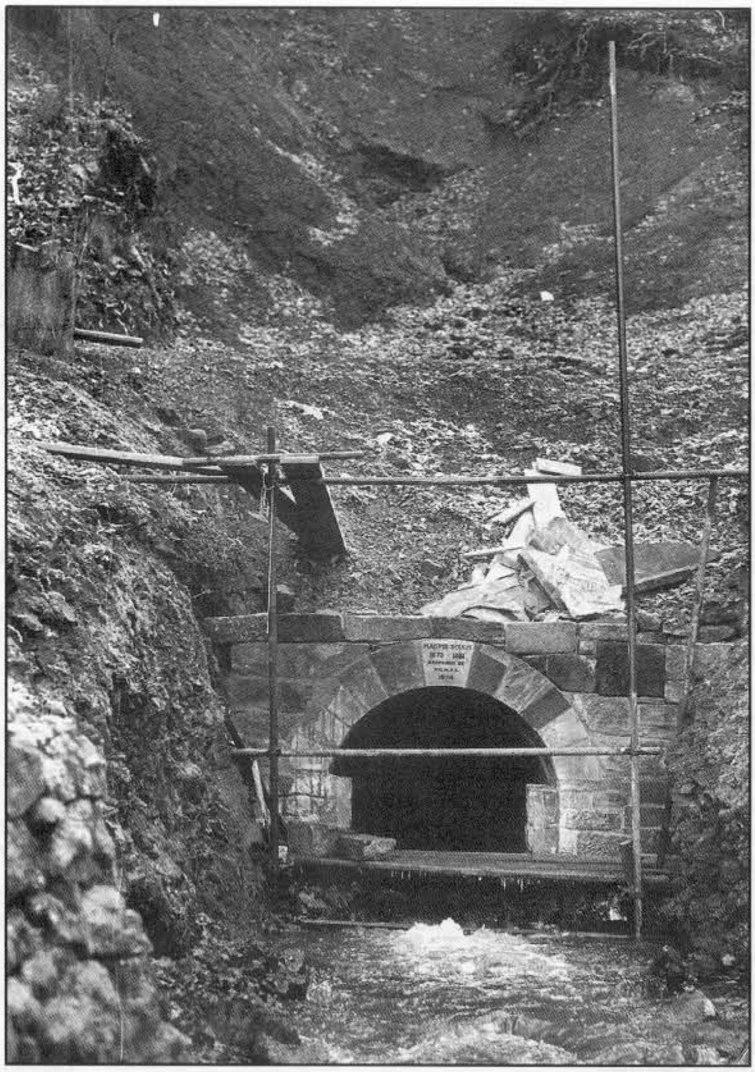
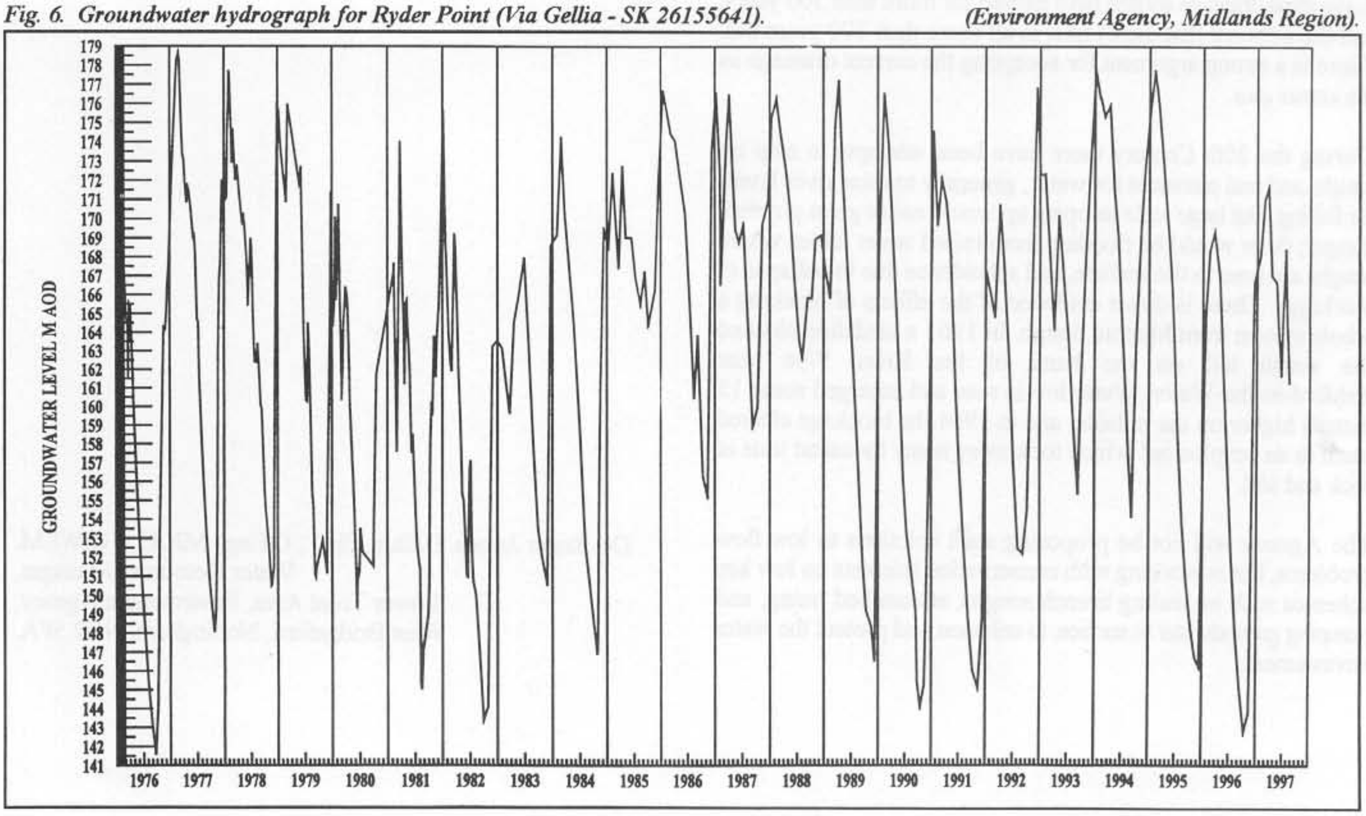


Plate 3. Magpie Sough during reopening by PDMHS in 1973. Water had "exploded" out of the shaft at top centre, removing thousands of tons of scree and spoil. Local newspapers blamed re-opening for the drying up of the River Lathkill - though its bed had, in fact, been dry for weeks! Photo: H.M. Parker.

Fig. 6. Groundwater hydrograph for Ryder Point (Via Gellia - SK 26155641). *(Environment Agency, Midlands Region).*



LOCAL EFFECTS OF SOUGHS ON THE ENVIRONMENT

The soughs may not affect strategic water resources, but the local and environmental effects are much more dramatic and problematic. The effects on the River Lathkill are a good example. The Lathkill is a tributary of the River Wye located on the limestone to the west of Bakewell (Fig. 5). Lathkilldale contains a river-based Site of Special Scientific Interest (SSSI). Part of the SSSI is a Special Area for Conservation (SAC), and part is a National Nature Reserve (NNR). The reasons for the Dale to have such status require there to be water in the river. For many decades the bed has been dry over some lengths through a combination of natural fissures and man made soughs, especially the Lathkill Sough.

Further downstream the Lathkill is affected by the extensive Hillcarr Sough system. This system was built to drain mines in the Alport area to the Derwent at Darley Dale. Significant losses of flow can be observed in streams where the sough crosses beneath them, and a good flow of around 30 Ml/d is maintained at the sough tail in dry weather.

Loss of flow in the Lathkill reduces the variety and numbers of species of fish, invertebrates and macrophytes, although Nature always compensates by an increase in other species. In Lathkilldale recorded losses include aquatic plants, invertebrates, crayfish (reason for SAC. designation), mayfly, dippers and grey wagtail; gains include Reed Sweet Grass (*Glyceria*).

Water tables in the limestone fluctuate rapidly and by many metres depending on rainfall, as is shown by the hydrograph record from the Agency's monitoring site at Ryder Point (Fig. 6). With a sough present as well as fissures, the stream flow can change from copious to a trickle, to dry, and back to copious, all within a few days.

REVERSING THE EFFECTS

Some mine drainage soughs have existed for more than 300 years, and the network that exists now is all more than 100 years old. There is a strong argument for accepting the current drainage as the *status quo*.

During the 20th Century there have been attempts to stop up soughs and seal entrances for water, generally to raise river levels for fishing. But large scale stopping up would cause great physical danger; there would be flooding from raised water tables where soughs are near to the surface, and subsidence due to collapse of workings. There is direct evidence of the effects of blocking a whole system from Magpie Sough. In 1961 a landslide blocked the sough tail on the bank of the River Wye near Ashford-in-the-Water. Water levels rose and emerged some 15 metres higher up the hillside, and in 1964 the blockage cleared itself in an "explosion" which took away many thousand tons of rock and soil.

The Agency will not be proposing such solutions to low flow problems, but is working with conservation interests on low key schemes such as sealing branch soughs, stream bed lining, and pumping groundwater to surface, to enhance and protect the water environment.

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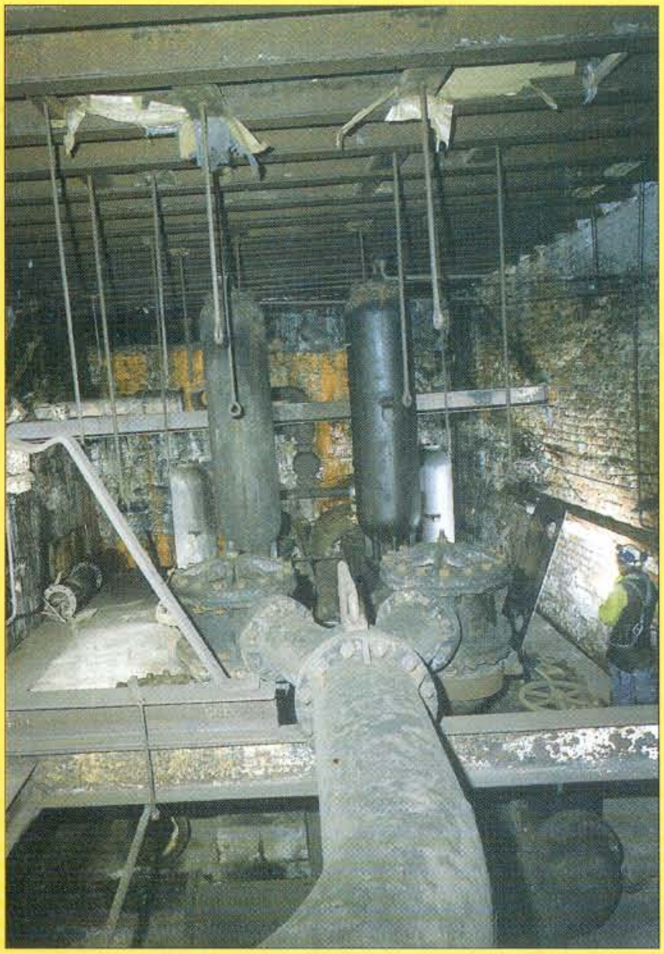

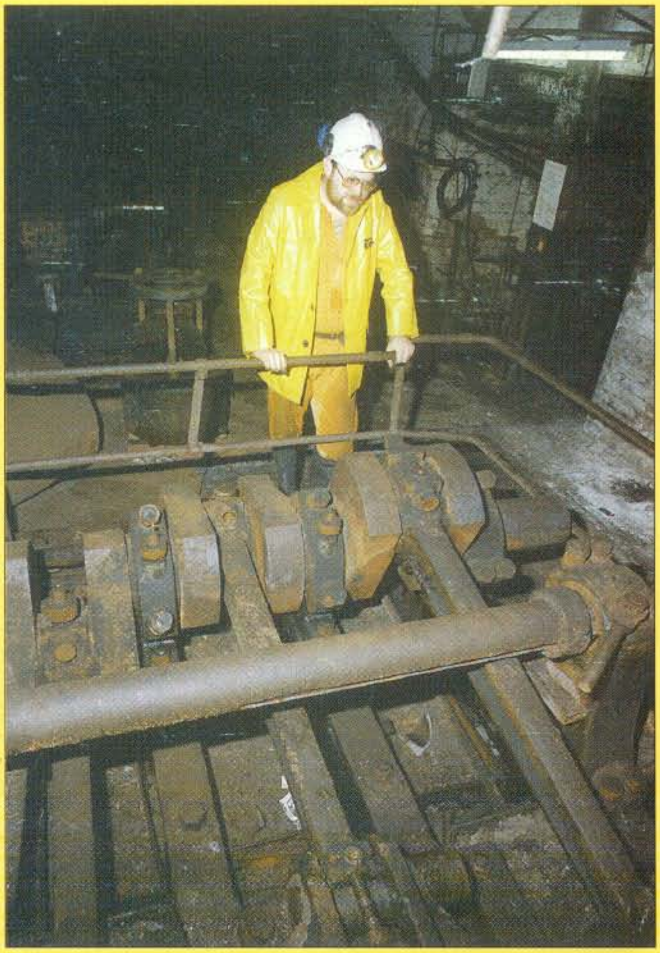

Mining for water: Manton Colliery, near Worksop: (top) Pumping chamber with late 19th century Joseph Evans' pumps., replaced by (right and below, left) ram pumps c.1940 and, in turn, (below right) c.1960 electrically driven cetrifugal pump. (Photos: Paul Deakin).