# Possible Environmental Impact of the Closure of Two Collieries in County Durham

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## ABSTRACT

In County Durham the forthcoming closure of two coastal collieries is, in effect, the final closure of a large hydraulically interconnected coalfield which has been progressively dewatered over three centuries. Groundwater will gradually rise through the previously worked strata after the cessation of coalfield dewatering. Past experience shows that the rising groundwater will develop high acidity and heavy metal loadings as oxidized pyrite remnants are dissolved. Conceptual modelling suggests that this acidic groundwater will ultimately discharge into the River Wear and its tributaries, with serious consequences for the aquatic ecology and human use of the River Wear system. Further environmental impacts may include (a) groundwater pollution in the adjacent Basal Permian Sands aquifer, (b) leaching from landfills intersected by the rising water table, (c) compromised integrity of foundations, (d) increased flows in old sewers below the new rest water level (leading to problems at sewage-treatment works and combined sewer overflows), (e) corrosion of other buried services, (f) surface gas emissions, and (g) long-term subsidence risk from old workings. The prevention of these impacts would involve long-term maintenance of regional dewatering, although local mitigation of most effects could be arranged – albeit at considerable cost. Current legislation fails to place responsibility for the prevention of such environmental impacts in the hands of any one organization; this 'vacuum of responsibility' needs to be addressed urgently if a pragmatic, consensual approach to environmental protection in abandoned coalfields is to be pursued.


*Key words:* Acidity; coal-mining; County Durham; environmental impact; groundwater; pollution prevention.

## INTRODUCTION

Coal mining has for centuries been synonymous with the north-east of England, and the expression 'like carrying coals to Newcastle' is still used in the English-speaking world as a description of a pointless exercise. At its peak, on the eve of the first world war, the north-east coalfield was indeed the most productive in the world, producing 56 million tonnes of coal per year with a workforce of more than 220 000[1]. However, the number of working mines was drastically reduced in several successive waves of mine closures during the 20th century so that by 1992 only five collieries remained in production in the north east, all of them producing coal from offshore workings accessed by coastal shafts. Nevertheless, the dewatering systems in the inland areas have remained in use to prevent groundwater flowing eastwards through interconnected old workings to these working coastal collieries.

In this paper attention is focused on the County Durham dewatering scheme, in which approximately 105 Ml/d are pumped from nine pumping stations in the exposed coalfield to protect two working coastal collieries at Easington and Seaham/Van Tempest (Fig. 1). The government announcements of October 1992 and March 1993 concerning plans to close many deep mines has prompted a preliminary appraisal of the potential environmental impacts of abandonment of the County Durham dewatering scheme. Conceptual modelling suggests that cessation of pumping will lead to the production of acidic groundwater with high metal loadings during water table rebound, and that the eventual emergence of such water at the surface in the Wear valley could have serious environmental impacts. The identification of these potential impacts, methods for their prevention or mitigation, and the administrative arrangements which successful prevention/mitigation will require, are discussed in this paper. While it is not claimed that the details of the scenario envisaged for County Durham are representative of possible conditions elsewhere in the UK, the range of possible environmental impacts could be used as a checklist in the development of detailed conceptual models for other coalfields.

## DURHAM COALFIELD HISTORY: DEWATERING AND WATER QUALITY

While the broad outlines of the development of the Durham coalfield, and by inference its dewatering scheme, are fairly easy to reconstruct, the evolution of water quality in the coalfield cannot be reconstructed so easily. Nevertheless, by collating the available data and other strands of evidence, a

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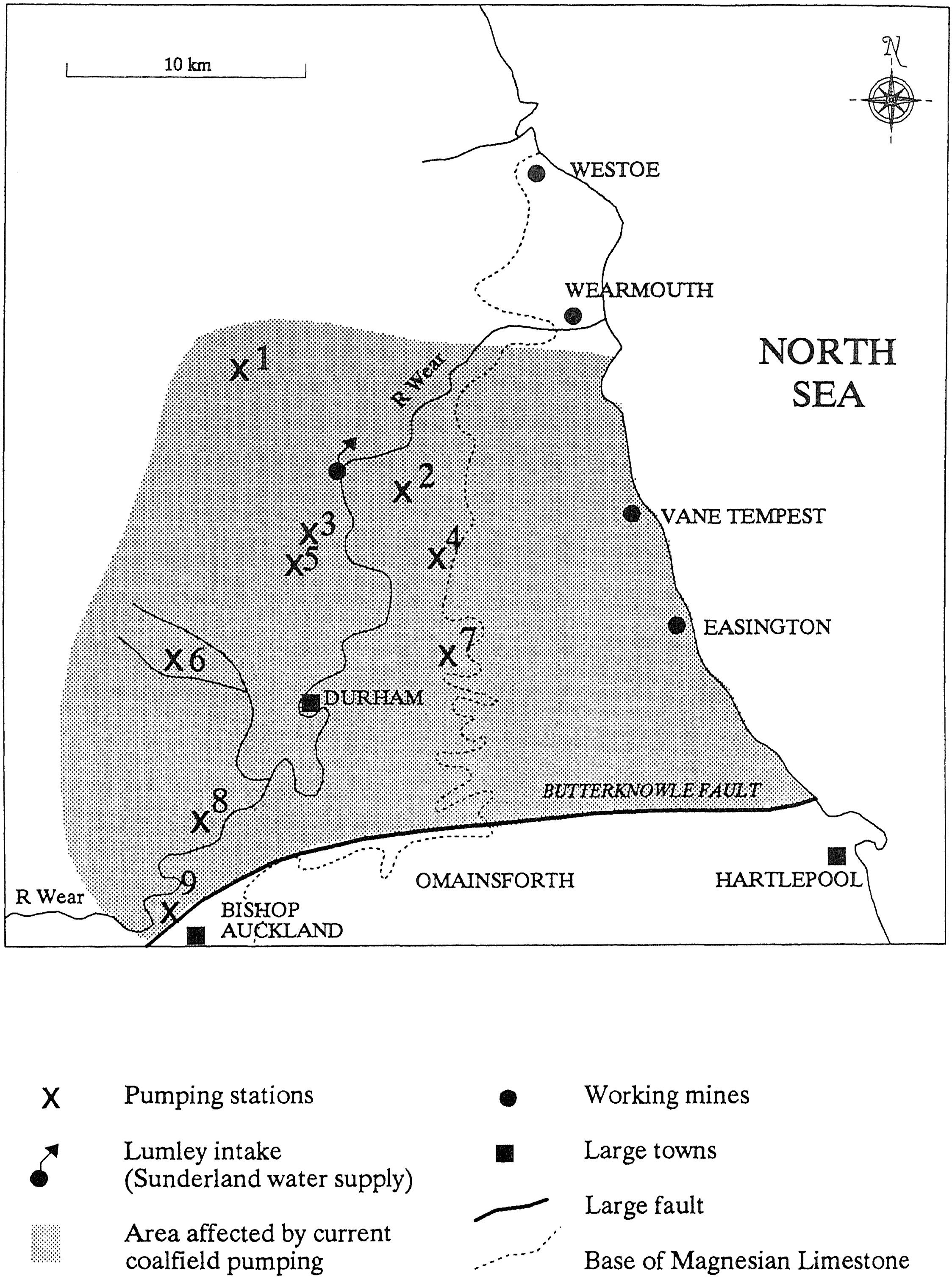


**Fig. 1. Durham coalfield showing areas affected by minewater pumping**

generalized picture of the hydrochemical history of the coalfield may be drawn up. The discussion which follows refers specifically to the area of the coalfield affected by the current dewatering system, unless explicitly noted to the contrary.

Before the onset of deep mining in the coalfield, there was no single water table within the Coal Measures; rather, the high degree of stratification in the geological sequence resulted in confined sandstone aquifers separated by shale and coal aquitards. There was very little meteoric groundwater circulation in this sequence, and much of the natural groundwater was highly saline (with total dissolved solids of up to 237 000 mg/l)[2]. Discharge of this groundwater gave rise to brine springs (flowing at up to 120 $m^3$/d) near Birtley (NS 275555), Lumley (NZ 290500), Framwellgate (near Durham City) and Butterby (NZ 284396)[3].

Disruption of this natural groundwater flow system commenced as early as 1644, which is the earliest reference to the 'deep mines of Harraton' (NZ 288538)[4], where a shaft was sunk to the Three-Quarter Seam. With the patenting of the efficient Newcomen pumping engine in 1712, the way was paved for the deepening of the mines and large-scale drawdown of the water table. The northern part of the area, as far south as Chester Moor (Fig. 1 and Table I), was extensively developed as early as 1800, and by 1825 mining development flanked the River Wear as far south as Butterby (NZ 284396). The most southerly part of the area (extending to Bishop Auckland and points west) experienced mining from 1825 onwards, with the most intense development after 1850. The concealed coalfield (where the Coal Measures are overlain by Permian strata) was progressively exploited after 1850 also, and Easington Colliery was sunk as late as 1890[5].

**TABLE I.** Pumping Stations in Coal Measures of County Durham

| Number on Fig. 1 | Site name | Grid reference | Discharge (Ml/d) |
|---|---|---|---|
| 1 | Kibblesworth | NZ 246 565 | 25.7 |
| 2 | Lumley 6th | NZ 310 507 | 2.9 |
| 3 | Chester Moor | NZ 269 493 | 8.6 |
| 4 | Nicholsons | NZ 329 483 | 3.1 |
| 5 | Kimblesworth | NZ 261 469 | 9.1 |
| 6 | Ushaw Moor | NZ 220 429 | 7.7 |
| 7 | Sherburn Hill | NZ 335 428 | 6.2 |
| 8 | Page Bank | NZ 231 358 | 11.8 |
| 9 | Vinovium | NZ 210 321 | 21.6 |

Information derived from published data[6].

The gradual disruption of the natural groundwater flow system was virtually complete by about 1870, by which time the brine springs listed above had ceased to flow[3] (although saline waters of the type which formerly discharged in these springs still persist in the deepest levels of the current mine workings[2]). Progressive dewatering of large areas of the coalfield was facilitated as adjacent mines became interconnected underground. In the northern part of the present area alone, the Lambton Coal Company had fifteen mines by 1911, most of which are said to have been interconnected at depth. It has been claimed that such interconnections have produced subsurface hydraulic continuity over distances as great as 50 km[6].

For over three hundred years, therefore, the exposed coalfield of County Durham has been progressively dewatered, and the current pumping levels represent the ultimate drawdown for the coalfield as a whole. A comparison of plans and figures published in 1973[7] and 1989[6] shows that the total quantity of water pumped in the exposed coalfield has remained constant for at least twenty years, even though the total number of pumping points has been reduced from 32 to 9 over the same period as mines have closed. Reflecting this steady pumping rate, groundwater levels in the dewatered area of the exposed coalfield are essentially stable[6] and lie up to 150 m below ground level in the northern part of the dewatered zone (around stations 1 and 2 in Fig. 1). Table I details the locations and mean pumping rates of the nine current pumping stations shown on Fig. 1. These stations discharge into the River Wear and its tributaries (with the sole exception of the Kibblesworth station which discharges into the River Team, a tributary of the Tyne), and they represent a substantial portion of the total flow of the Wear (particularly during dry spells when they may amount to almost 50% of the total flow at Lumley).

In detail, the current dewatering scheme is best envisaged as a series of adjacent ponds, each of which must be prevented from overspilling into the next if flooding in the final pond (the current coastal workings) is to be avoided[6]. Thus a southerly pond around Bishop Auckland is kept in check by pumping at Vinovium and Page Bank; if this was allowed to overspill into the central pond around Chester-le-Street, this central pond would itself overspill into the eastern pond (underlying the Magnesian Limestone), which is connected to the coastal collieries at Easington and Seaham/Vane Tempest. The Kibblesworth pumping station apparently controls a large northern pond in old workings beneath the Team-Derwent watershed; hydraulic connection is also known to exist between this northern pond and the central pond around Chester-le-Street.

Water quality variations during this history of dewatering are poorly documented. However, it is clear that the ingress of fresh surface waters when the workings were active in the exposed coalfield led to the production of acidic mine-drainage waters. Fluctuations in water levels within the mines, which were often quite marked during working, favoured

**TABLE II.** Water Quality of Current Pumped Discharges

| Site name | pH | TDS (mg/l) | Condcutivity (μS/cm) | Total iron (mg/l) | Total zinc (mg/l) | Sulphate (mg/l) |
|---|---|---|---|---|---|---|
| Kibblesworth | 7.1 | 3185 | 4900 | 0.630 | 0.056 | 690 |
| Lumley 6th | 7.1 | 2700 | 3400 | 1.110 | 0.003 | 500 |
| Ches*er Moor | 7.2 | 3140 | 3410 | 0.800 | 0.024 | 820 |
| Nicholsons | 7.1 | 3100 | 3620 | 5.800 | 0.034 | 1170 |
| Kimblesworth | 7.3 | 1800 | 1960 | 5.000 | 0.030 | 380 |
| Ushaw Moor | 6.9 | 1000 | 1366 | 0.865 | 0.060 | 580 |
| Sherburn Hill | 7.3 | 2090 | 2380 | 8.600 | 0.035 | 840 |
| Page Bank | 6.8 | 1930 | 2300 | 0.745 | 0.019 | 775 |
| Vinovium | 6.9 | 1560 | 1847 | 1.250 | 0.049 | 600 |

Information collated from entries on the public register of the National Rivers Authority. TDS = Total dissolved solids. Conductivity at 20°C. Wherever possible, all results are from the same sample; however, some data are from different sample entries, screened for their consistency with the time series as a whole.

the flushing of pyrite oxidation residues into solution, with the concomitant lowering of pH to 4 or less, and the transport of high concentrations of dissolved iron and other metals. Indications of the quality of water during active working are preserved (to give but one example) in the impressive mound of ochre (iron (III) hydroxide) deposits in the bed of the Lumley Burn around the former drainage outfall of the Lumley 6th Pit (NZ 309509), which attests to the former transport of high concentrations of iron in the acidic mine waters. By contrast, the water produced by the modern pumped discharge at Lumley 6th, which is part of the regional dewatering system (Tables I & II; Fig. 1), is of neutral pH and is depositing little or no ochre at present.

The instance of Lumley 6th illustrates the general observations that (i) acidic drainage can develop in active workings subject to fluctuating water levels, and (ii) groundwater quality in mined Coal Measures may be relatively good when drawdown is held steady for many years at or near the base of historic working depth. This second point is illustrated by Table II which gives some representative hydrochemical results for the nine current pumping stations in the exposed Durham coalfield (where drawdown has been essentially stable for several decades)(6). All the stations produce waters of neutral pH with fairly high total dissolved solids (TDS), and notably high sulphate concentrations. These high-TDS inputs to the Wear system have a cumulative impact on the overall TDS levels of the River Wear; downstream from the lowest outfall, the TDS of the River Wear range up to 800 mg/l, a value which is markedly higher than those encountered in the neighbouring Rivers Tyne or Tees.

Experience to date in southern County Durham (just outside the regional dewatered zone) is consistent with the model of hydrochemical evolution just described, and also allows extension of the model to include predictions of what will happen when dewatering ceases and water table rebound occurs. Investigations(8) at Mainsforth colliery (NZ 312310) (Fig. 1) during the years immediately preceding its final closure in 1976 showed that the water discharged during the maximum extension of mining (i.e. when the water table had been pumped down to its lowest level) was of relatively good quality, with total iron generally less than 1 mg/l and total dissolved solids less than 1300 mg/l. However, when the water table was allowed to rise and flood successively higher levels of former workings in the pit (beginning in mid-1973), the water quality deteriorated rapidly, with total dissolved solids >3500 mg/l, total iron >100 mg/l and sulphate concentrations ≤1300 mg/l. When pumping resumed with the water table at the higher levels, the water produced was so acidic and heavily laden with iron that it caused serious degradation of the tributary of the River Skerne to which it was discharged(7).

A gradual improvement in quality was noted when the water levels were subsequently held steady by pumping, further supporting the model outlined above. However, it is important to note that the improvement in water quality was very slow, and many decades would have been required before the pH and iron loadings approached pre-rebound values. Similar experiences in Scotland(9,10,11) have also shown a gradual, though very slow, improvement in water quality after rebound has occurred. The Scottish studies also serve to confirm that the first flush of acidic ferruginous discharge at the surface, when water table rebound is complete, is at a higher flow rate and of considerably poorer quality, than the long-term ferruginous discharge. In the Mainsforth example, the colliery lies south of the Butterknowle Fault (Fig. 1), which is a major barrier to groundwater flow in the Durham coalfield, and the final water table rebound had the effect of feeding water into the overlying Magnesian Limestone Aquifer, in which the low pH values were presumably quickly buffered by reaction with calcite and dolomite. Regional groundwater levels in the Magnesian Limestone increased by as much as 10 m over an area of 4 km radius around Mainsforth, as evidenced by the hydrograph of the

Rushyford broehole (NZ 28752896) held in the national groundwater archive at Wallingford[12]. Thus a polluting surface discharge was probably averted by fortunate geological circumstances.

## CONCEPTUAL MODEL FOR CESSATION OF DEWATERING IN COUNTY DURHAM

The Government's white paper on the future of the coal industry released in March 1993[13] signals the forthcoming end of mining activity in east Durham: Seaham/Vane Tempest colliery is to close in the immediate future and Easington colliery is to be placed in care and maintenance for an unspecified period. As the entire County Durham dewatering scheme will continue to operate solely as part of the care and maintenance scheme for Easington colliery, and no coal production will take place to defray the costs of pumping, it might be reasonably anticipated that the stay of execution for Easington will be brief. In October 1992, British Coal signalled their intention to cease all puping in the area when the last mine closes, remove all pumps and backfill the shafts. In lieu of any changes in plans, therefore, three hundred years of progressive dewatering in County Durham will come to an abrupt end in the near future.

Fig. 2(a) is a schematic cross-section across the dewatered zone from the vicinity of Lumley to the coast between Seaham and Easington, showing the current water levels maintained by pumping within the coastal workings and at the nine stations listed in Table I. The water table elevation is plotted using the most recently published data[6]. If all the pumping is discontinued, recharge from rainfall on the exposed coalfield will continue to enter the Coal Measures, leading to a gradual rise in the regional water table. At first, this will lead to the development of an eastward flow of groundwater from the central pond around Chester-le-Street as the deep depressions in the water table in the eastern pond around Easington fill first (Fig. 2(b)). After some time (possibly a decade or more) the rising water table will intersect the base of the overlying Magnesian Limestone, which contains its own regional groundwater flow system.

Although considerable fracture-controlled leakage from the Limestone into coal workings has been noted at Mainsforth[8] and Westoe collieries[14], there does not appear to be much scope for the reverse process (flow from Coal Measures into the Limestone) to happen in the Easington District, since the hydraulic connection between the two geological units is not very great. This is evidenced by:

*(a)* The existence of the 'perched' groundwater flow system in the Limestone – it is clearly easier for water to flow laterally in the Limestone than vertically into the Coal Measures; and

*(b)* Observations of British Coal that very little water enters the Easington workings from the Limestone[15].

Apart from leakage into the Limestone, which will be insufficient to prevent continued head build-up in the Coal Measures, there remains the possibility that the few unsealed shafts and ventilation tunnels along the coast might transmit sufficient water to prevent the build-up. However, the mined Coal Measures are unlikely to be sufficiently permeable that they could efficiently transmit all the regional groundwater flow to a few gravity discharge points on the coast. Permeabilities of about 4 m/d have been measured in mined Coal Measures north of the Tyne[16]; such values are sufficiently low that groundwater velocities on a macro-scale will be fairly low (mm or cm/day) under regional hydraulic gradients after cessation of pumping.

As neither leakage into the Limestone nor discharge from coastal shafts will be sufficient to prevent build-up of head in the Coal Measures, logic suggests that the rising water table will finally be arrested only when low-lying discharge areas are intersected. The most obvious of these is the Wear valley (Fig. 2(c)), and in the long-term discharges by diffuse seepage and point leakage (around old shafts, adits and/or fractures which have developed during mining subsidence; cf the account of Henton[9]) are predicted to occur thoughout the Wear valley from west of Bishop Auckland to the western outskirts of Sunderland (where the Magnesian Limestone enters the river bed). The time-scale necessary for total rebound to occur, and therefore for the full discharge of mine waters in the Wear valley to be established is necessarily on the scale of decades (though initial localized breakthroughs could occur much sooner).

Preliminary calculations using a long-term recharge rate of about 60 Ml/d for the outcrop area and a void space of $6 \times 10^8$ m$^3$ for the mined-out Coal Measures, the total recovery is predicted to take around 30 years. The equilibrium discharge to the River Wear system is predicted to approximate to the natural recharge rate or the current pumping rate, i.e. to fall in the range 60–100 Ml/d.

Recalling the model for hydrochemical evolution of coalfield waters outlined above, it is important to stress that the water produced by pumping during steady dewatering (Table II) is relatively good compared with the highly acidic and metal-rich waters which can reasonably be expected to develop during water-table rebound[9,18,19]. This is simply because the circulation of air in the mine during coal-working allows oxidation of pyrite in the Coal Measures, so that it is readily soluble to form sulphuric acid when the water table rises through the old workings. Thus the discharges from the present pumping stations (Table II) are not a particularly

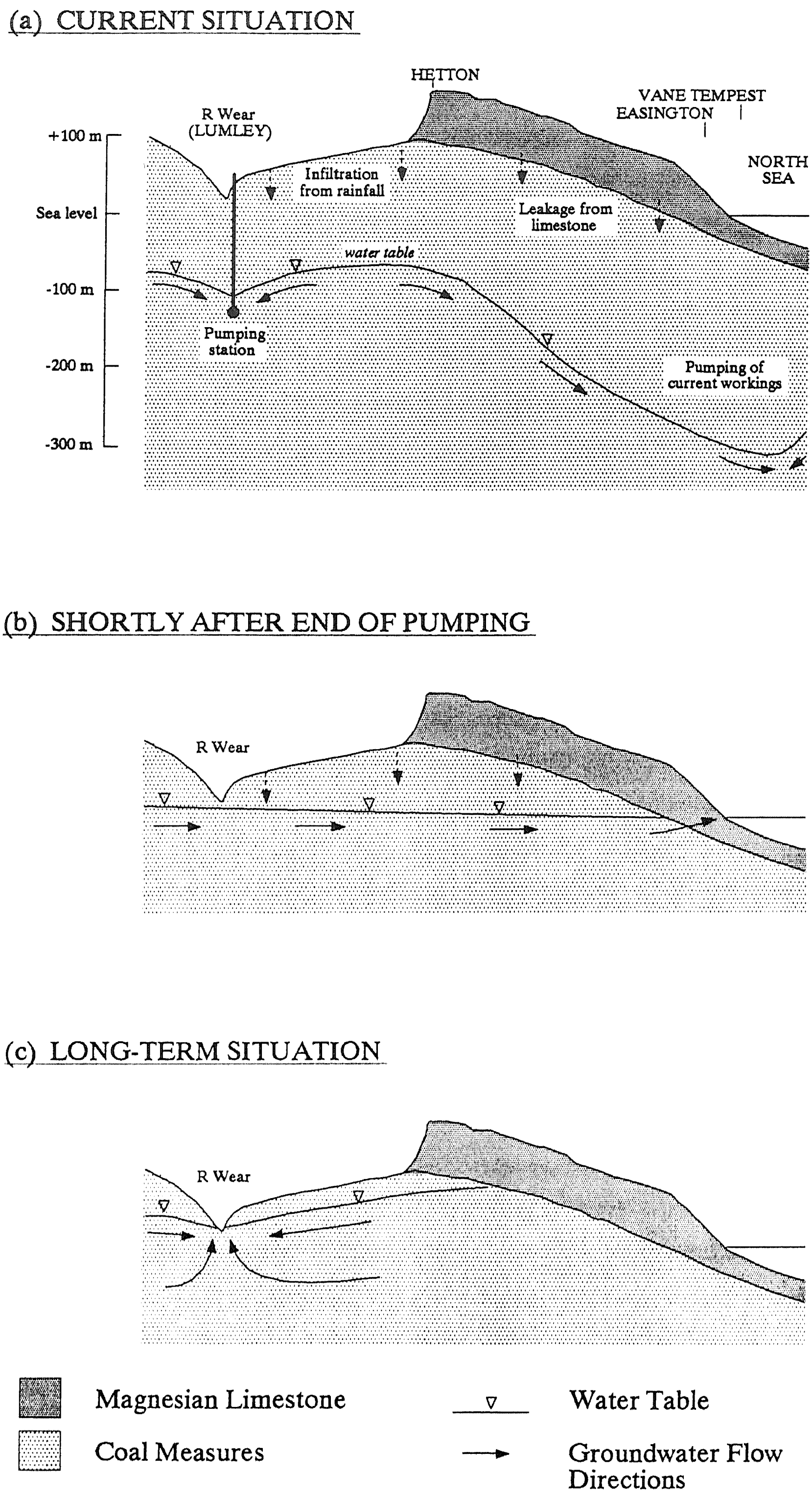


**Fig. 2. Conceptual model of hydrological changes upon cessation of minewater pumping in County Durham**

good guide to the quality of water which is predicted to discharge in the Wear valley some years from now.

By analogy with the published water quality data for Mainsforth and for various other sites in the UK[8,9,10,11,17,18] and the US[19], the first-flush discharges can be expected to have low pH (<4), up to 2000 mg/l total iron, perhaps as much as 100 mg/l of other heavy metals, and sulphate concentrations in excess of 1000 mg/l. After the peak loadings of the first-flush, the concentrations of the species noted above will probably drop to lower (though still very high) levels, and over a period of several decades (perhaps a century or more), quality will gradually improve until the state of the River Wear finally begins to approximate to that of the present day.

To fully predict the processes and patterns of water-table rebound in a system as complex as the Durham coalfield, the conceptual model outlined above ought to be translated into a numerical model which could be used to:

(i) Check the consistency between concepts and available data; and
(ii) Investigate (by sensitivity analyses) where our lack of knowledge poses the greatest limitations on our ability to predict water table rebound and acidic discharges. This could be a useful guide in the design of long-term monitoring strategies.

In a separate study, the National Rivers Authority recently commissioned some preliminary modelling work on the problem of water-table rebound in County Durham[20]; the conceptual model developed in that study is similar to the one outlined here. Hopefully, extensions of this work in the future will aid in the formulation of strategies for the prevention and/or mitigation of adverse environmental impacts.

## ENVIRONMENTAL IMPACT, PREVENTION, MITIGATION

Wherever rising groundwater levels occur, a number of environmental problems might be anticipated; most of these have been reviewed recently by Brassington and others[12,21]. In the case of County Durham, however, the groundwater quality which will develop during water-table rebound leads to a number of problems not encountered where rising groundwater is of good quality. Again previous experiences in Scotland[9,10,11,18] are a useful guide in preparing a catalogue of potential problems in County Durham.

Table III lists a number of environmental impacts which may arise from water-table rebound in County Durham, along with techniques for the mitigation of these effects. Perhaps the most critical of all the potential impacts (and certainly the most visible) is the polluiton of the River Wear and its tributaries, which can be expected to have serious consequences for the ecology of the river[22], and could render the public water supply intake at Lumley unusable. North East Water would have to seek alternative resources to make up the potential 20% shortfall in the supply to the City of Sunderland; indeed the shortfall could be even greater if some of their public supply wells to the south of Sunderland (which penetrate the Basal Permian Sands Aquifer) were also rendered unusable by the ingress of polluting Coal Measures water.

With regard to groundwater pollution, the Basal Permian Sands (which locally lie between the Coal Measures and the Magnesian Limestone Aquifer) are clean quartz sands which are highly permeable but (unlike the Limestone) have little or no natural buffering capacity. Thus Coal Measures water rising into these sands could cause significant pollution (Table III). As regards the Limestone itself, the experience in the Mainsforth area[8,12] illustrates that the Limestone can buffer invading Coal Measures water (though there must be some fear of the persistence of high sulphate concentrations) and the cessation of dewatering might locally add to the total resource in the aquifer. Indeed, the long-term effect of the rise in the water table near Mainsforth has been gradually to increase the baseflow from the Limestone into the River Skerne, improving water quality by adding to the flow available for dilution of sewage effluents.

Subsidence risk will be increased only where old 'bord-and-pillar' workings are intersected by the rising water table. This appears to be happening already in the area around Tynemouth, where water table rebound commenced some years ago. Areas where all mining has taken place by longwall techniques are not expected to show any further subsidence as a result of water-table rebound.

Other long-term envrionmental problems associated with the aftermath of mining include problems of landscaping and re-using former pit-heaps and pit yards. Except where old shafts become the foci for acidic discharges, these environmental problems are largely independent of whether or not water-table rebound occurs. One hazard associated with landscaping old pit heaps has come to light lately at the former Watergate Pit near Gateshead (NZ 226602). At this site, a pit heap which was abandoned in the early 1980s suddenly caught fire by spontaneous combustion in 1991. Two years later, after receiving a derelict land grant from the Department of the Environment, Gateshead Council have begun a remediation programme involving controlled excavation and burn-out of the heap section-by-section.

While localized mitigation/remediation methods are listed in Table III, it must be stressed that prevention is better than cure, but this can only be ensured by the indefinite continuation of pumping in the exposed coalfield. In designing appropriate long-term pumping strategies, it would be important to

TABLE III. POSSIBLE ENVIRONMENTAL IMPACTS OF WATER TABLE REBOUND IN DURHAM COALFIELD

| Impact | Consequences | Mitigation |
|---|---|---|
| Pollution of River Wear and tributaries | 1. Could render public water supply intake at Lumley unusable<br>2. Serious reduction in biodiversity leading to absence of fish<br>3. Loss of amenity value and use of river for contact sports<br>4. Potential hazards to livestock | Localized controls of discharges by installation of retention and treatment facilities |
| Groundwater pollution in adjacent aquifers (in particular the Basal Permian Sands and localized Quaternary Sand and Gravel) | 1. Long-established public supply wells near Easington may become unusuable<br>2. Private springs and boreholes in Quaternary deposits may become unusable | 1. Partial backfilling of public supply wells (albeit with consequent loss of yield)<br>2. Source replacement for small private sources |
| Intersection of landfills, foundations, sewers and buried services by risen water table | 1. Leaching of metals and other species from landfills which were formerly above the water table (Wear valley and Team valley)<br>2. Increased flows (with poor quality water) in old sewers in low-lying areas (Durham, Chester-le-Street, Team valley?), leading to problems at treatment works and at storm overflows<br>3. Acidic high-sulphate groundwater may attack Portland cement in foundations, and otherwise cause buoyancy related problems (same urban areas) | Localized dewatering schemes in vulnerable areas. |
| Subsidence | 1. Rising groundwater in old 'bord-and-pillar' workings can lead to slaking of seat-earths and other incompetent lithologies, leading to collapse of old pillars and shafts | Local grout injection at new development sites and in urban areas where problems develop |
| Surface gas emissions | Some methane and carbon dioxide may be forced out at the surface ahead of the rising water table | Venting schemes using old shafts and purpose-drilled boreholes; difficult to predict optimum siting. |

recall that even partial recovery of the water table will generate acidic waters which would require treatment before discharge. Therefore, the reduction in pumping costs gained by allowing a partial recovery in levels (albeit below the river bed) might be offset by the increased costs of treatment (at present the pumped waters listed in Table II are suitable for discharge without treatment).

If long-term pumping is deemed too expensive, then other options are:

*(a)* To allow water-table rebound to occur in an uncontrolled manner, and face the consequences listed in Table III, with localized attempts at mitigation of environmental impacts where problems arise. It must be noted that mitigation of the major problems of surface water pollution is unlikely to be satisfactory; attempts to mitigate a previously uncontrolled acidic mine discharge from the abandoned Dailly coalfield in Ayrshire have met with little success[11]; and

*(b)* To undertake a phased shutdown of the dewatering scheme, allowing each pond to overspill to the surface in turn, so that the total loading entering the River Wear during any period is never overwhelming. Pumping could continue for many decades in neighbouring ponds until the ferruginous discharge from the latest closed pond has declined to tolerable levels. In the long term, all pumping would cease, though the entire shutdown process may take over a century. It is hard to envisage any other shutdown strategy which will neither cause considerable deterioration of the environment in County Durham, nor incur the considerable costs of pumping and treating water after partial water table rebound.

## VACUUM OF RESPONSIBILITY

The prevention of environmental degradation when coalfields are closed presupposes that some organization has formal responsibility, and suitable funding, to undertake the necessary prevention/remediation works. Unfortunately, the current administrative framework in the UK for the prevention of pollution after coalfield closure is far from clear. This has led to the development of a vacuum of responsibility in which the organisations with a major interest in the issue (British Coal, National Rivers Authority, Department of the Environment, Department of Trade and Industry) are all apparently declining to accept or apportion responsibility.

With regard to British Coal, the relevant legislation can be read as encouraging the Corporation to presume that they bear no legal responsibility for the environmental consequences of the cessation of dewatering. For instance, the Environmental Protection Act 1990 exempts mining operators from the long-term 'duty of care' imposed on other industrial land users. Furthermore, British Coal could defend itself against prosecution under s. 85 of the Water Resources Act 1991 (which prohibits 'causing or knowingly permitting' river pollution) by citing s. 89 of the same Act, which exempts 'permitting' discharge from abandoned mineworkings from liability under the Act. Whether 'causing' pollution by stopping pumping could be found to be an offence is far from clear, although limited case law suggests that this may be the case; the appeal decision holding the then National Coal Board responsible for 'causing' pollution at Dalquharran, Ayrshire, by discontinuing a dewatering programme(11) sets a precedent which does not favour the notion that British Coal has no liability under current legislaton(23). This is small comfort, however, since prevention must be preferred to cleaning up after the onset of pollution.

The National Rivers Authority (NRA) has made few public statements on the issues so far, and it is presumed that internal discussions must still be in progress. However, in a BBC North-East television interview on 8 February 1993, an NRA spokesman indicated that the Authority regards British Coal as responsible and would seek changes in relevant legislation if necessary.

The Department of Trade and Industry received several submissions from local authorities(24) and others during the Coal Review suggesting that the costs of pumping to prevent environmental degradation in County Durham should be taken into account when the economics of Easington and Vane Tempest collieries were assessed. The outcome of the review suggests that these issues were not considered relevant (neither colliery was given a total reprieve), and when the Coal Review White Paper finally appeared in March 1993, the only references to environmental issues were brief statements noting that a reduction in coal burning for power generation will help to reduce atmospheric emissions of $CO_2$ and $SO_2$; there is no mention of potential acidic mine-drainage problems(13).

The views of the Department of the Environment are presumably represented by the answer to a parliamentary question given by Mr Maclean, the Environment Minister on 17 February 1993, to the effect that '. . . *It is for British Coal and the National Rivers Authority . . . to consider what action may need to be taken to avoid pollution . . .*'(25).

As each organization passes responsibility to another, the circle is completed and the vacuum of responsibility remains unfilled. This situation would be perplexing enough if the shortcomings in legislation had only just been realized; however, as long ago as 1973, the then Northumbrian River Authority was concerned about this same vacuum of responsibility. Planning ahead for the day (now rapidly approaching) when the dewatering scheme would be shut down, they wrote that:

> '. . . *no clear responsibility exists under present legislations for the treatment of minewater discharges . . . these problems have been raised at a national level . . . with central Government Departments. As yet, however, no satisfactory solutions have been found . . .*'(7)

Twenty years later, 'satisfactory solutions' are still awaited.

## TOWARDS A CONSENSUS

In an increasingly litigious culture, talk of using test cases as a means of determining responsibility for minewater discharges is already to be heard in some quarters. However, there are two obvious problems with adopting such a confrontational approach to pollution control:

(i) A test case can only be heard when pollution has already commenced, and it is therefore of no use in preventing pollution in the first place; and
(ii) The considerable skills, experience and energy of British Coal would be squandered in defending court cases rather than in working cooperatively with other institutions in the planning of cost-effective pollution control strategies.

At a philosophical level, the 'polluter pays principle' is not ideally suited to a situation which has developed over more than three hundred years, in response to national needs and priorities. British Coal has merely inherited the unconscious 'sins' of our forefathers. It therefore seems unfair (as well as counter-productive) to attempt to attach strict liability for any problems which may arise to British Coal.

The ideal outcome would be for the Government to clear the air by explicitly granting responsibility and funding to some public body (be it British Coal, the NRA or some other organization) to coordinate the environmentally sound decommissioning of the coalfields. Research, planning, monitoring and engineering for the prevention and/or minimization of pollution and other environmental impacts could then be undertaken in an atmosphere of consensus, drawing upon the skills, experience and data of British Coal, the NRA, the British Geological Survey, Department of the Environment, Department of Trade and Industry, the academic community and consultancies.

Failure to resolve these administrative problems will mean that local authorities, water companies, developers and the inhabitants of the coalfields will be left to pay for the clean-up of problems which arise in years to come. This would not be particularly just, as the coalfields developed over hundred of years in response to **national** needs and priorities. As many of the coalfields are in areas of the country which already have Assisted Area status, the means to pay for environmental protection may in any case be unavailable locally without central government intervention.

## CONCLUSIONS

1. More than three hundred years of progressive regional dewatering of the Durham coalfield are set to come to an end when Vane Tempest and Easington collieries are closed in the near future.
2. Basic conceptual modelling suggests that water-table rebound will occur over a wide area, with the following potential environmental impacts:
   - *(a)* Surface water pollution in the Wear catchment;
   - *(b)* Groundwater pollution in adjacent aquifers, particularly the Basal Permian Sands;
   - *(c)* Leaching from landfills intersected by the rising water table;
   - *(d)* Compromised integrity of foundations and underground services, with sulphate-rich minewaters attacking Portland cement;
   - *(e)* Temporarily increased risk of surface gas emissions; and
   - *(f)* Long-term subsidence risk as old bord-and-pillar workings are rendered unstable by invading water.
3. Effective pollution prevention presupposes that the current administrative vacuum of responsibility will be filled by the appointment of some public body as the appropriately financed environmental caretaker of the abandoned coalfields.
4. Failure to respond to this challenge will leave local authorities, water companies (and thus their customers), developers and individual property owners to pay for a situation which developed in response to **national** needs and priorities over several centuries.

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