IMC

IMC Consulting Engineers

Report

on

Minewater Recovery

in

Northumberland South of the Stakeford Dyke

for

The COAL AUTHORITY

7207/3

February 2001

CONTENTS

APPENDICES

1.0 INTRODUCTION

The monitoring of minewater recovery in the abandoned mine working in Northumberland south of the Stakeford Dyke has shown that all the collieries are hydraulically connected and recovering as a single unit. Forward projection of the exponential recovery curve indicates that unless suitable measures are taken surface discharges of minewater are likely to occur by 2004. The area where these gravity discharges are most likely to occur are the low lying ground in Blyth, the coast adjacent to Seaton Sluice (IMC 1996) and the Tyne Valley near Newcastle.

This report was requested by the Coal Authority to look in detail at the mining connections in the area, the potential surface outflow points and to investigate the alternative methods of controlling the minewater recovery so as to prevent surface minewater discharges. The report also looks at the requirements for minewater treatment to meet anticipated discharge consents and the likely effects of minewater recovery on the adjacent mining areas.

The monitoring of minewater levels at Algernon Colliery south of the Ninety Fathom Fault suggests that this area is hydraulically connected to the zone between the Ninety Fathom Fault and Stakeford Dyke and any assessment of the requirements for minewater control in the area between the Stakeford Dyke and Ninety Fathom Fault must also include this area south of the Ninety Fathom Fault.

2.0 AREA OF INVESTIGATION

2.1 Mining Areas

The area investigated in this report is defined by the Stakeford Dyke to the north, the outcrop of the coals to the west and the mining barriers around the Algernon/Rising Sun/Hebburn block to the south. (Figure 1)

The Stakeford Dyke is known to be an effective barrier by comparison of the water levels in the mines south of the dyke and the water levels north of the dyke which are controlled by the pumping from the Ellington and Lynemouth complex operated by RJB Mining (UK) Ltd. (Report on the Closure of Ellington Combine). At Ashington and Newbiggin shafts to the north of the Stakeford Dyke the water levels are static at approximately 102 metres B.O.D. while at North Seaton to the south of the dyke the minewater level is at only 14 metres B.O.D. and continues to recover (Figure 2). The Stakeford Dyke is expected to remain as an effective barrier to minewater movement.

The effectiveness of the barriers around the Algernon/Rising Sun/Hebburn block are not all proved. The barrier between Hebburn and the Westoe/Wearmouth block is confirmed by the large difference in water levels between the two blocks of 186 metres (Figure 3). The effectiveness of the barriers between the Algernon/Rising Sun block and the Unsworth/Washington block (area 2c) and the west Newcastle area (part of 2a) which is connected through to the block controlled by Kibblesworth pumping station (area 4d) is not known due to a lack of minewater monitoring points in these blocks. The drilling of boreholes in both the Unsworth/Washington block (2c) and in the Newcastle area (2a) is planned in the near future to address the problem concerning the lack of knowledge about these connections. (See Figure 1).

Information from the British Coal report on Recovery of Ground waters in South East Northumberland suggests that cessation of pumping at Felling south of the Tyne in the Unsworth/Washington block in the 1850s resulted in the inundation of Wallsend and Hebburn pits. This would infer that the areas are linked and therefore water may be flowing south from this block and that pumping at Kibblesworth or Lumley 6th is affecting the minewater recovery in the Algernon/Rising Sun Hebburn area.

2.2 Geographical Area

The geographic area extends from Newbiggin-By-The –Sea in the north to the River Tyne in the south and includes the build up area of Hebburn and Jarrow south of the Tyne. South of the Ninety Fathom Fault, which runs approximately through Gosforth to Whitley Bay, the western boundary of the area runs through the centre of Newcastle. North of the Ninety Fathom Fault the western boundary follows approximately a line from Dinnington to Morpeth.

Topographically the area is generally flat with occasional low sandstone hills but becoming more undulating to the west where levels reach 85 metres above sea level (A.O.D.). The area is drained by the incised valleys of the Rivers Wansbeck and Blyth in the north and the River Tyne in the south with the smaller Seaton Burn between. The valleys together with the low lying ground associated with the coast are the areas potentially at risk from future minewater discharges.

3.0 BACKGROUND INFORMATION

3.1 Geology

3.1.1. Superficial Deposits

Boulder Clay overlies much of the area to a depth of between 5 and 20 metres but with thicknesses of up to 60 metres in the buried glacial drainage channels. Smaller areas of glacial sands and gravels are common over the area with river alluvium in the main valleys and marine, tidal and estuarine deposits along the coast and in the river estuaries.

There are several small patches within the area of investigation where there are no superficial deposits and Coal Measure strata are directly below the surface soil. Three of these exposures have been associated with surface mine gas emissions at Cramlington, Seaton Sluice and North Shields.

3.1.2 Solid Geology

The solid geology comprises Coal Measure strata with the exception of the igneous dykes, which are of Tertiary age and two minor outcrops of Permian Magnesian Limestone in the Whitley Bay area.

The Coal Measures form a shallow asymetric syncline with its axis running north – north east to south – south west approximately through Longbenton. The syncline is tilted to the east so that the upper seams outcrop towards the coast but the lower seams continue below the North Sea.

The major faults in the area trend east - north east to west – south west, these are the Stakeford Park Dyke which forms the northern boundary of the area of interest and the Ninety Fathom Fault which separates the area north of the dyke from the Algernon/Rising Sun/Hebburn area. The throw of the Ninety Fathom Fault varies from 200 to 210 metres in the western suburbs of Newcastle to between 137 and 360 metres near the coast north of Tynemouth. (B.G.S. Geology of the district around Newcastle-upon-Tyne). Other fault trends are north – north west to south – south east and west – north west to east – south east, the latter being associated with the Mull volcanics tertiary dyke system.

The Coal Measures consist of a number of sedimentary cycles made up of coals, sandstones, siltstones and mudstones. The sandstones vary from coarse grained beds with moderate permeability to fine grained micaceous sandstone where permeability is mainly secondary, i.e. along fractures.

The worked coals of both Northumberland and Durham are confined to 200 metre interval although intervals between individual seams can vary greatly. The individual seams can be correlated across the coalfield but various names have been used in different localities. Table 1 lists the names used in this report and the corresponding letter codes used by British Coal for correlation across the coalfield.

The main sources of water inflow to the abandoned mines in the area of interest are probably from the superficial deposits either directly into shallow workings or via permeable sandstone horizons. Additional recharge can be expected where shallow working occur in those areas with no superficial deposits and from shallow under sea workings. Additional flows can also be expected from mine entries and from backfilled opencast voids. Where coals have been worked by long wall methods close to major sandstones the strata will be extensively dewatered. As water levels recover in mines these sandstones will re-saturate, possibly with contaminated water and may provide pathways for surface discharge.

3.2 Mining

This area has been associated with coal mining since Roman times and records exist of workings in the Blyth area in 1236. By the start of the nineteenth century mining in Northumberland was very well established with many collieries operating over the whole of the coalfield. Fifty collieries were vested into the National Coal Board in 1947 but rapid closures in the 1960s left eleven operating collieries by the turn of the decade. By this time undersea exploitation was well advanced from the coastal collieries of Ellington, Lynemouth, Newbiggin, North Seaton, Cambois, Bates and Mill collieries. The final closures came in 1985/6 leaving only the single, combine mine of Ellington/Lynemouth, which passed into the ownership of RJB Mining (UK) Ltd, in 1994.

Opencast mining commenced during the war but became a major feature in the area during the 1970s and 1980s with huge sites operating in the Morpeth area. Much of the agricultural area north of the River Blyth and especially north of Ashington has been or is being opencasted. Opencast mining has an influence on rising minewaters and mine gas due to the connection between the open void and underground old workings. During the working of a site the ground water levels are lowered to allow excavation and the rebound, when pumping ceases, may cause problems.

A total of twenty one seams (See Table 1 for nomenclature) are known to have been worked underground and other unrecorded seam workings at crop are almost certain. The Plessey (L), Northumberland Low Main (K), and Yard (G) have been almost totally extracted over the whole area and extensive workings occur in many of the other seams.

In the area between the Stakeford Dyke and Ninety Fathom Fault there were several pumping stations operating just prior to the closure of the last operating deep mine at Bates in 1986. The pumping stations were at Dinnington, Weetslade, North Seaton, Choppington 'A', Bedlington 'A', Isabella, New Delaval and Bedlington 'E'. Water had also been pumped from Brenkley, the only other operating mine in the area, which closed just before Bates.

The total amount of water pumped from the area between the Stakeford Dyke and the Ninety Fathom Fault was approximately 4,400 gpm (333 l/s). The amount of water that would be discharged at surface, should recovery be allowed, should be considerably less than the amount pumped. Based on the percentage reduction from the modelling work carried out in the mining block north of the Stakeford Dyke the surface discharge is likely to be between 15 and 20% of the amount pumped, i.e between 600 and 800 gpm.

The closure of Bates resulted in the cessation of all pumping in the area between the Stakeford Dyke and Ninety Fathom Fault. British Coal anticipated that as water levels recovered the area would form a common pond with a general migration of water to the coastal area during the filling process. British Coal were however uncertain about the Weetslade Burradon area and suggested that a proportion of this water may in fact migrate south through the Ninety Fathom Fault to the Algernon/Rising Sun/Hebburn area resulting in surface discharges in the Tyne Valley. No details were given of this possible pathway, but there is a known roadway connection between the two areas at Eccles Colliery at approximately 9450ft A.M.D. (167.64 metres B.O.D.). (Figure 4).

South of the Ninety Fathom Fault in the Algernon/Rising Sun/Hebburn area there has been no pumping since the 1960s when the last mines closed. The last recorded water level prior to the recent monitoring at Algernon Borehole was in 1980 when the recorded level at an unspecified site was 9668ft A.M.D. (101.19m B.O.D.).

The potential outflow points identified by British Coal south of the Ninety Fathom Fault were Hebburn A and B shafts, both of which are connected to an underground drift which discharged to the Tyne and Wallsend 'H' shaft which has an overflow via a 42 inch concrete pipe to the Tyne (see Figure 11). No details are available for the amounts of water pumped south of the Ninety Fathom Fault, but it is likely to be considerably less than the area to the north of the dyke assuming that the total inflow is related to the area worked.

The mining information supports the evidence from the mine water recovery monitoring that open mining connections exist through the Ninety Fathom Fault and that any proposals for control of mine water in the workings between the Stakeford Dyke and Ninety Fathom Fault will also significantly affect the area south of the Ninety Fathom Fault and vice versa.

TABLE 1 - SEAM NOMENCLATURE

Index Letter	This Report (Northumberland)	Durham Coalfield	Remarks
DE 1	Moorland		Historically worked at outcrop
DE 2	Ashington		Worked in the vicinity of Ashington
E	High Main		) *
F1	Metal		) Worked separately or combined *
F2	Five Quarter		) *
G1	Bentinck	Top Main	
G(2)	Yard	Main	*
H1	Top Bensham	Top Maudlin	
H2	Bottom Bensham	Bottom	
H	Bensham	Maudlin	*
J	Durham Low Main	Five-Quarter	
K	Low Main	Brass Thill	*
K/L	Broomhill Main		
L	Plessey	Hutton	*
M	Bottom Plessey	Ruler	
N	Beaumont	Harvey	*
O	Hodge		
P	Tilley		
Q1	Top Busty		
Q2	Bottom Busty		
R	Three-Quarter		
R/S	Stobswood New		
S	Brockwell		
T	Victoria		
U	Marshall Green		

* = extensively worked

3.3 Water Abstraction

Based on the Environment Agency list of water abstraction licences for water from the Coal Measures there are five abstractions in or adjacent to the area of investigation (Figure 1 and Table 2). Two of these abstractions, Saltwick Farm and Street Hoyse Farm are outside of the general area of workings and will not be affected by minewater recovery. The Steeley abstraction at Gateshead is just outside of the current area of investigation in the Unsworth Washington block (area 2c) where mine waters are probably controlled by pumping from either Kibblesworth or Lumley 6th shafts.

Table 2
Licenced Water Abstractions

Name	Licence Holder	Grid Ref	Licenced Annual Abstraction (m^3)
1 Saltwick Farm	E and J W Storey	NZ 173 807	4812
2 Street Hoyse Farm	Vortayn Ltd	NZ 178 719	8200
3 Steetley	Steetley Quarry Products	NZ 263 640	250,000 (2 BH's)
4 Brunswick Green	Ready Mixed Concrete	NZ 225 726	14,000 (2 BH's)
5 Siemens Silverlink	Siemens Ltd	NZ 320 696	N/A

The abstractions by Ready Mixed Concrete at Brunswick Green and Siemens at West Chirton are both into areas of old workings. The Siemens pump borehole (Appendix B) contacted old workings at 104-5 metres, probably the High Main, and proved a water level similar to Algernon Borehole prior to the current recommencement of water level recovery in this area. Details of the Brunswick Green Borehole are not known, or the use of the water at either site but both are likely to be for industrial processes and are probably already contaminated to some degree due to contact with mine workings. It is unlikely that any system put in place to control mine waters in the area would have any significant effect on these abstractions unless sited close to the abstraction points. It is not known if either well is currently abstracting water, but the monitoring borehole at Algernon would suggest that there is no significant abstraction from the Siemen's well.

3.2 MINEWATER RECOVERY

3.3 Current Position

In the study area water level monitoring is currently undertaken at the following sites.

Table 3 - Coal Authority Monitoring Sites

Site	No.	Type	Depth to Water	Level
North Seaton	S57	open shaft		13.3m B.O.D.
Choppington 'A'	S22	open shaft		14.5m B.O.D.
Bedlington 'A'	S14	open shaft		15.2m B.O.D.
Bates	S11	2 open shafts		16.5m B.O.D.
New Delaval	S55	2 open shafts		19.0m B.O.D.
Seaton Delaval	S68	2 open shafts		17.0m B.O.D.
Hastings	S169	Borehole		16.3 m B.O.D.
Algernon	S279	Borehole		2.6m B.O.D.

The monitoring points are concentrated in a 5 kilometre wide strip parallel to the coast and only one of the monitoring sites, Algernon, is south of the Ninety Fathom Fault. Two possible monitoring sites for boreholes have been identified in the area south of the Ninety Fathom Fault and this information has been passed to the Environment Agency who have agreed to pay for the drilling if surface access can be arranged. The approximate sites of the proposed boreholes are shown in Figure 1.

In the mining units adjacent to the area of interest the levels of mine water recovery, apart from the Westoe/Wearmouth block where water levels are still very deep, are controlled by pumping. North of the Stakeford Dyke minewaters are controlled at approximately 100 metres B.O.D by pumping at Ellington/Lynemouth while south of Newcastle and under the western side of Newcastle water levels are probably held at between 14 and 33 metres B.O.D. by pumping at Kibblesworth, based the Environment Agency monitoring boreholes at Tyneside House. It should be noted that there is a very high hydrostatic head operating against the pillars between the Algernon/Rising Sun/Hebburn block and the Westoe area of about 186metres (1.87 MPa or 270 p.s.i.). The pillars are reportedly greater than 80 metres width (NCB June 1981) and therefore are not likely to fail. In addition the pressure against the pillars has previously been as high as 235 metres of water without any failure. It is likely however that given the difference in hydrostatic head there is some flow through the pillars and shallow connections may exist above the current water levels which ultimately may allow the Algernon/Rising Sun/Hebburn area to be hydraulically connected to Westoe / Wearmouth.

Dataloggers are used to monitor water levels at three sites, Bates (S11) Seaton Delaval (S68) and Algernon (S279). The monitoring at Bates shows that, as in other coastal collieries with undersea workings, the water level rises and falls with the tide. The range of water level fluctuation per tide varies from just over 2 metres at spring tides to 0.6 metres at neap tides. (Figure 5). The use of this fluctuation as an energy source and its affect on mine gases in shallow workings above the water level should be investigated. It may also be significant if gravity discharges develop as the outflow may vary with the tide.

The current water levels and the hydraulic gradients that have developed within the zone north of the Ninety Fathom Fault are shown in Figure 6. There is a general movement of water towards the deeper areas of the basin with the lowest levels in the area of New Delaval (19m B.O.D.) and Bates (16.5m B.O.D.). Small inaccuracies probably exist in the water levels, as the surface levels for each site have not been surveyed to a common datum.

The hydraulic gradients over the area vary from 1 in 2000 to 1 in 520, the highest being between Algernon south of the Ninety Fathom Fault and Seaton Delaval. The 1 in 520 gradient is similar to gradients observed in other coalfields but may to some degree be affected by a restricted flow through the roadway at Eccles Colliery (Figure 4) which connects the working north and south of the Ninety Fathom Fault. If the gradient observed between Seaton Delaval and Algernon is extrapolated south then water levels would be about 3 metres above sea level in the Tyne valley and close to the level (+ 4.25m) of the potential overflow points at Hebburn and Wallsend Collieries. These sites should be immediately checked as to their state, accessibility and any current water discharge. The shafts associated with overflows were all fitted and capped but later checks showed the fill had subsided in some shafts and these were topped up presumably through access points in the caps. The positions of Wallsend 'H' and Hebburn 'A' and 'B' shafts should be identified to establish if the caps are still accessible and if possible the current level to the fill checked.

The potential surface discharge from the sites at Wallsend and Hebburn or other low lying areas to the west of the area under Newcastle will be dependant on the hydraulic gradient within the area south of the Ninety Fathom Fault. The proposed boreholes in this area are vital in providing data for understanding the mine water flows and general recovery levels in this block.

4.2 Projected Recovery

The mine water recovery rates at all the monitored sites in the area of investigation are showing the same exponential curve (Figure 7). These recovery curves are believed to be independent of the mining void to be filled in cases such as Northumberland where the area of recovery is large and workings extend to near surface. In these cases the dominant feature affecting recovery is believed to be the reduction in flow with reduction in the difference in peizometric lead. This means that the recovery curves can be projected forward to predict when the mine water levels will reach surface and given the current hydraulic gradients where the surface outflows will occur.

Figure 8 shows the projected water levels in terms of depth below ground level. At Bates the water will probably reach the surface at some time in 2004 with the other shaft and monitoring points some years later. Figure 9 shows the projected mine water recovery to O.D. at the various monitoring sites. If the current hydraulic gradient in the mine workings persists then the areas at the most immediate risk are the low lying areas south of the Ninety Fathom Fault as the levels in this area using Algernon recovery are projected to reach ordinance datum in early 2001. The next area of risk would be the low lying areas around the mouth of the Wansbeck where recovery is projected to reach ordinance datum in early 2003.

The evidence from the projection of mine water recovery is that there is an imminent risk of mine water outflow in the Hebburn/Wallsend area. If a gravity discharge is allowed to develop the most likely outflow points would be the tunnels connected to the filled shafts but other pathways exist which the water may take if there is a high resistance in the Hebburn/Wallsend shafts or the overflow tunnels. However, it is unlikely because of the distances involved and the limited connection through the Ninety Fathom Fault that any gravity discharge in the Tyne valley would control waters over the whole of the area and a further discharge would almost certainly occur in the area between the Stakeford Dyke and Ninety Fathom Faults. Similarly any gravity discharge or pump control in the northern area is unlikely to prevent outflows in the Tyne Valley.

The areas should therefore be treated as separate blocks for the purpose of minewater control and separate schemes for the two areas would be recommended.

Once in place the area controlled by each scheme could be assessed and the possibility of a single scheme based on either of the sites could then be accurately evaluated.

5 OPTIONS FOR CONTROL OF MINEWATER RECOVERY

5.1 Minewater Quality

No data could be found regarding the qualities of the pumped minewaters when the mines were operational in the area between the Stakeford Dyke and the River Tyne. Data has been obtained for all the adjacent areas and British Coal carried out discrete depth sampling at Bates, Bedlington, Choppington, North Seaton, Seaton Delaval and New Delaval in 1993. Details of the available water quality data are in Appendix A. (Ref. Recovery of Groundwaters in S.E, Northumberland B.C.C 1994).

Stratification of the minewaters had taken place in the shafts sampled, in particular at Bates and North Seaton where water levels had risen above the highest inset, with generally low iron and sulphate contents. However, any re-commencement of pumping is highly likely to result in flow paths and a mixing of the minewaters resulting in an initial deterioration of quality. The best comparison for water quality during pumping is the adjacent area north of the Stakeford Dyke. Here the waters were generally neutral with total iron contents below 10 mg/l, sulphate below 2,000 mg/l and chloride below 1,000 mg/l. However the evidence from Frances pump test indicates that the basal waters sampled in the various shafts in 1993 may well be representative of the initial waters if pumping at depth is recommenced. In this case, the waters may become slightly acidic with pH's between 6.25 and 7.0, total iron content up to 100 mg/l and chloride up to 28,000 mg/l; the latter is probably an extreme value.

If waters can be discharged by gravity, then it is highly likely that the qualities will be similar to the surface waters with a low total iron, probably less than 5 mg/l. Therefore if gravity discharges can be obtained in a controlled manner which would allow the waters still to be treated, then this would be the best option.

5.2 Minewater Treatment

The minewater treatment required will be dependent on the water quality about which there is only limited information. If a gravity discharge could be established, then the waters should have a near neutral pH value and low concentration of iron. It could therefore be treated simply by single stage aeration and settlement. Based on the assumption of between 600 and 800 gpm (45.60 l/sec) flow, a typical treatment system would require three lagoons, two primary settlement ponds after aeration and a third for secondary settlement. An area of reeds would be used to reduce iron content to < 2 mg/l. Figure 12 shows a typical layout for the area at Bates.

As noted in section 5.1 the quality of a pumped minewater may be considerably worse due to the mixing of waters from varying depths and sources. Unfortunately, the analyses carried out by British Coal in 1993 in various shafts did not determine alkalinity or acidity. It is therefore not possible to determine if a mixed water would contain sufficient alkalinity for simple aeration and settlement on its own to be effective. It is recommended that further sampling of the open shafts be carried out to ascertain the current water quality and determine the alkalinity and acidity. In planning any treatment works at present, it would therefore be prudent to allow for alkali treatment even if this is not ultimately required. For an iron content above about 20 mg/litre the system would need to be multi-staged, i.e. with two or more aeration and settlement lagoons in series. A typical multi-stage system for a pumped flow of approximately 1000 gpm (76 l/sec) with an alkali dosing plant and flocculation would require two aeration lagoons with cascades plus a further one or two lagoons for settlement. The area required for this type of system could be fitted into the same area as a simple aeration scheme as the chemical treatment with flocculation reduces settlement time. Both systems will generate an ochreous sludge which will require disposal off site.

5.3 North of the Ninety Fathom Fault

In this area, the presence of old shallow workings and the large number of shafts in the low lying areas around Blyth and Seaton Sluice makes it difficult to accurately predict the point where minewaters will discharge if recovery is allowed to proceed to surface. It is therefore essential that in the later stages of recovery, pumping is carried out to control the rate of recovery. Once recovery is under control, then the options for the long-term treatment and discharge of the water could be more accurately assessed in terms of both quantity and quality. The establishment of a controlled gravity discharge would be the best long-term solution.

5.3.1 Options for pumping and treatment site

The are six open shafts in the area between the Stakeford Dyke and Ninety Fathom Faults which in theory could be used for pumping to control minewaters. However Bedlington 'A' is in a housing estate and New Delaval is a golf course and neither has a suitable site for a treatment area.

At the remaining four sites at North Seaton, Choppington 'A', Seaton Delaval and Bates there is the potential to construct a treatment works if the land can be acquired. Two of these sites, Choppington 'A' and North Seaton, are at the northern edge of the area and as such, it is considered unlikely that minewater levels could be controlled over the whole area as far south as the Ninety Fathom Fault from either of these sites without additional pumping from either Bates or Seaton Delaval.

This leaves Bates and Seaton Delaval the only two viable alternatives for a pumping and treatment site at existing open shafts. There is also the alternative of drilling a new pumping borehole (or boreholes) with a pumping station and treatment works sited on suitable available land.

5.3.1.1 Bates Shaft, Blyth

This option is considered to be the optimum site for a pumping and minewater treatment works for the following reasons:

- The site is close to the areas at greatest risk from surface discharge namely Blyth town and the Rivers Blyth and Wansbeck ensuring minewater levels can be controlled in those areas.

- There is suitable land available adjacent to the estuary for construction of a treatment works and discharge point (see Figure 10).

- The available land is currently either derelict or used for industrial purposes.
- Bates Colliery workings are believed to be well connected underground to the other mines in the area.
- The present natural flow of minewater in the underground workings is towards Blyth, so pumping in this area should not markedly change the flow paths in the workings.

The points not in Bates' favour are:

- The discharge consent may be more onerous due to the S.S.S.I in the estuary.
- The area to the south of Bates is a residential area.

5.3.1.2 Seaton Delaval

This site is not considered to be the optimum site for a pumping water treatment works for the following reasons:

- It is more remote from the areas at high risk of surface discharge at Blyth and in the valleys of the Blyth and Wansbeck and as such, will be required to pump higher quantities of water at a lower level and therefore require a larger treatment area.
- The land adjacent to the Seaton Delaval shafts has been reclaimed and is used for forestry and farming.
- The site is some distance from the potential discharge points into either Seaton Burn or the sea.

5.3.1.3 A new Pump Borehole site

This option is not considered practical at this stage in the minewater recovery for the area between the Stakeford Dyke and Ninety Fathom Faults, but may be used in the future to control minewaters in local water levels once the risk areas are more clearly defined. The reasons that this option is not considered practical at this stage are:

- To ensure that a new pump borehole would control the recovery over the whole of the area and protect the low lying areas around Blyth and the Wansbeck and Blyth valleys, it would need to be sited in the Blyth area and drilled into a major roadway, probably in a shaft pillar. The optimum site for such a borehole would therefore most likely be the existing Bates site.
- The optimum use of pumping boreholes is considered to be in conjunction with a shaft pumping and treatment scheme whereby the boreholes could be sited into shallow workings in the valleys of the Wansbeck, Blyth or Seaton Burn

and used to control the shallow and less contaminated waters locally. Where the quality of water at these sites was good enough, then the establishment of gravity discharges would be considered.

5.4 South of the Ninety Fathom Fault

There is currently insufficient monitoring of water levels in the area south of the Ninety Fathom Fault. The only monitoring station is into the Yard workings from Algernon Colliery which shows a recovery rate similar to the area north of the Ninety Fathom Fault. There are two boreholes planned for the area of Newcastle and work commenced on the first of these boreholes on 26 February 2001. The information provided by these boreholes on the connectivity, the rate of recovery and the flow direction in this block is vital for the design of any minewater control scheme but the main options available for the minewater in this block are discussed.

It was the opinion of British Coal that as minewaters recovered there would be discharges of water along the Tyne Valley and this is the most likely scenario based on the current information. The likely quantity and quality of these discharges is not known, but the discharge points are most likely to be from the shafts in the Hebburn and Wallsend areas (see Figure 11). The possibility still exists that minewaters in this area could be controlled by flow to the adjacent areas north of the Ninety Fathom and south of the Tyne, but in assessing the options it is assumed that waters would recover to surface.

5.4.1 Gravity Discharge

The development of gravity discharge(s) is probably the best long-term option for the control of minewater in this block given the depth of mine workings and the absence of low lying areas of land. However this would be dependant on the quality and quantity of the discharge and any requirements to treat the water before discharge into the Tyne. Monitoring of the potential discharge points at Hebburn and Wallsend (see Figure 11) is in place and should pick up the first signs of discharge as minewater levels continue to recover. If no discharges are observed, then there is the increasing risk of a sudden outburst as the piezometric level in the workings increases. It would be prudent therefore if this option was pursued to have a large diameter borehole in place with a suitable area for minewater treatment adjacent to the potential gravity discharge points at either Hebburn or Wallsend. This would allow either a gravity discharge or the option of pumping to control minewater.

5.4.2 Minewater Pumping and Treatment

A minewater pumping and treatment scheme is not considered to be the best option for this area unless the minewater discharges are likely to occur away from the Tyne in environmentally sensitive areas where a treatment scheme cannot be put in place. Any pumping scheme should be designed primarily as a gravity discharge with pumping as a back-up.

5.4.2 Enhancing connection to adjacent areas

There is the possibility with the area south of the Ninety Fathom Fault of making connections to adjacent areas where minewater levels are lower as in the Westoe and Washington/ Unsworth blocks. This option has not been considered in detail as there may already be a flow in these directions which will become apparent from the proposed monitoring boreholes.

6 CONCLUSIONS

- The area of Northumberland south of the Stakeford Dyke for the purposes of minewater control should be considered as two separate blocks divided by the Ninety Fathom Fault.
- Minewaters are continuing to recover at the same exponential rate in both blocks suggesting there is an hydraulic connection through the Ninety Fathom Fault.
- In the area between the Stakeford Dyke and Ninety Fathom Fault recovery is projected to reach sea levels in the vicinity of North Seaton and Choppington in early 2003 and the surface at Bates in 2004.
- South of the Ninety Fathom Fault recovery to sea level will probably occur in 2001 with possible outflows from Hebburn 'A' and 'B' shafts or Wallsend 'H' shaft.
- The areas of low lying land around Blyth and the Wansbeck and Blyth valleys make the establishment of a controlled gravity discharge difficult, therefore pumping will be required, probably for a number of years, to ensure no uncontrolled discharges occur.
- The optimum site for the establishment of a pumping and treatment works to control minewaters between the Stakeford Dyke and Ninety Fathom Faults is at the former Bates Colliery in Blyth.
- The quality of the pumped minewater is not known, but is likely to be of a quality that can be treated simply by aeration and settlement to meet the required discharge consents.
- The quality of any minewaters allowed to gravity discharge is also not known but they are likely to be of much better quality with iron concentration less than 5 mg/l.
- Some gravity discharges may be of a quality that does not require treatment depending on the receiving water body.

7 RECOMMENDATIONS

- A minewater pumping scheme and treatment works should be established at the former Bates site in Blyth.
- The treatment works should be designed to cope with up to 1000 gpm (75 l/sec) and an iron content of up to 100 mg/l.
- Water samples of the shaft columns at the open shafts should be taken to determine the current water qualities including the alkalinity and acidity.
- Monitoring of the potential discharge points at Hebburn and Wallsend should be carried out monthly.
- Once the water levels and recovery rates are established from the new Environment Agency boreholes south of the Ninety Fathom Fault, the strategy for minewater control in this area should be assessed.

Load = 7500 mg/s
40 mg/l × 15 l/s =
= 6000 mg/s

REFERENCES

1 Recovery of Groundwaters in South East Northumberland

British Coal Corporation. May 1994

2 Geology and Land-use Planning Morpeth-Bedlington Ashington

BGS Technical Report Wardell Armstrong/90/19

3 Risk of Surface Minegas Emissions and Minewater Recovery in North East England.

IMC Report for the Coal Authority. May 1999

4 Northumberland Rising Minewater Study.

IMC Report for the Coal Authority. December 1996

5 Report on Pumping and Water Problems in the Northumberland and Durham Coalfield.

N.C.B. June 1981

6 Addendum to the North East Area Report on Pumping and Water Problems.

N.C.B. December 1985

7 Report on the Closure of Ellington Combine.

IMC Report for the Coal Authority and RJB Mining (UK) Ltd. March 2000

8 Geology of the District around Newcastle-upon-Tyne.

Memoir Sheet 50. B.G.S. 1998.

Figure 1

Area of minewater investigation

PO Box 18
Mill Lane
Huthwaite
Sutton in Ashfield
Nottinghamshire NG17 2NS

Tel: Mansfield (01623) 441444

INTERNATIONAL MINING CONSULTANTS LIMITED

NOTES	REV	DATE	BY	CHKD	APPRVD	MODIFICATIONS	STATUS

THE COAL AUTHORITY

MINEWATER RECOVERY
IN NORTHUMBERLAND
SOUTH OF THE STAKEFORD DYKE

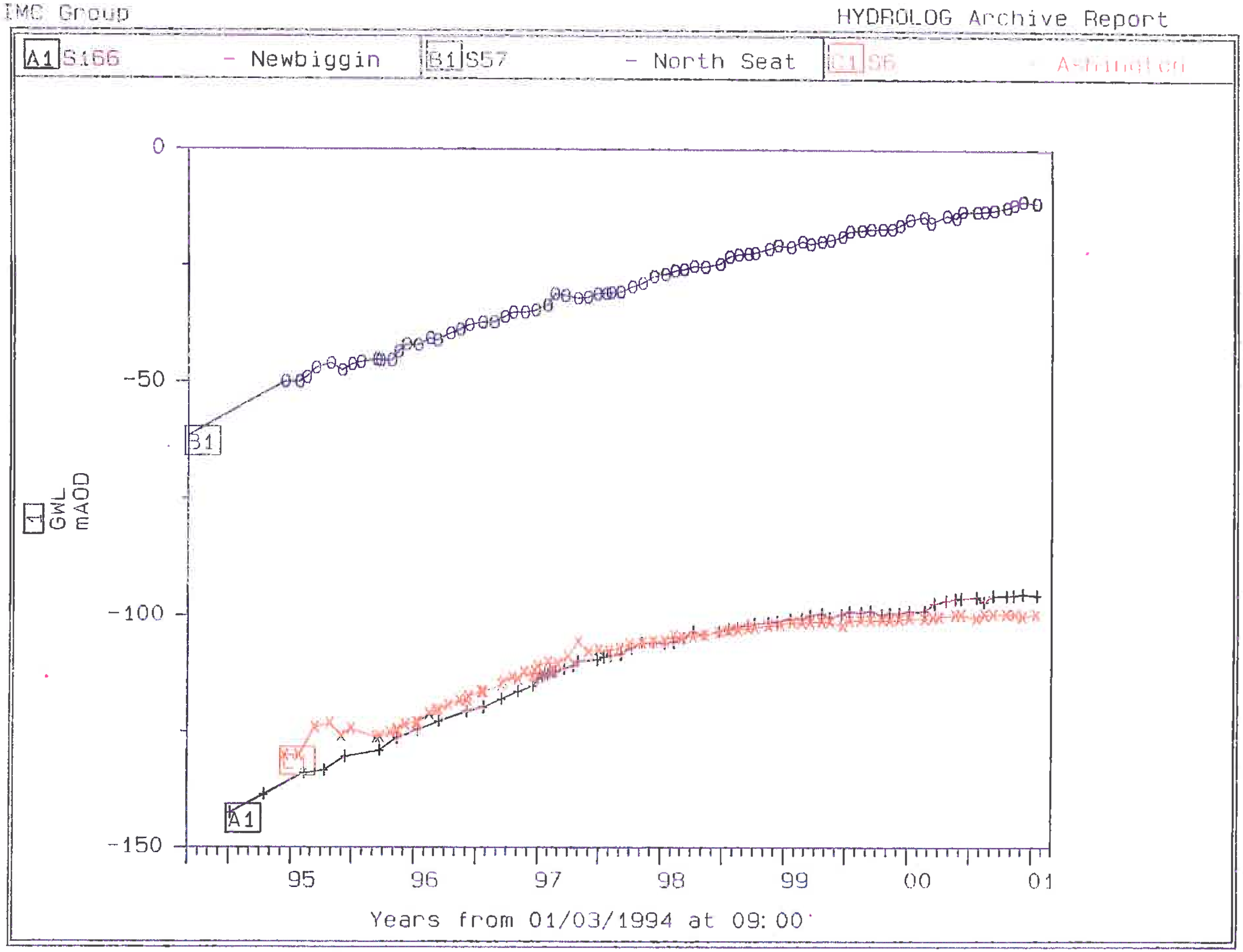
DRAWN/DATE	CHECKED/DATE	APPROVED/DATE	SCALE
			Scale 1:50,000

INTERNATIONAL MINING CONSULTANTS LIMITED

PROJECT	STATUS	NUMBER	REV
		Figure 1	

Figure 2

Comparison of water levels north and south of the Stakeford Dyke

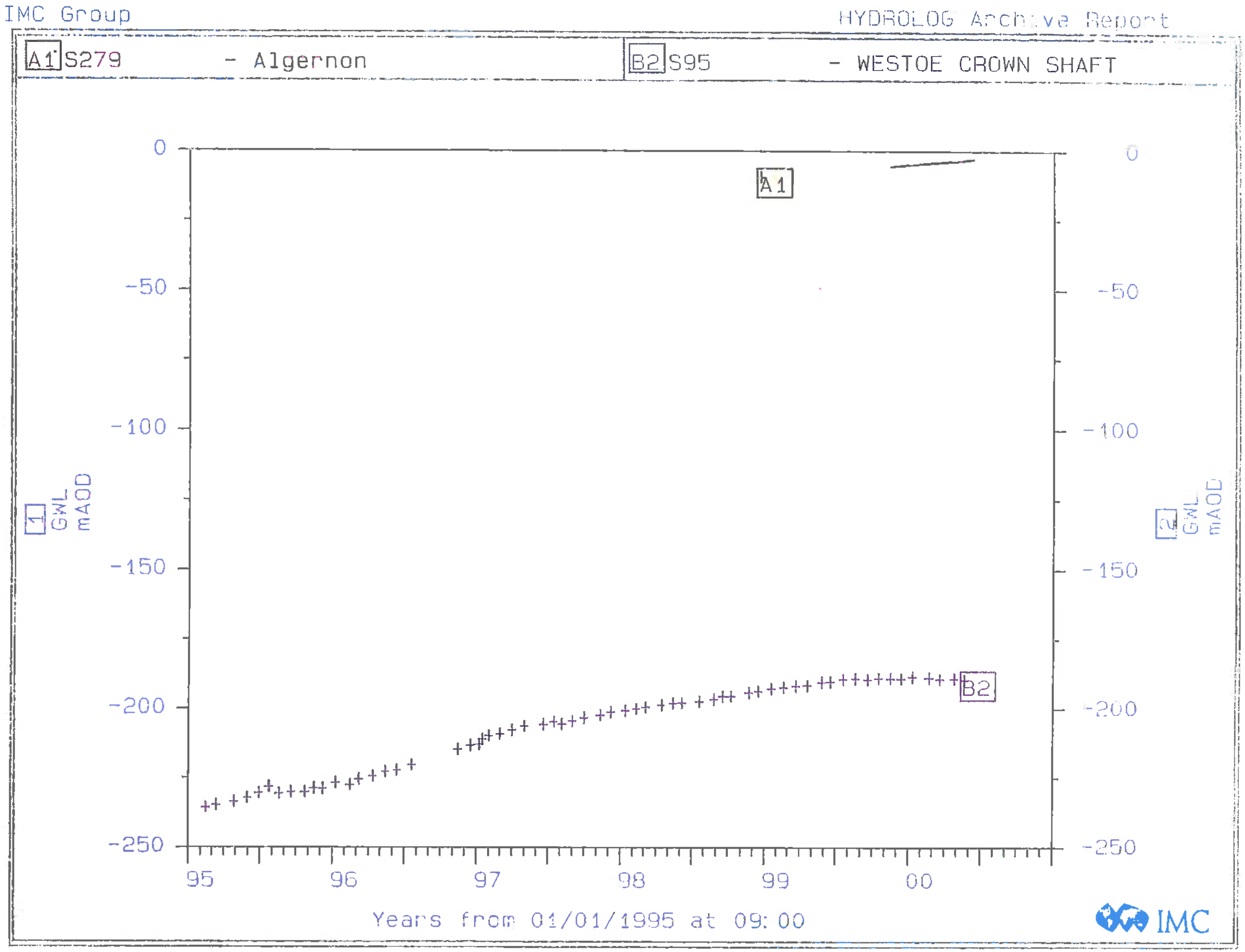


COMPARISON OF WATER LEVELS NORTH AND SOUTH OF THE STAKEFORD DYKE

Figure 2

Figure 3

Comparison of water levels at Algernon and Westoe Collieries

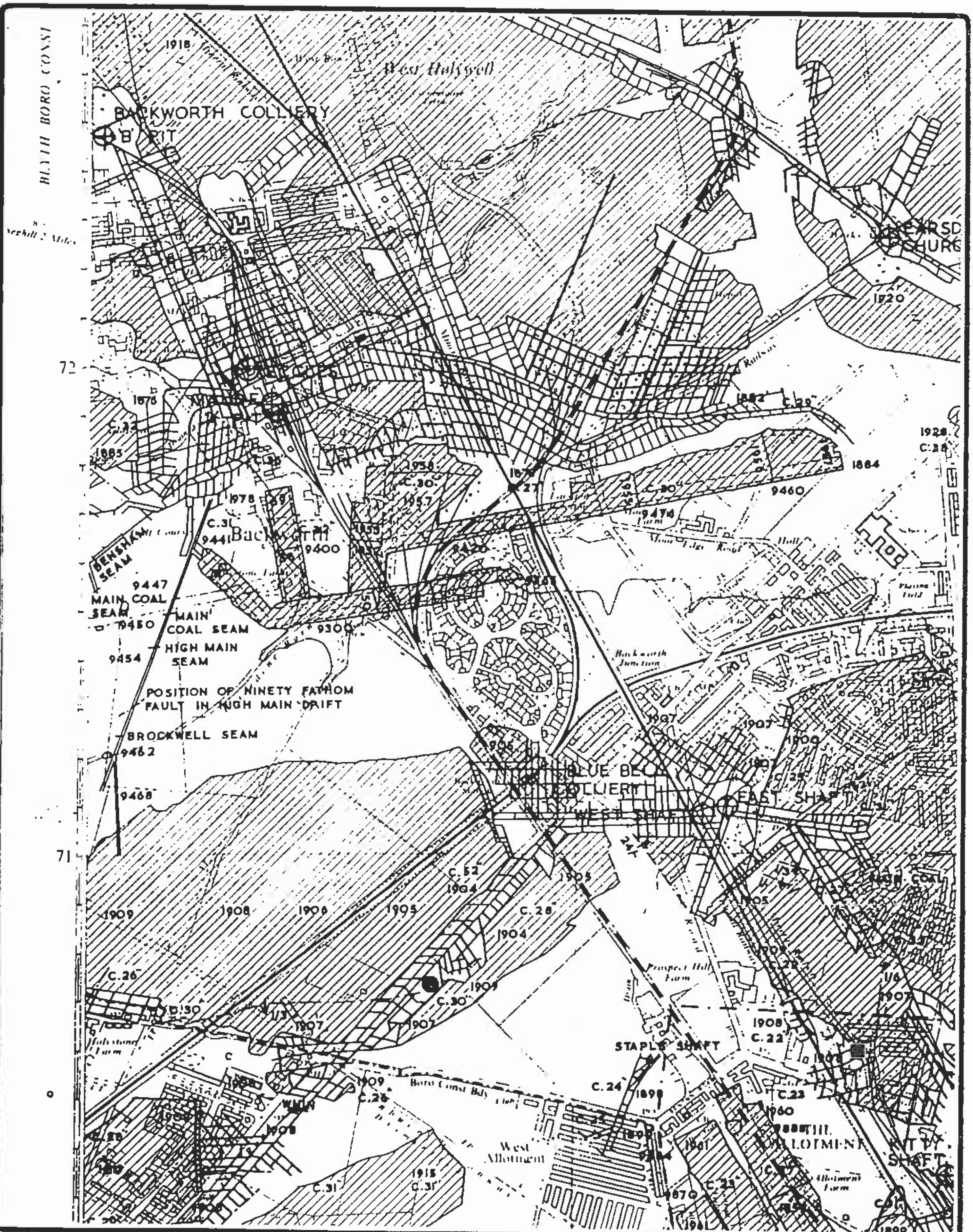


COMPARISON OF WATER LEVELS AT WESTOE AND ALGERNON

Figure 3

Figure 4

Mining Connection at Eccles Colliery



PROJECT	**Minewater Control in Northumberland**
ENGINEER	KW
TRACED BY	JG
CHECKED BY	
APPROVED BY	
DATE	October 2000
DRG. No.	Figure 4

IMC

TITLE

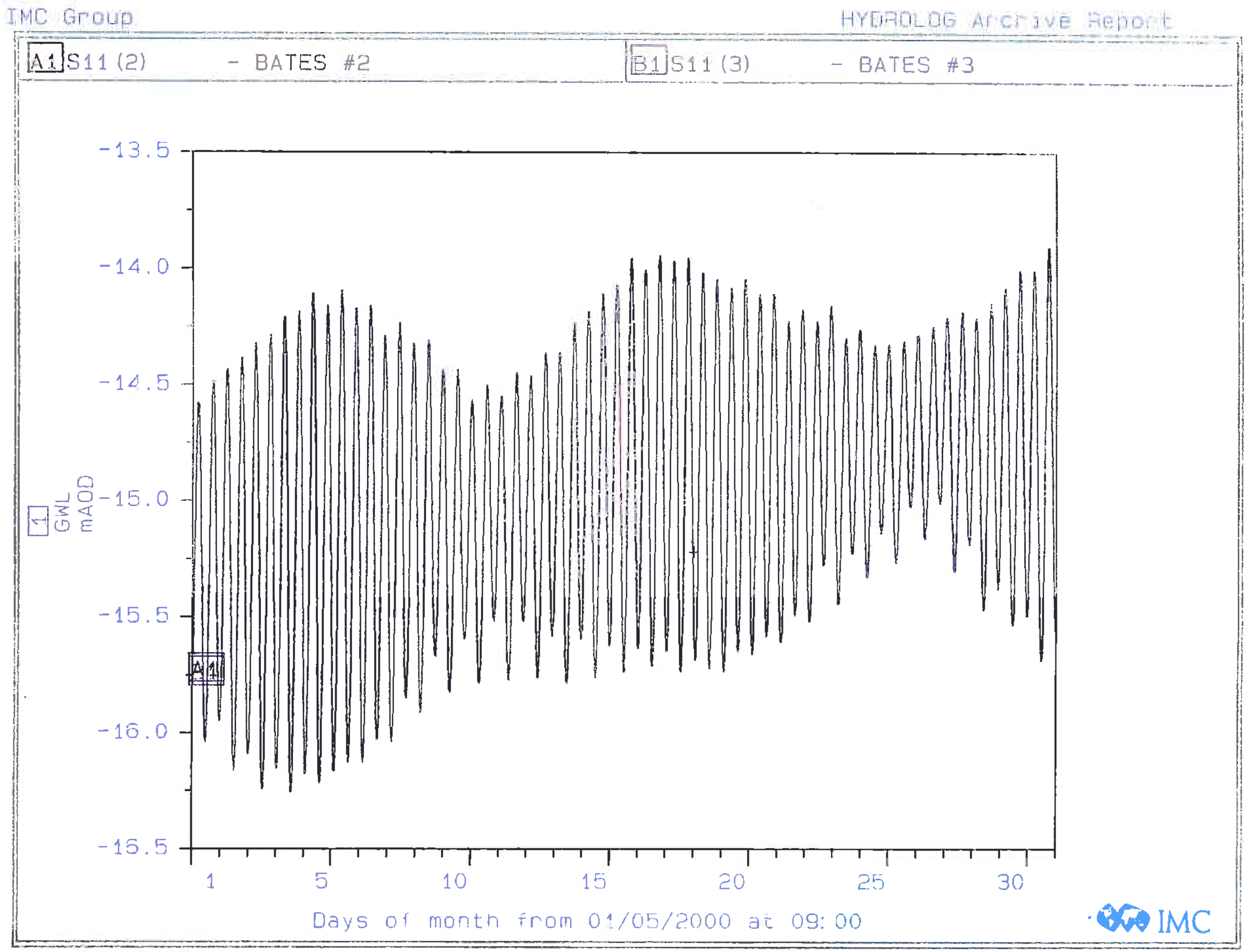
ROADWAY CONNECTION THROUGH NINETY FATHOM DYKE AT ECCLES COLLIERY

Scale 1:10560

Heatherbank B139B

Figure 5

Tide related fluctuations in water level at Bates Colliery



TIDE RELATED FLUCTUATIONS IN WATER LEVEL AT BATES COLLIERY

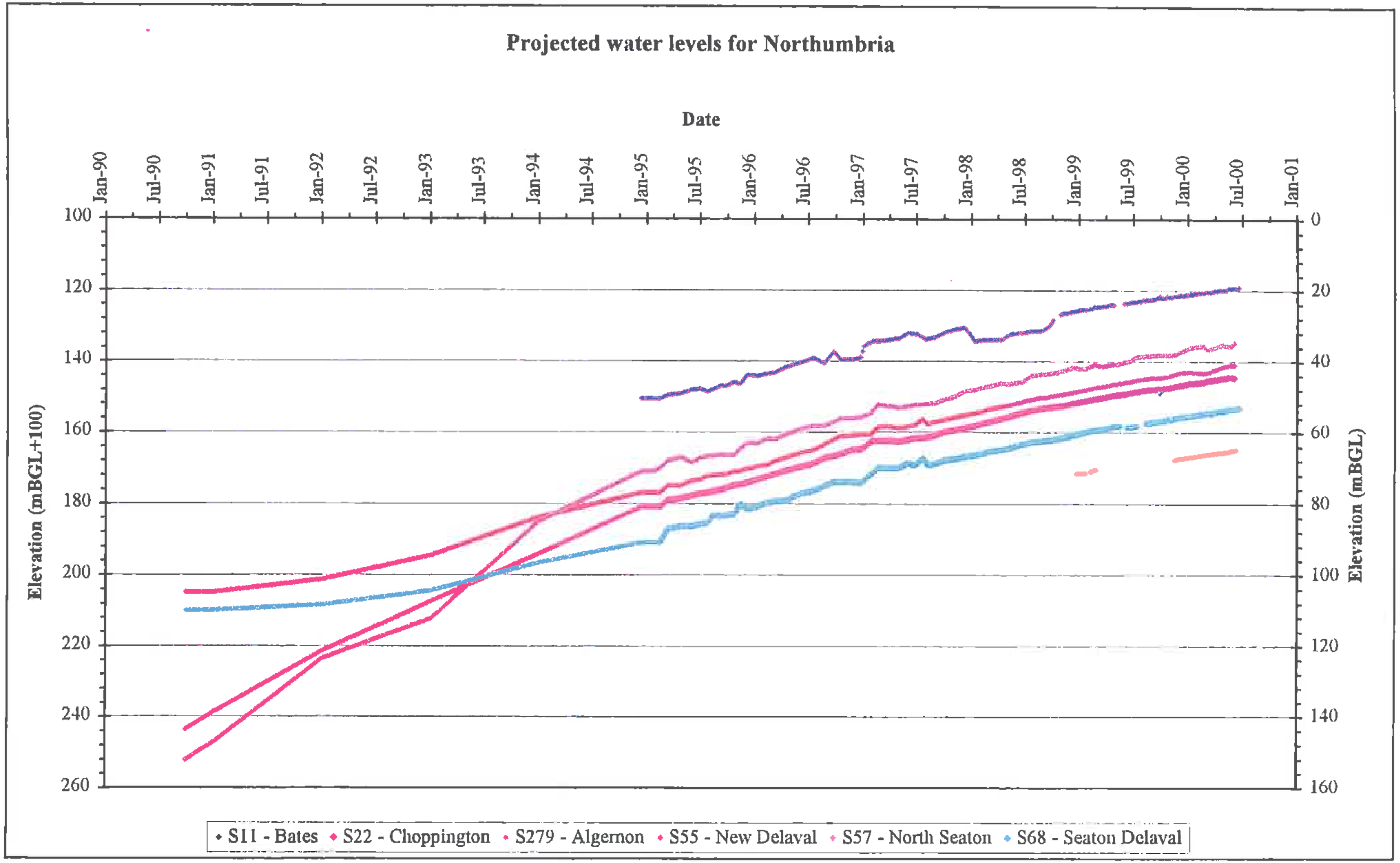
Figure 5

Figure 6

Area of minewater investigation showing current water levels and hydraulic gradients

Figure 7

Minewater Recovery curves at the monitoring sites since 1990



MINEWATER RECOVERY IN NORTHUMBERLAND SINCE 1990

Figure 7

Figure 8

Projected Minewater Recovery relative to ground level

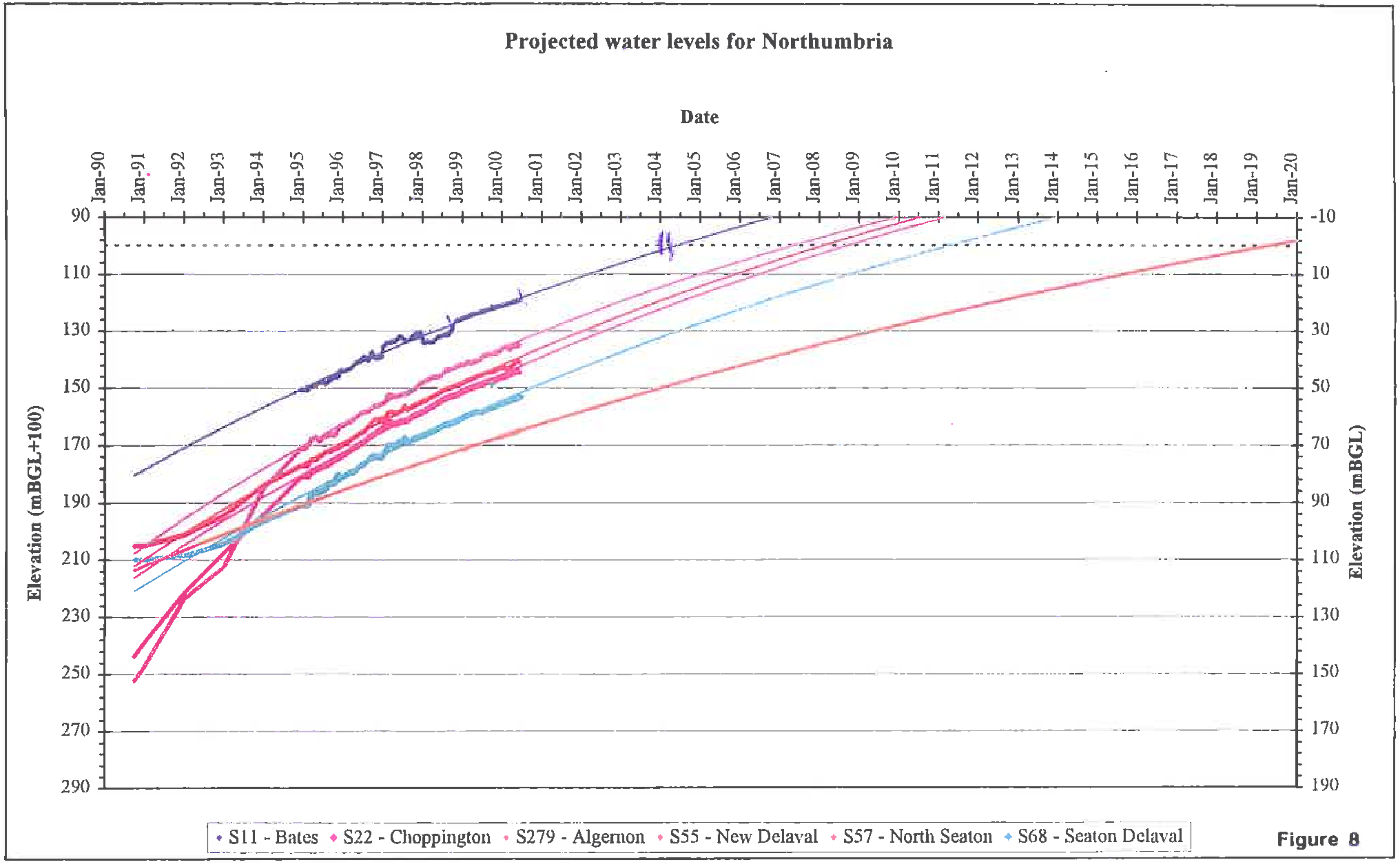


Figure 8

PROJECTED MINEWATER RECOVERY RELATIVE TO GROUND LEVEL

IMC

Figure 9

Projected Minewater Recovery relative to ordnance datum

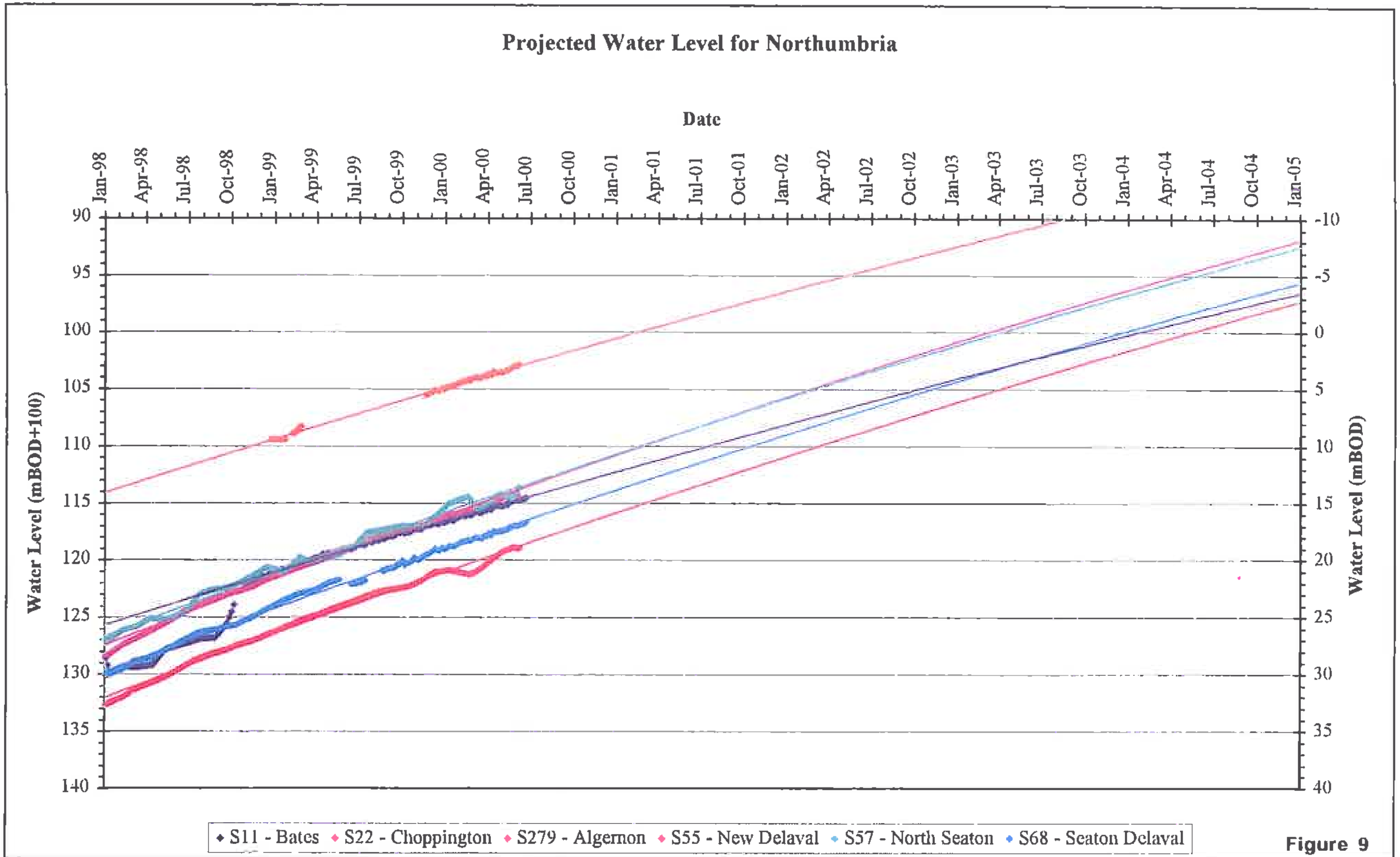


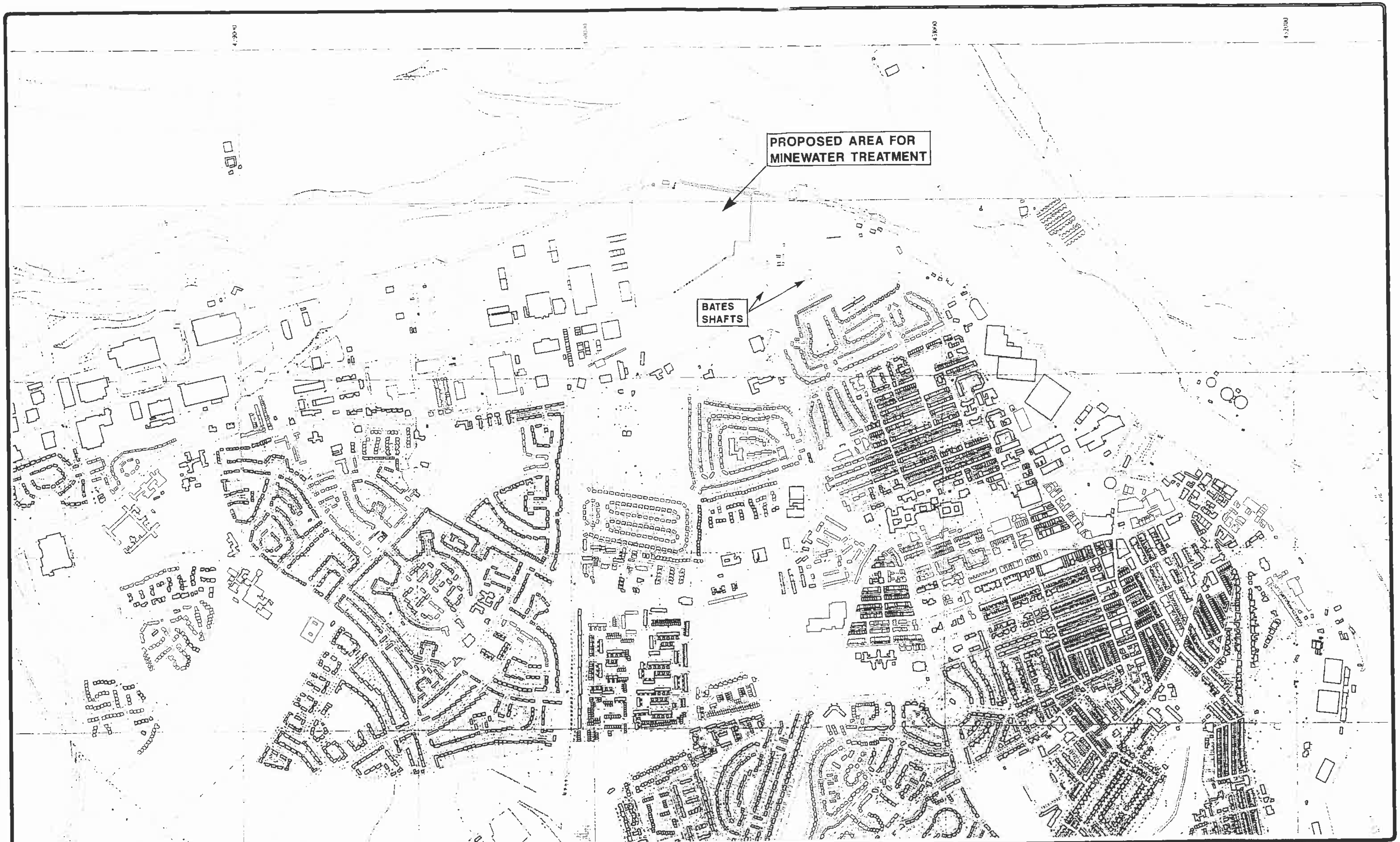
Figure 9

PROJECTED MINEWATER RECOVERY RELATIVE TO ORDNANCE DATUM

IMC

Figure 10

Plan of Bates Site showing approximate area of land required.



PROJECT	Minewater Control in Northumberland
ENGINEER	KW
TRACED BY	JG
CHECKED BY	
APPROVED BY	
DATE	MARCH 2001
DRG. No.	Figure 10

IMC

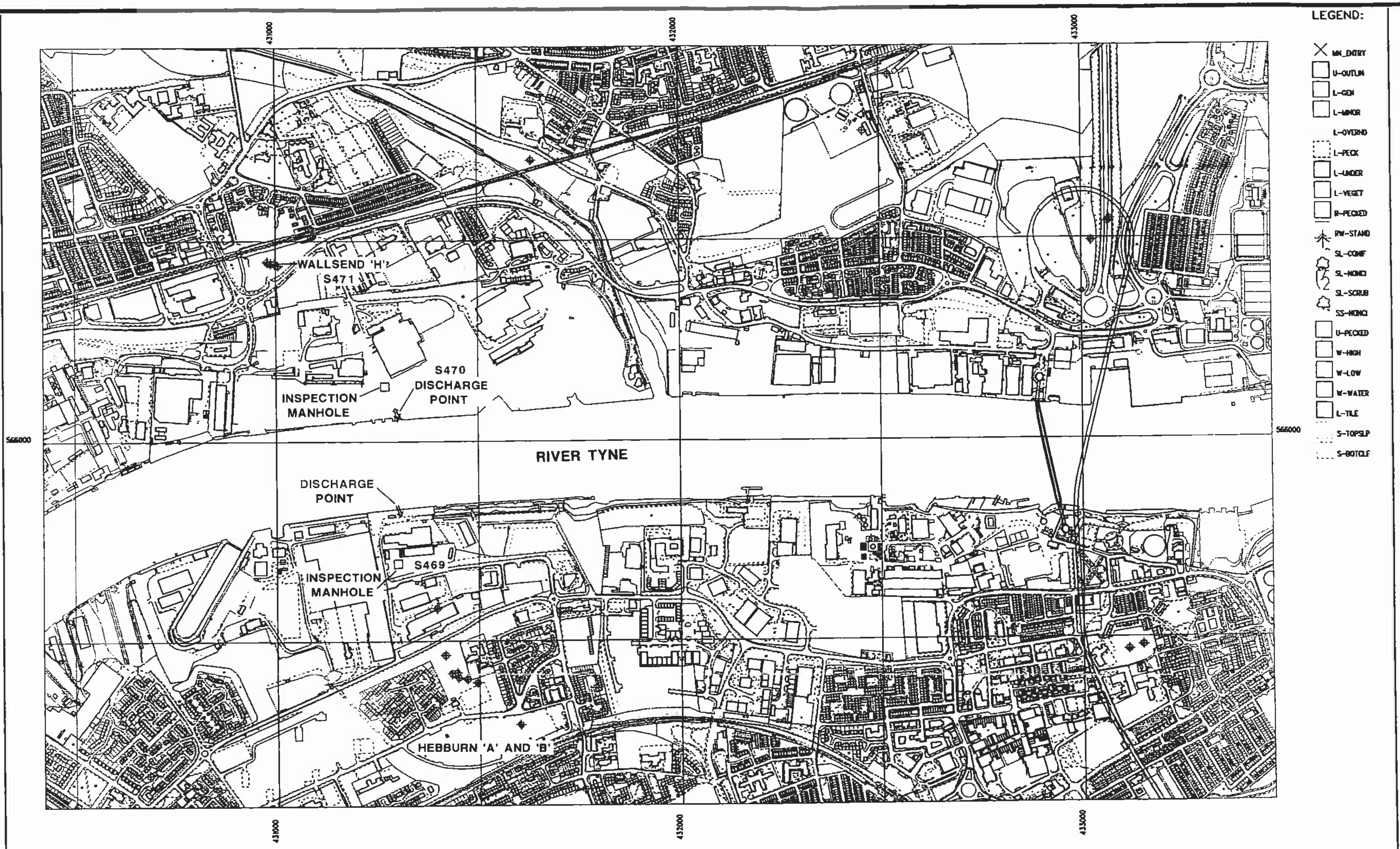
TITLE

PLAN OF BATES SITE SHOWING THE APPROX. AREA OF LAND REQUIRED FOR A MINEWATER TREATMENT SCHEME

Scale 1:10,000

Figure 11

Plan showing Wallsend and Hebburn Shafts and potential discharge points



COAL AUTHORITY MINING FEATURES CHECK PLOT

Scale: 1:10000

0.0 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0
Metres

N

USER: interprd DATE: 28/JUL/2000 TIME: 10:53

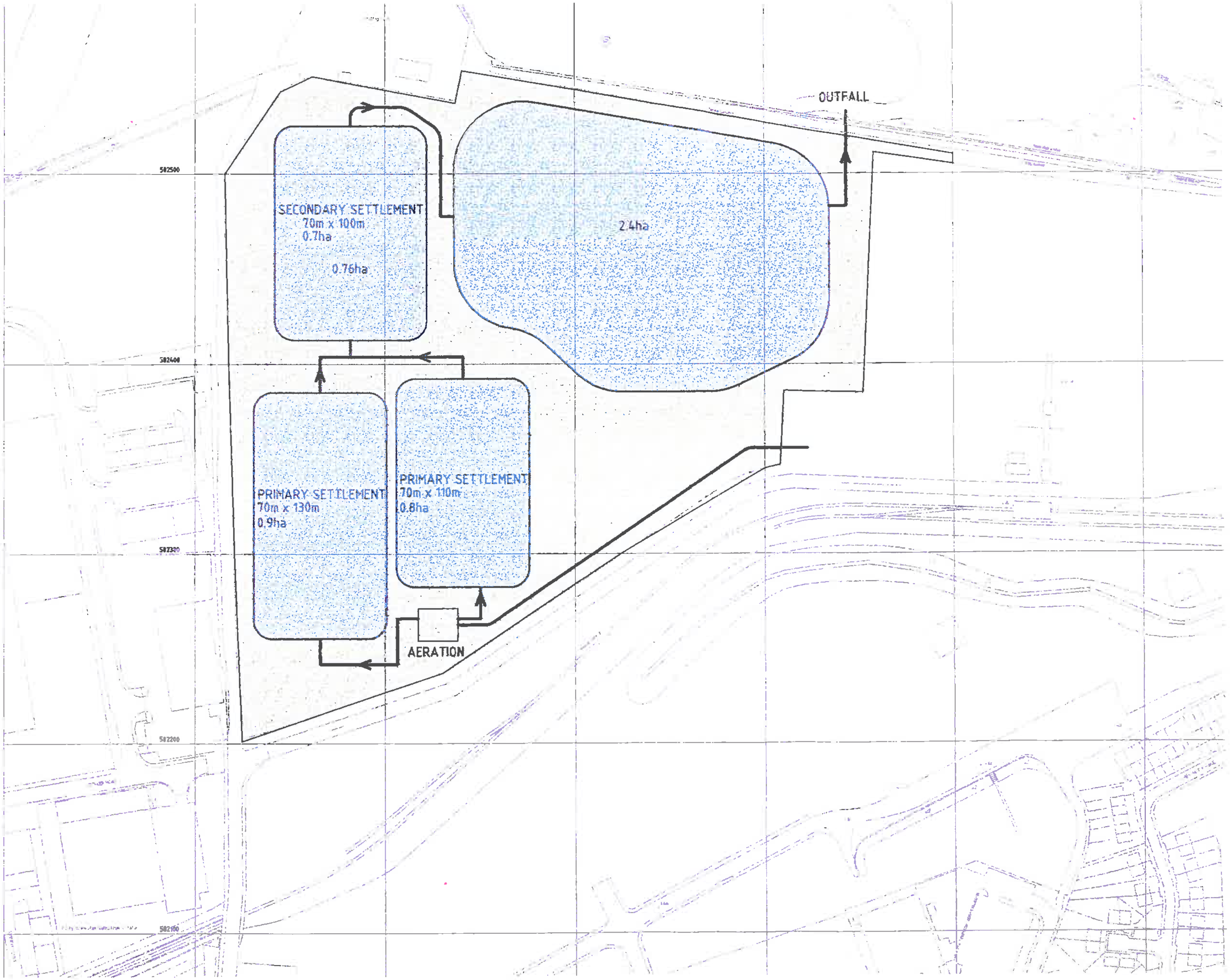
PROJECT	Minewater Control in Northumberland	ENGINEER KW	IMC
TITLE	POTENTIAL DISCHARGE POINTS AT WALLSEND AND HEBBURN	TRACED BY JG	
		CHECKED BY	DATE October 2000
		APPROVED BY	DRG. No. Figure 11

Heatherbank B13EE

Figure 12

Example of typical minewater treatment layout superimposed on Bates area

Figure 12



NOTES

REV	DATE	BY	CKD	APD	MODIFICATIONS

SAVED LOCATION PATH

DO NOT SCALE - IF IN DOUBT ASK

CLIENT

The COAL AUTHORITY

200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG
Tel: 01623 427162

PROJECT TITLE

BATES MINEWATER TREATMENT SCHEME

DRAWING TITLE

PROVISIONAL LAYOUT PLAN

DRAWN / DATE	CHECKED / DATE	APPROVED / DATE	SCALE
BP 1/3/01	JPO 1/3/01	JPO 1/3/01	1:500

STATUS	PROJECT	NUMBER	REV
PRELIMINARY	7246 /	01 /	

IMC

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APPENDIX A

Minewater Chemistry N.E. England

APPENDIX A(i)

Pumped Minewater Analysis

NORTH-EAST PUMPED MINE WATERS

COMMENTS ON WATER CHEMISTRY

Introduction

The following notes refer to the chemical composition of waters at sites from which water was pumped in the 1980's. Where possible, results from the 1980's have been compared with later analyses. This mainly applies to pumping stations in Durham; where Dr. Younger studied samples taken in 1995 and IMC have recent results on file. Sites were water was pumped in 1993 were tested as part of a nation-wide survey, these results are included.

The results of analysis are given in the appended table. Where the ionic balance was within 5%, probable combinations of ions have been calculated. Note that, in most cases, the values determined experimentally for Total Dissolved Solids (TDS) are lower than those calculated as the sum of individual ions. This applies to recent samples and appears to apply to those from the 1980's.

Unfortunately, the information available from the 1980's does not include sufficient parameters to completely characterise these waters. In particular, alkalinity has not been reported.

1 Page Bank/ Ushaw Moor/Vinovium

All three of these sites have a selection of results. Those from 1993 appear anomalous, as hardness and sulphate concentrations are low for all three sites.

These waters are of the same general type, with moderate TDS values, and are high in bicarbonate. The main source of water would be near-surface groundwater. There have been only minor changes to composition since 1986.

Page Bank and Vinovium both had slightly acidic pH values in 1986, recent results suggest that this is no longer the case. All three waters are net-alkaline, with a very low total iron content (< 5 mg/l). Any iron resulting from dissolution of pyrites will have been deposited underground prior to pumping.

Ushaw Moor water has the lowest TDS value. It has a higher proportion of hardness salts to TDS than the other sites, and the lowest sulphate concentration.

Vinovium water contains magnesium sulphate. The concentrations of ions in the Page Bank water are intermediate between those found for the other two; these samples have the highest TDS values. Both waters show a slight reduction in sulphate since 1986, but only marginally so.

There should be no change to the general chemical composition if these waters were allowed to mix.

2 Ashington Area

There are very few results available for this area.

The chemical composition of each of these waters is different.

The Ashington (Carl Shaft) water was similar to that found at Vinovium. The iron determined would be expected to be in suspension.

The Morpeth Moor water had the lowest TDS value of any of the waters pumped in the 1980's and had low sulphate and iron concentrations, indicating little contact with pyrites.

The Newbiggin water was a different type : saline water, probably originating from undersea workings. This type of water has a chloride in excess of c.5000 mg/l and a sulphate concentration in excess of c.1000 mg/l, which is not indicative of contact with pyrites. The iron content of these samples is moderate.

The two samples taken from Woodhorn were entirely different from each other. The 1986 sample was a saline water, similar to that from Newbiggin. The 1993 sample, presumably pumped from a different horizon, would have originated from near-surface groundwater.

3 Durham Coast Area

There are very few sample results later than 1990 available for discharges from sites in this group, but depth samples were taken from Dawdon and Hawthorn in January 2000.

There are several different types of water in this group.

The Dawdon water had high hardness and chloride concentrations, but not as high as found at Newbiggin. This suggests a mixture of saline water, probably originating from undersea workings, with water from nearer the surface. The sulphate concentration was ***suspiciously*** low. When samples were taken at different depths in Dawdon shaft, the water nearest the surface had a similar low sulphate value, but lower hardness and chloride concentrations (650 and 2350 mg/l compared with 2500 and 7300 mg/l). Deeper water was highly saline (chloride 40,000 – 70,000 mg/l) with a sulphate concentration greater than 2500 mg/l. It is possible that the pumped minewater contained a mixture of waters from different horizons, but in that case I would expect the sulphate concentration to have been greater.

The pH value suggests that the water is net-alkaline, so the iron determined would be expected to be in suspension

Both samples from Easington water were very saline, with a chloride concentration more than four times that of seawater. The water was probably a deep-zone brine. Unlike that at Wearmouth (below), it contained sulphate, which may have originated from contact with pyrites or from "seawater" type brines. The iron content was relatively low compared with the sulphate concentration.

The Eppleton water had a very similar composition to that of the Ashington (Carl shaft) and Vinovium waters, i.e. near-surface groundwater.

A full analysis is available for the Hawthorn water, which had a much higher proportion of sulphates to TDS than at sites previously discussed. It appears to have been near-surface groundwater, which had had long contact with pyrites. Due to its high bicarbonate content, the iron content was low.

When samples were taken at different depths in Hawthorn shaft, the results were very different. The water nearest the surface had a low TDS value (850 mg/l compared with c.4000 mg/l) and comprised mainly bicarbonate salts (c.75%). The concentrations of all parameters were lower than in the 1987 sample. Deeper water, from below the Main Coal goaf, was highly saline (chloride 30,000 – 60,000 mg/l) with a sulphate concentration greater than 3000 mg/l and only a trace percentage of bicarbonates.

The pumped water may have been collected from workings in shallow seams or it may have contained a mixture of waters from different horizons. There is no indication of the presence of any significant proportion of deep-zone water in the 1987 sample.

It is suggested that the water found in the shaft nearest the surface had run into the shaft and would not be typical of water pumped from that depth.

The Murton water had, in 1983, a slightly higher chloride concentration than found at Hawthorn, but a lower sulphate concentration. The main constituent was probably near-surface groundwater, which had been in contact with pyrites. The pH value suggests that the water was net-alkaline, so the iron determined would be expected to be in suspension. The 1993 sample was a more saline water with a lower sulphate concentration, suggesting that it was pumped from a different horizon

The hardness/chloride/sulphate relationships of the 1982 sample of Seaham water suggest a mixture of saline water, probably originating from undersea workings, with water from nearer the surface. Again, the pH value suggests that the water is net-alkaline, so the iron determined would be expected to be in suspension. The 1981 sample was of "Staple" water. This was very low in dissolved salts and would be mainly near-surface groundwater.

The only analysis available for Vane Tempest looks "strange". Allocation of cations to the values quoted for chloride and sulphate gives a minimum TDS value of 76,000 mg/l, rather than the 42,000 mg/l quoted. The quoted pH value (2.2) is very unusual for a pumped minewater. The very high sulphate suggests long contact with pyrites, which could generate very high acidity and iron concentrations, but would still not be expected to give a pH value as low as 2.2. ***I consider this analysis unreliable without confirmation.***

4 Chester South Moor, Kibblesworth, Kimblesworth

All three of these sites have a selection of results.

The Chester Moor samples are generally low in chloride and high in alkalinity, suggesting that the water originates from near-surface groundwater. The moderate sulphate concentrations suggest some contact with pyrites. There has been a reduction in chloride concentration since 1993. Due to the high bicarbonate content, the iron content in all samples was low.

The Kibblesworth samples show higher hardness and chloride concentrations, but lower sulphate values. This suggests that they were a mixture of near-surface groundwater and deeper saline water. As at Chester Moor, recent samples show lower chloride concentrations than in 1987, indicating a lower proportion of saline water.

The Kimblesworth sample from 1987 is similar to the Ushaw Moor water, with a low chloride concentration and a moderate TDS value indicating that the main source of water was near-surface groundwater. More recent samples show less variation than at Chester Moor or Kibblesworth, with a marginal increase in chloride concentration. Probable combinations show that Chester Moor and Kimblesworth waters are similar but not identical.

In all three cases, the waters contain sufficient bicarbonate alkalinity to deposit iron underground and retain only trace amounts in the discharge.

The variation in the chloride concentration of these waters over the years has had little effect on other parameters. This suggests that there should be no significant change to the general chemical composition if these waters were allowed to mix.

5 Nicholson's, Sherburn Hill

The waters as sampled in 1987 appear similar, with low chloride concentrations and relatively high sulphate concentrations.

Recent results for Nicholson's show little change, other than variations in hardness and sulphate concentrations. They suggest that the proportions of anions are similar to those at Page Bank.

The samples from Sherburn Hill had higher hardness values than those from Nicholson's, but were otherwise of a similar type. There are variations in composition between samples, but no trend is apparent. Samples taken at different depths in Sherburn Hill shaft in January 2000 showed little variation with depth. However, they showed higher TDS values than any of the pumped water samples, with sulphate concentrations exceeding 1100 mg/l.

All results suggest that the waters originate from near-surface groundwater but have had significant contact with pyrites. They are net-alkaline, so the iron determined would be expected to be in suspension.

6 Chatershaugh, Lumley Sixth

Additional results are available for Lumley 6th but not for Chatershaugh.

Waters from these sites have a similar analysis, which is different to that of most sites previously discussed. The TDS values are moderate and the chloride concentration exceeds that of sulphate. This suggests that they are a mixture of near-surface groundwater and deeper saline water and have had limited contact with pyrites.

The probable combinations for the Lumley 6th water show a similarity with Kibblesworth water.

The Chatershaugh sample had a higher sulphate concentration than in found at Lumley 6th in 1986, but similar to that found at Lumley 6th in 2000. The hardness value was lower.

Both waters are net-alkaline with a low iron concentration.

7 Wearmouth, Westoe

The Wearmouth water was a very saline deep-zone brine. Personal memory recalls that many underground feeders contained barium rather than sulphate and that problems occurred when this type of water, originating from deep workings, came into contact with sulphated water from seams closer to the sea bed. Note that of the two samples, one contained excess barium and one excess sulphate. The presence of significant concentrations of barium is unusual for the north-east, being more typical of the East Midlands and Yorkshire. This water is naturally slightly acidic. I would expect this type of water to be generated only when the colliery was operational, and that any post closure water would be less saline and contain excess sulphate.

The Westoe water was mainly saline water originating from undersea workings, although the chloride concentration is higher than in most other samples of this type.

J M Froggatt
16.01.01

North - East Minewaters

Date	pH	Calcium	Magnesium	Total Hardness	Sodium	Potassium	Ammoniacal Nitrogen	Total Iron	Total Alkalinity	Sulphate	Chloride	Ionic Balance %	Total Dissolved Salts Calc	Total Dissolved Salts Determined	Ca Bicarb	Ca Sulph	Mag Bicarb	Mag Sulph	Sod Bicarb	Sod Sulph	Sod Cl	Pot Cl
															Percentage of total in meq/l							
5 Nicholson's, Sherburn Hill																						
Nicholson's																						
24.03.00	7.1	150	69	662	590	35		18	830	800	130	3.64	2787	2200	20		16		9	45	8	2
1995	7	173	71	728	530	26		6	735	1052	112	-1.97	2861		23		15		1	53	6	2
16.03.93	6.9	90	50	433	549	23	0.8	7.1	750	490	150	5.90	2268									
07.01.87	7.1			680				7		1170	140			2650								
Sherburn hill																						
24.01.99	6.7	199	107	943	189	20.6	0.8	3.3	462	802	81	-1.22	1963		34	3		31		24	6	2
22.07.98	7.2	232	107	1025	230	25		2	568	721	128	1.72	2136	1860	38	1		29		20	10	2
16.04.98	7	200	92	883	260	23		13.8	392	710	106	7.03	1870	1840								2
1995	6.7	221	107	998	238	23		7.7	550	967	93	-4.62	2320		36			28		27	7	2
16.03.93	6.8	130	80	658	240	20	0.5	6.3	550	480	110	-0.08	1732		27		19	8		33	11	2
07.01.87	7.1			870				12.6		870	150			2000								
6 Chatershaugh, Lumley Sixth																						
Chatershaugh																						
23.01.86	7.7			370				1.2		590	750			3190								
Lumley																						
10.07.00	7.2	170	71	720	300	29		14	840	550	510	-20.50	2655	2500								
12.05.00	7.3	170	71	720	970	30		7.3	910	650	620	7.58	3621	2900								
04.04.00	7	180	73	754	880	39		7.4	910	630	650	4.45	3562	2900	18		12		6	27	35	2
21.01.00	7.2	180	72	750	890	41		6.9	790	300	740	12.06	3187	3000								
1995	6.9	149	61	626	577	27		4.2	895	420	462	-1.84	2788		20		13		14	19	32	2
15.03.93	6.8	80	40	366	590	23	0.4	3.7	850	170	560	-3.95	2501		12		10		29	10	37	2
07.01.87	7.6			600				2		370	640			2390								
7 Wearmouth, Westoe																						
Wearmouth																						
17.03.93	5.4	9820	2320	34201	43400	519	20.0	99	50	90	89120	1.38	145340		$CaCl_2$ · 19				8*		72	1
04.06.85	5.5			33200				43		Ba 176	105000			170700								
Westoe																						
11.03.93	6.6	1210	1870	10804	26300	706	1.4	3.9	180	4340	44400	1.15	79047			4		3	9*		83	1
28.02.83	6.8			9410				4.2		2840	38500			66330								

* Magnesium chloride not sodium bicarbonate.

North - East Minewaters

Date	pH	Calcium	Magnesium	Total Hardness	Sodium	Potassium	Ammoniacal Nitrogen	Total Iron	Total Alkalinity	Sulphate	Chloride	Ionic Balance %	Total Dissolved Salts Calc	Determined	Ca Bicarb	Ca Sulph	Mag Bicarb	Mag Sulph	Sod Bicarb	Sod Sulph	Sod Cl	Pot Cl
															Percentage of total in meq/l							
	Eppleton																					
23 02 84	7.5			700				0 2		70	410			930								
	Hawthorn																					
03.06 87	7	210	126	1049	865			2 3	876	1620	256	-0 01	4146		18		12	6		52	12	
	Murton																					
11.03.93	7 7	330	120	1324	1470	558	3 9	1 4	560	330	2120	-0.81	6996		11	5		9		20	41	14
24.11 83	7.3			410				16		1180	520			3040								
	Seaham																					
04 11 82	6 9			1160				10 8		1300	2930			7020								
10.06 81	8			408				0 2		77	160			590								
	Vane Tempest																					
27.08 82	2 2			1500				352		14910	33000			41900								
4	Chester Moor, Kibblesworth, Kimblesworth																					
	Chester South Moor																					
10 07 00	7 3	88	36	370	650	18		1 4	1100	600	110	-2 06	2844	2100	12		8		41	31	7	1
04.04 00	7 5	90	37	379	700	28		1 5	1200	630	120	-2 29	3069	2000	12		6		43	29	7	1
21.01 00	7.4	90	36	375	670	28		1 5	1000	550	130	3 02	2724	2100	13		6		36	33	8	2
20.10.99	7.6	89	36	372	660	25		1 2	1100	600	120	-1 52	2872	2100	12		8		40	32	6	2
1995	8 6	79	35	343	683	20		0 85	1050	672	132	-2 22	2902		11		8		38	33	9	1
16.03 93	7	40	20	183	780	19	0 4	0 6	1080	270	270	4.45	2717		6		5		51	16	21	1
07 01 87	7 1			420				2 2		700	310			2650								
	Kibblesworth																					
10 07 00	7 3	160	55	629	350	19		2	610	400	330	-2 76	2058	1700	28		15	1		28	26	2
21.01 00	7 2	160	55	629	490	28		2 8	530	380	400	7 40	2160	1900								
20 10 99	7 4	160	56	633	410	24		2 9	580	380	500	-3 95	2238	1500	26		12	3		14	43	2
1995	7	162	52	621	782	27		0 9	755	395	909	-1.92	3248		17		9		6	18	49	1
16 03 93	7 2	120	50	508	541	20	0 5	0 8	730	290	540	-2 39	2452		17		12		13	14	42	2
07.01 87	7 1			600				2 6		460	1100			3300								
	Kimblesworth																					
10.07.00	7.3	110	43	454	420	16		2 9	690	430	140	1.85	2001	1600	21		13		18	33	13	2
09.05 00	7.3	110	42	450	560	16		3 1	720	480	140	8 65	2226	1600								
22.01.00	7.1	106	42	438	380	21	0 6	1 6	712	448	107	-1.57	1972		20		13		21	34	9	3
1995	7.2	90	34	367	446	16		1.7	835	356	138	-1 65	2098		17		10		35	24	13	1
16.03.93	6.9	60	20	233	374	12		2 2	780	240	120	-6.07	1778									
07.01 87	7.3			480				1		340	100			1410								

* Magnesium chloride not sodium bicarbonate.

North - East Minewaters

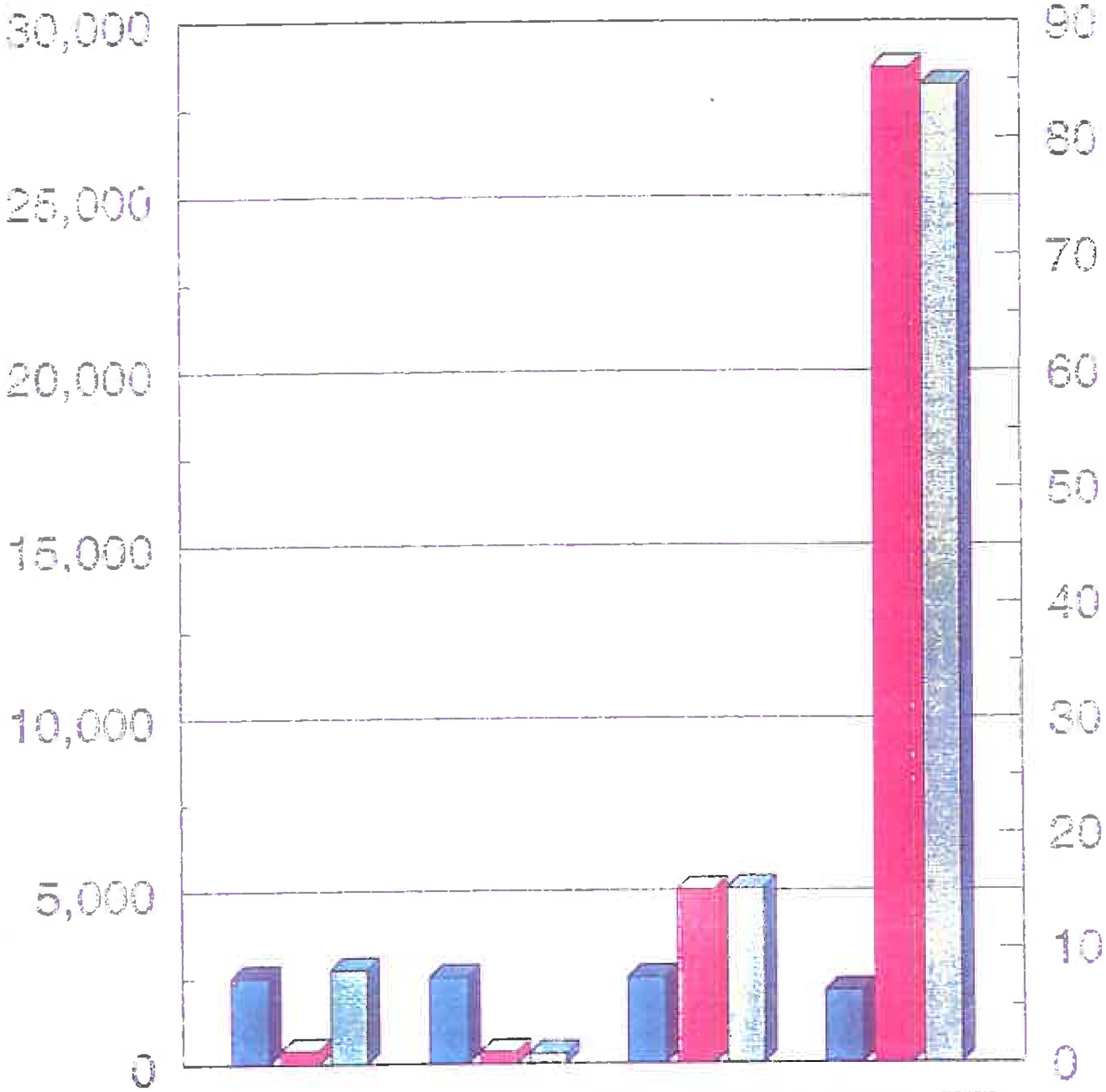
Date	pH	Calcium	Magnesium	Total Hardness	Sodium	Potassium	Ammoniacal Nitrogen	Total Iron	Total Alkalinity	Sulphate	Chloride	Ionic Balance %	Total Dissolved Salts Calc	Total Dissolved Salts Determined	Ca Bicarb	Ca Sulph	Mag Bicarb	Mag Sulph	Sod Bicarb	Sod Sulph	Sod Cl	Pot Cl
															Percentage of total in meq/l							
1 Page Bank, Ushaw Moor, Vinovium																						
Page Bank																						
14.10.00	7.2	146	77	685	355	31	0.8	0.79	764	554	118	-0.36	2215		24		21		6	38	8	3
10.07.00	7.5	140	73	654	380	28		130	720	500	110	4.00	2109	1600	25		21		5	37	9	3
09.05.00	7.2	170	88	791	460	32		1.2	690	740	120	5.72	2452	1800								
04.04.00	7.3	170	87	787	390	38		0.95	750	660	120	2.21	2380	1800	26		20	2		41	8	3
1995	6.7	142	73	659	350	30		0.85	654	601	113	0.53	2107		25		21			43	8	3
16.03.93	6.7	100	60	500	377	29	1.5	0.7	730	390	170	-0 62	2019		18		18		17	29	15	3
23.05.86	6.7			630				0.6		660	160			1960								
Ushaw Moor																						
04.04.00	6.9	120	84	649	91	23		0.35	620	270	44	-4 93	1388	870	34		37	3		19	4	3
29.9.98	6 8	115	81	624	140	24		0 45	560	148	43	10.45	1234	882								
1995	6.7	108	67	549	178	23		0.56	700	232	51	-2 61	1513		28		29		16	20	4	3
16 03.93	6 7	70	50	383	83	17	0.4	0 5	540	140	50	-12.84	1069									
23.5 86	6 8			610				3		250	50			980								
Vinovium																						
10.07.00	7	160	94	791	200	18		0.98	560	550	88	-0 50	1793	1500	32		13	18		27	8	2
04.04.00	7.3	160	91	779	240	25		0.81	630	510	99	1.03	1894	1400	31		18	11		30	8	2
21 01.00	7	150	87	737	260	26		1.2	560	450	100	6 46	1756	1500								
01.11.99	7 1	160	89	770	240	27		0.78	540	510	99	4 40	1784	1500	33		11	19		25	9	3
10 10 99	7.2	150	94	766	220	21	0.4	0.61	596	524	79	0 51	1815		30		17	13		31	7	2
1995	6 8	149	85	726	216	23		0 5	625	510	79	-1 87	1824		30		21	8		32	7	2
16.03.93	6.9	90	60	475	250	17	0.4	1.7	600	320	90	-1.04	1560		22		24		12	30	10	2
23.05.86	6 6			760				2		640	90			1710								
2 Ashington Area																						
Ashington (Carl Shaft)																						
17 02.86	7.5			770				7 6		460	90			1320								
Morpeth Moor																						
14.02.86	7.2			360				0.4		110	220			740								
Newbiggin																						
18 03.93	6.4	810	680	4854	6390	141	0.8	9.4	210	1940	11200	2.41	21418		1	10		1	15*		72	1
23.05.86	6.9			5900				19		1930	15300			27430								
Woodhorn																						
18 03 93	7 6	130	70	616	100	10	< 0 2	2 3	380	380	120	-5 65	1274									
28.01.86	7.6			2370				10		1800	4460			10460								
3 Durham Coast																						
Dawdon																						
09.02.83	7.1			2500				18		150	7300			12200								
Easington																						
11.03.93	6.5	2130	1410	11191	50180	4470	6.8	7.6	140	5020	84500	0.63	147890			4			5*		86	5
07.10.83	6.6			13200				48.5		3470	84500			142830								

* Magnesium chloride not sodium bicarbonate.

British Coal Corporation

Non Operational Collieries Group

Bates Water Monitoring Shaft - Graph Showing Basic Water Chemistry



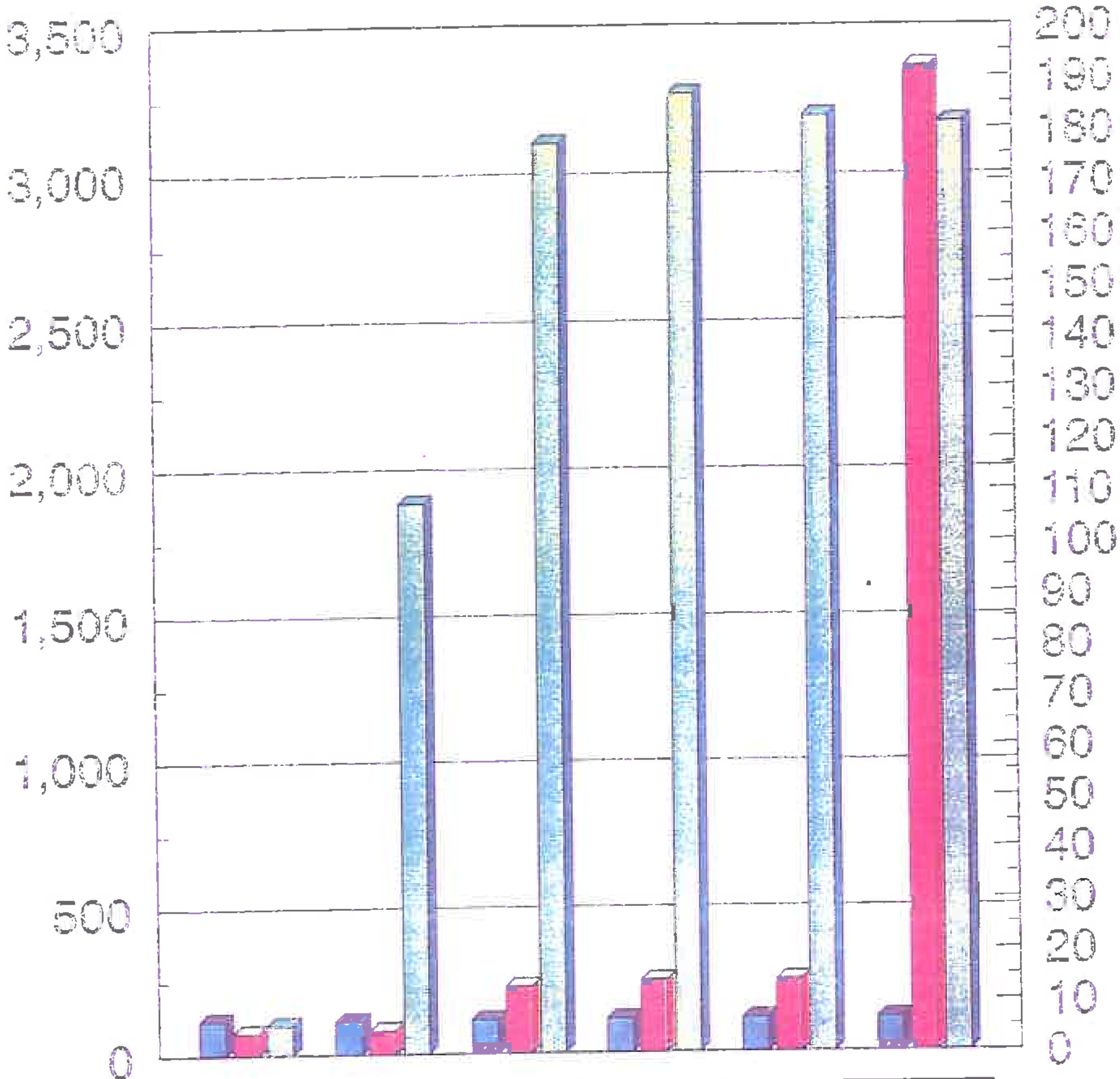
depth (feet)	262	427	591	745
p.h.	7.49	7.50	7.43	6.27
iron mg/l	1.20	1.05	15.00	86.00
chloride mg/l	2,719.00	302.00	5,045.00	28,180.00

APPENDIX 1

British Coal Corporation

Non Operational Collieries Group

Bedlington A Water Monitoring Shaft - Graph Showing Basic Water Chemistry



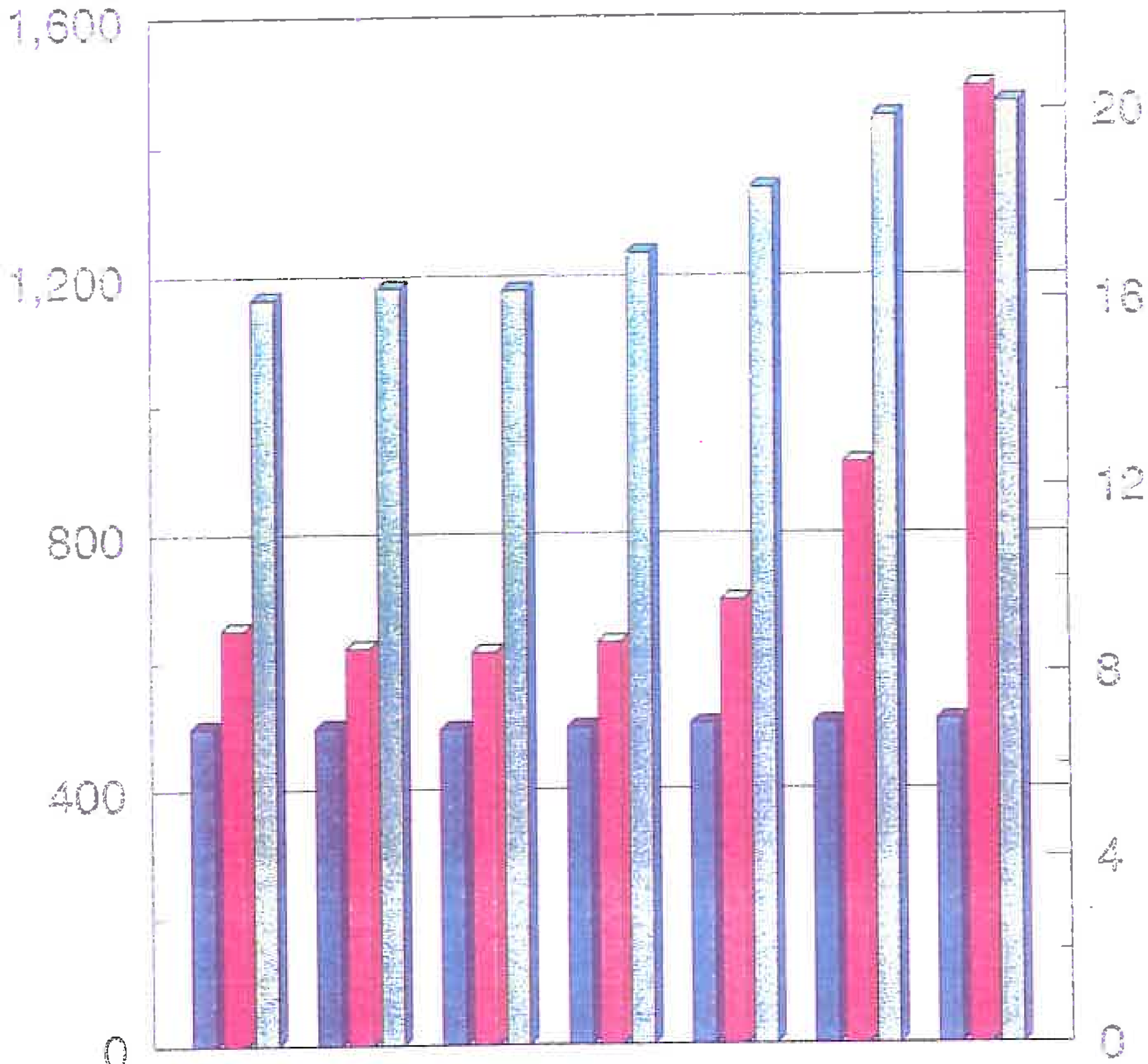
depth (feet)	344	394	528	604	659	778
p.h.	6.65	6.55	6.55	6.55	6.55	6.55
iron mg/l	4.25	4.65	13.00	14.00	14.00	192.00
chloride mg/l	100.00	1,885.00	3,103.00	3,268.00	3,196.00	3,173.00

APPENDIX 1

British Coal Corporation

Non Operational Collieries Group

Choppington A Water Monitoring Shaft - Graph Showing Basic Water Chemistry



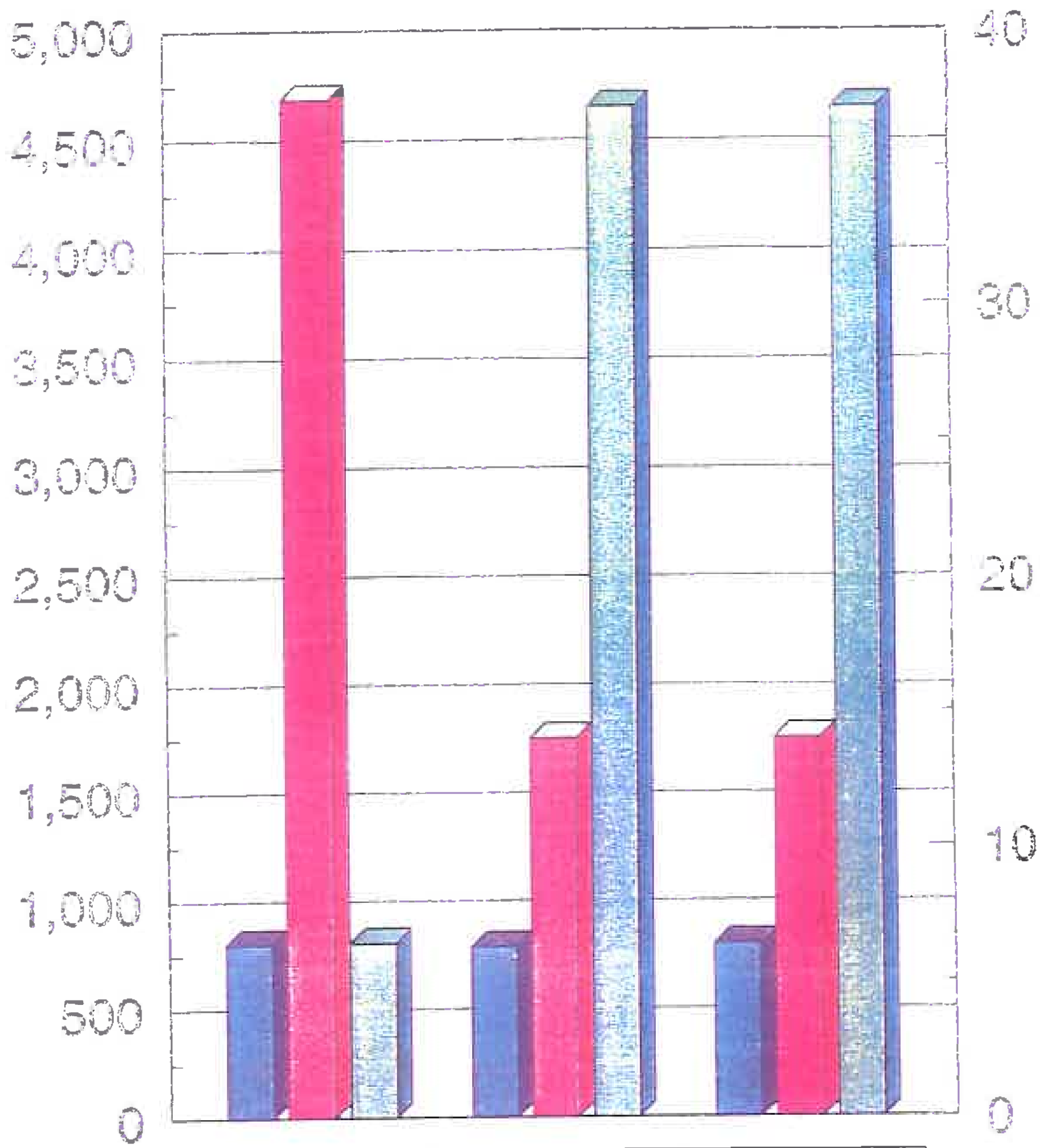
depth (feet)	331	344	381	466	607	745	899
p.h.	6.83	6.83	6.79	6.82	6.89	6.90	6.96
iron mg/l	8.95	8.55	8.45	8.65	9.55	12.50	20.50
chloride mg/l	1,165.00	1,182.00	1,178.00	1,235.00	1,335.00	1,446.00	1,466.00

APPENDIX 1

British Coal Corporation

Non Operational Collieries Group

New Delaval Water Monitoring Shaft - Graph Showing Basic Water Chemistry



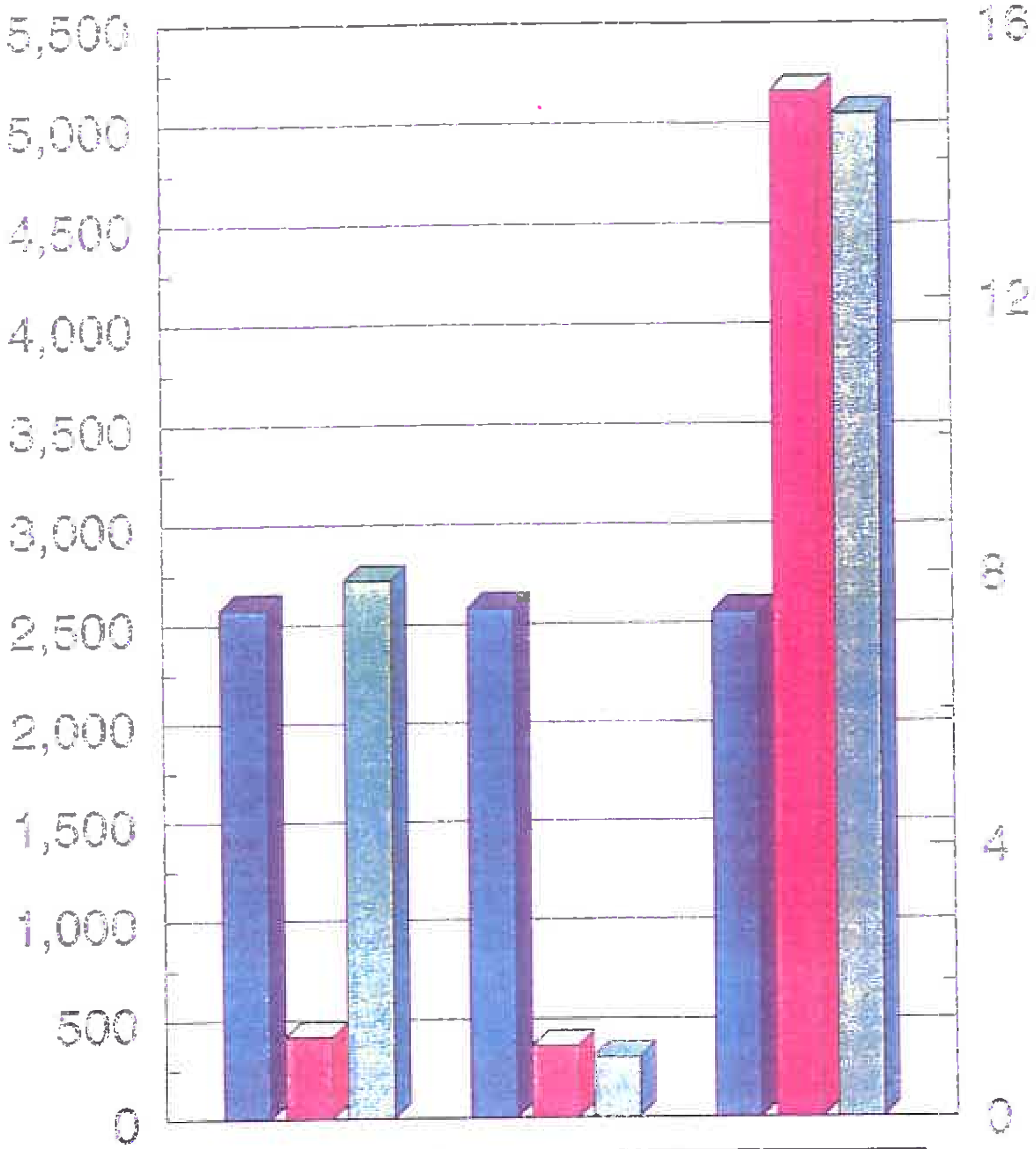
depth (feet)	354	367	450
p.h.	6.39	6.28	6.37
iron mg/l	37.50	14.00	14.00
chloride mg/l	804.00	4,650.00	4,650.00

APPENDIX 1

British Coal Corporation

Non Operational Collieries Group

North Seaton Water Monitoring Shaft - Graph Showing Basic Water Chemistry



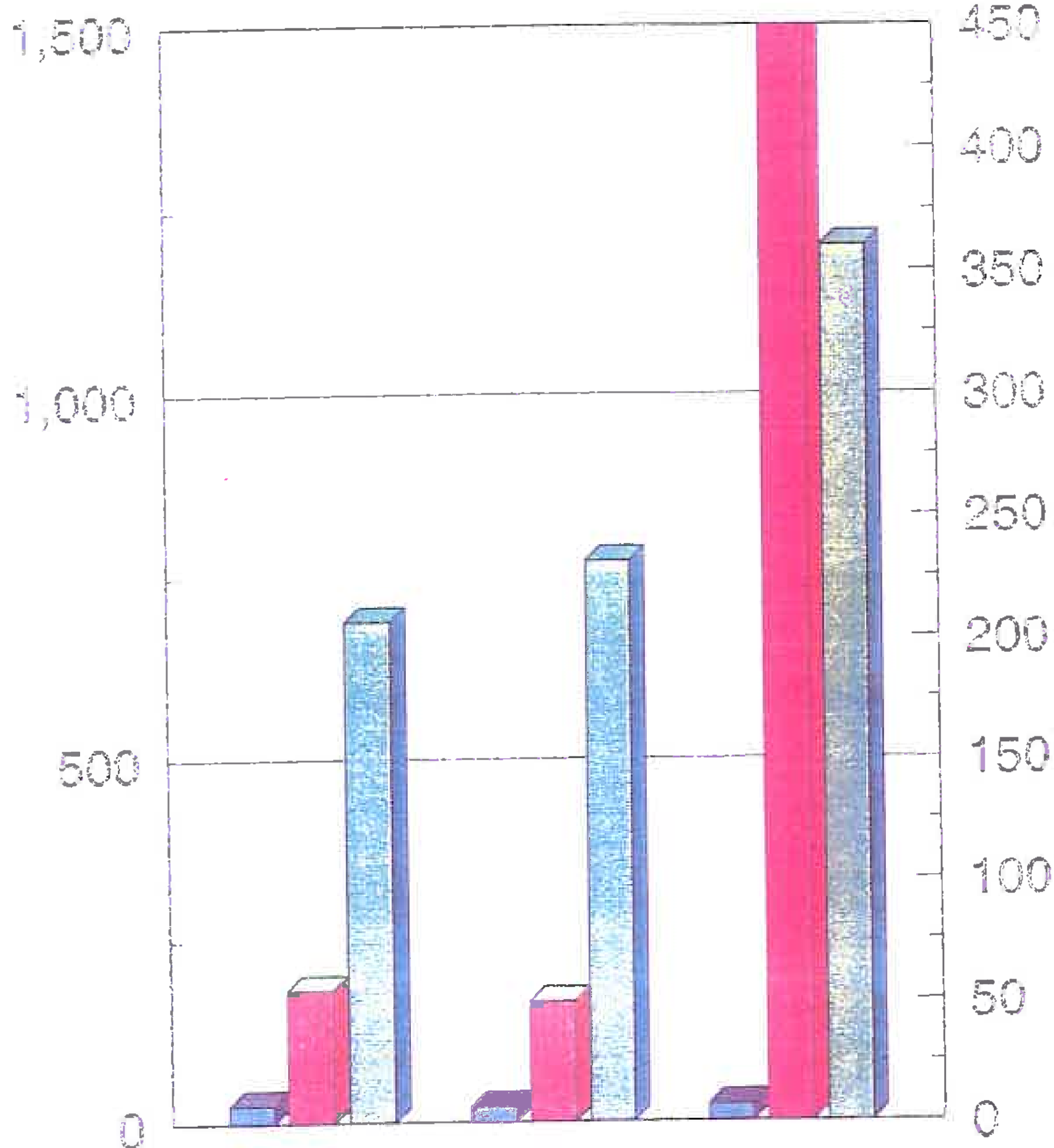
depth (feet)	262	427	591
p.h.	7.49	7.50	7.43
iron mg/l	1.20	1.05	15.00
chloride mg/l	2,719.00	302.00	5,045.00

APPENDIX 1

British Coal Corporation

Non Operational Collieries Group

Seaton Delaval Water Monitoring Shaft - Graph Showing Basic Water Chemistry



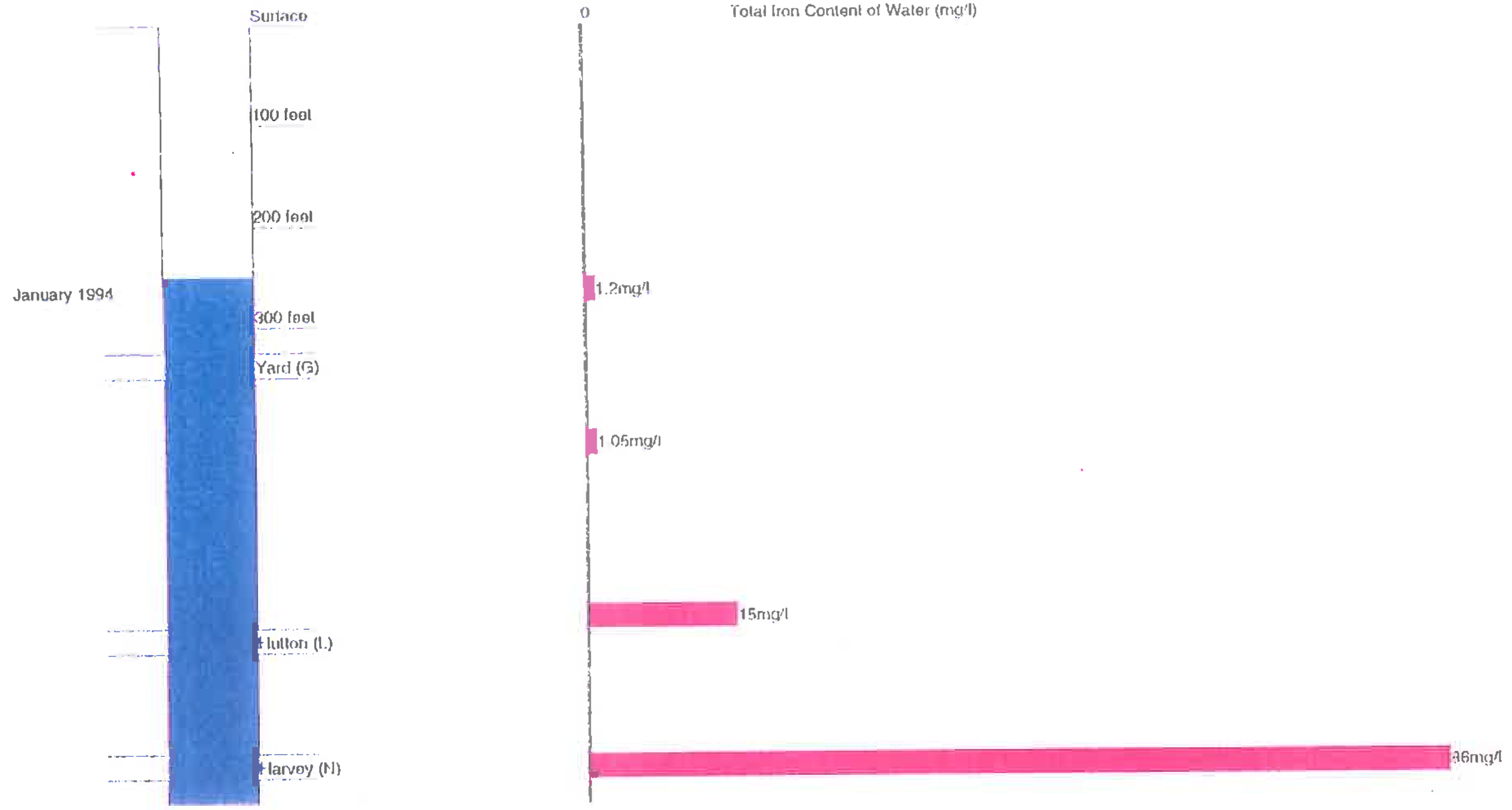
depth (feet)	361	427	459
p.h.	7.36	6.28	6.90
iron mg/l	54.50	49.50	450.00
chloride mg/l	689.00	771.00	1,200.00

APPENDIX 1

British Coal Corporation
Non Operational Collieries Group

Recovery of Groundwaters in South East Northumberland

Diagrammetric Section through Bates No 2 Shaft



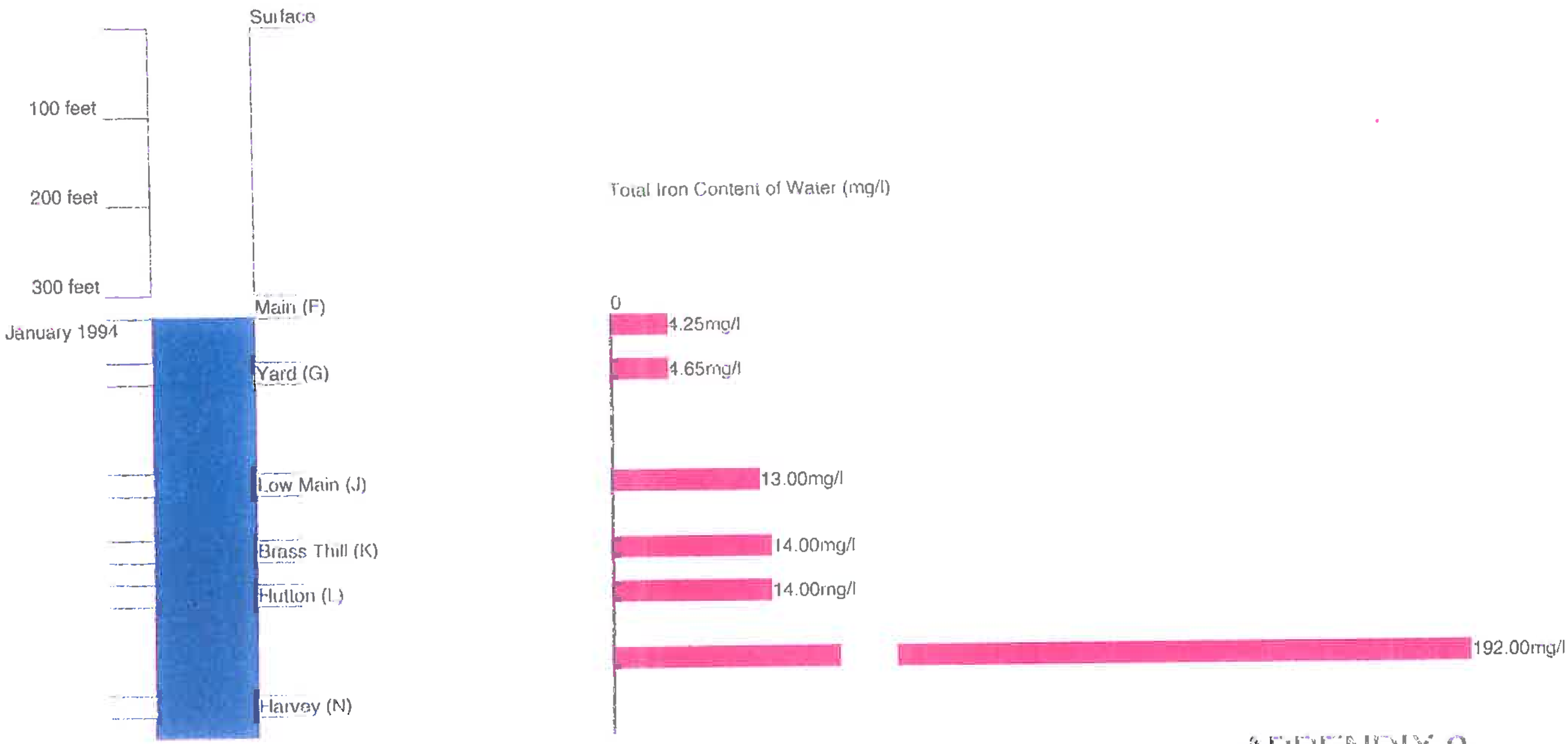
APPENDIX 2

British Coal Corporation

Non Operational Collieries Group

Recovery of Groundwaters in South East Northumberland

Diagrammetric Section Through Bedlington 'A' Colliery Shaft



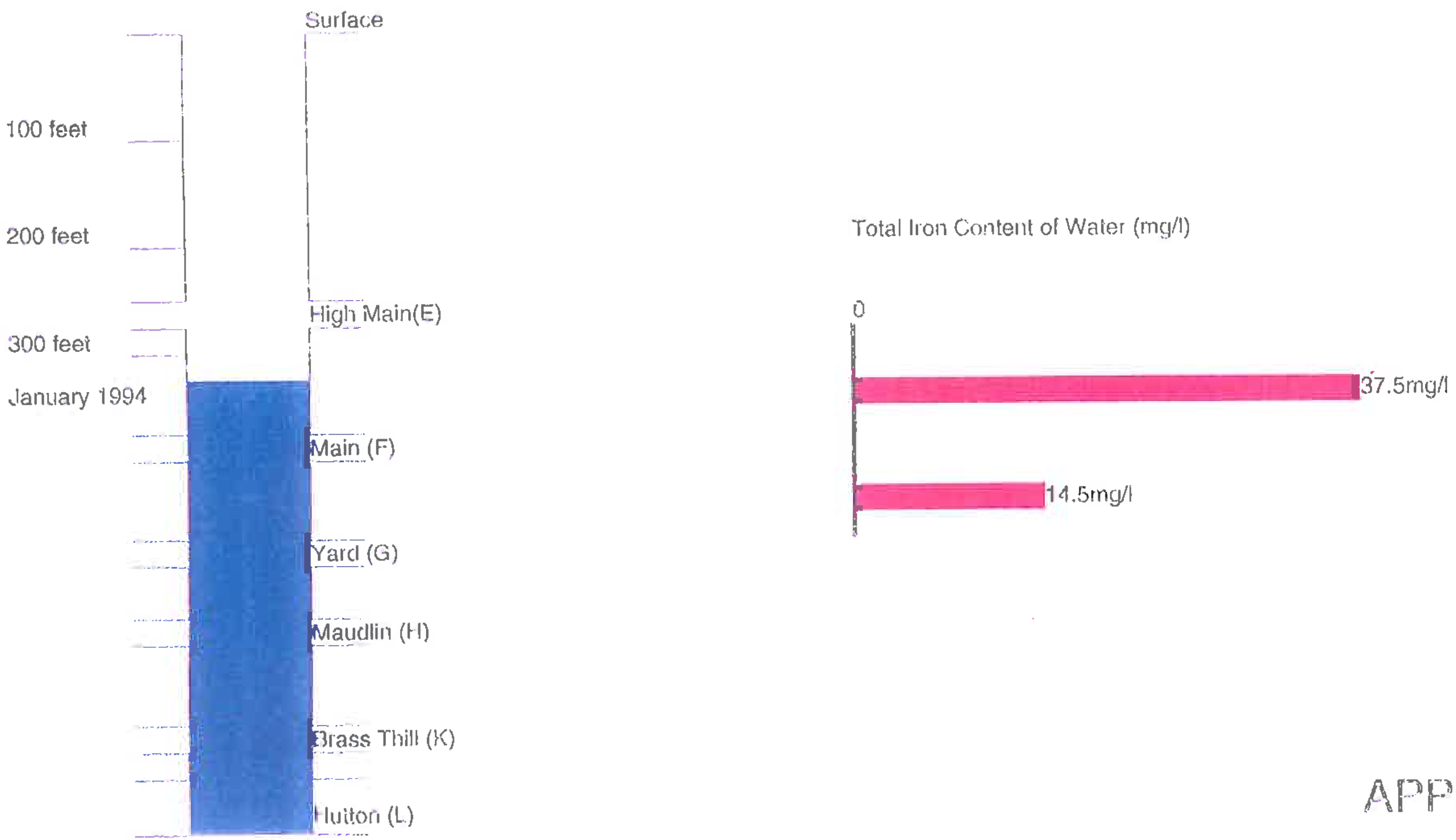
APPENDIX 2

British Coal Corporation

Non Operational Collieries Group

Recovery of Groundwaters in South East Northumberland

Diagrammetric Section through New Delaval Colliery Shaft



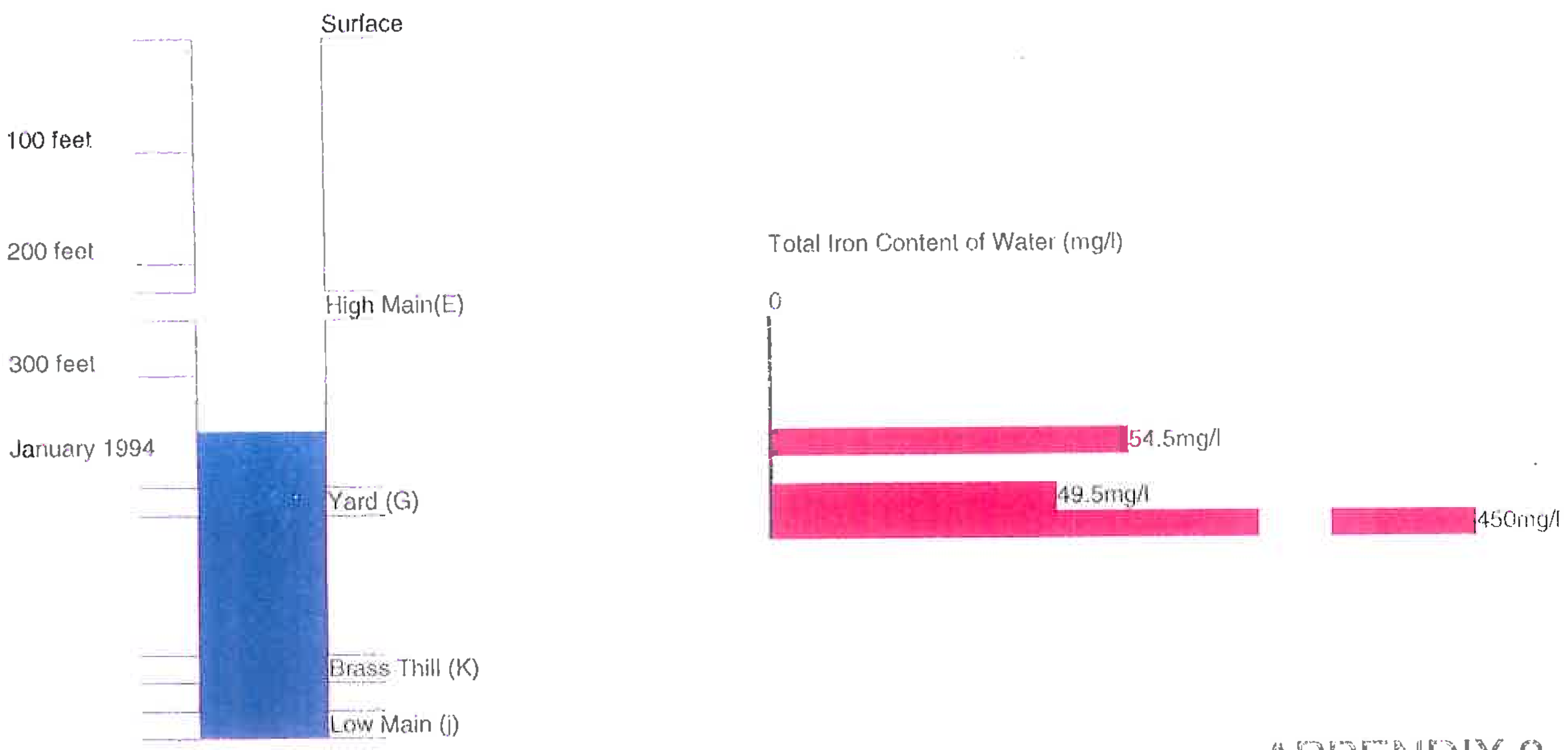
APPENDIX

British Coal Corporation

Non Operational Collieries Group

Recovery of Groundwaters in South East Northumberland

Diagrammetric Section through Seaton Delaval Colliery Shaft



APPENDIX 2

British Coal Corporation

Non Operational Collieries Group

Recovery of Groundwaters in South East Northumberland

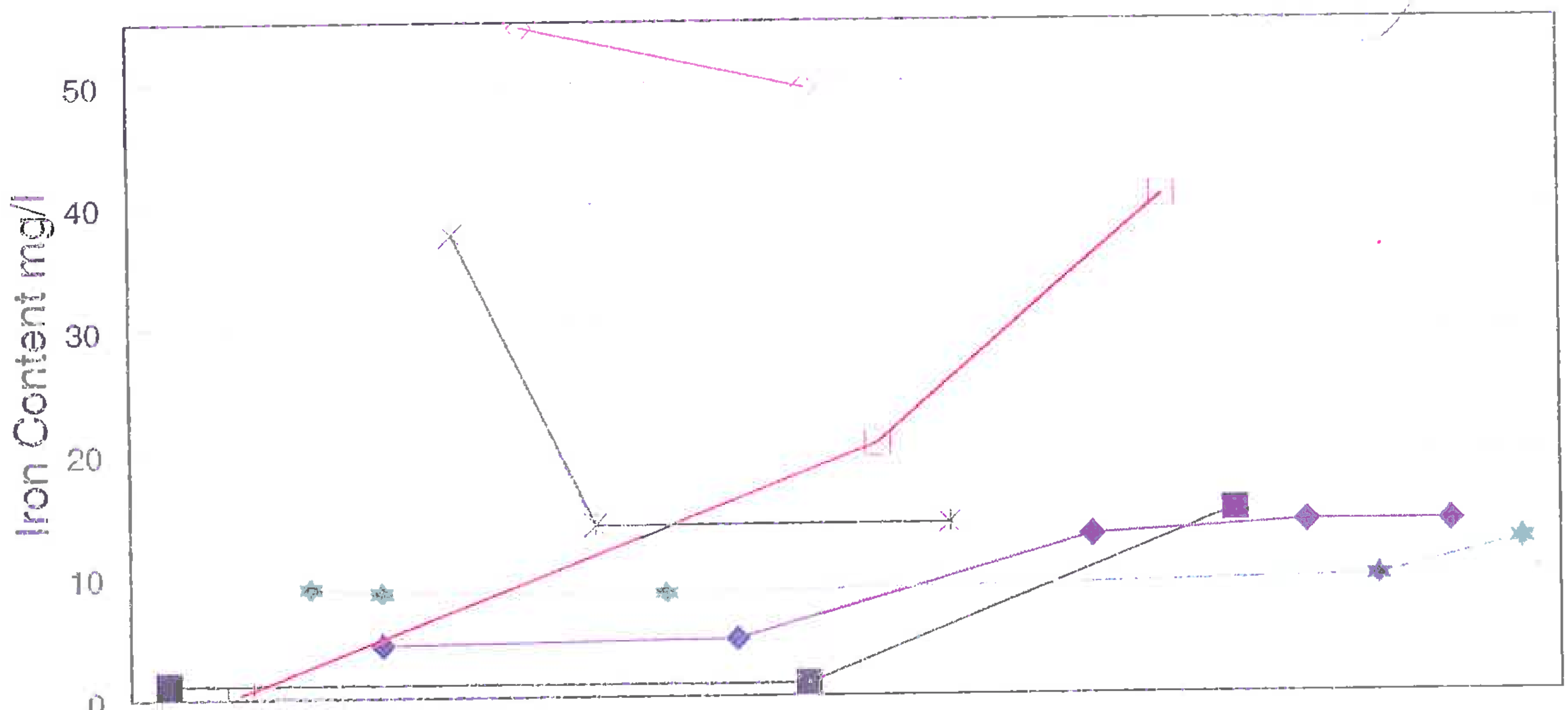
Diagrammetric Section through North Seaton Shaft

APPENDIX 2

British Coal Corporation

Non Operational Collieries Group

Variation in Iron Content - South Northumberland Water Monitoring Stations



Depth Below Surface (feet)	262	312	331	344	354	361	367	381	394	427	446	450	459	528	548	591	604	607	659	745
BATES	1.20									1.05						15.00				
BEDLINGTON				4.25					4.65					13.00			14.00		14.00	
CHOPPINGTON			8.95	8.55				8.45										9.55		12.50
NORTH SEATON		0.30									20.50				40.50					
SEATON DELAVAL						54.50				49.50										
NEW DELAVAL					37.50		14.00					14.00								

Figure 12