NATIONAL RIVERS AUTHORITY
AWDURDOD AFONYDD CENEDLAETHOL

WELSH REGION
RHANBARTH CYMRU

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AAC

NRA

Guardians of the Water Environment
Diogelwyr Amgylchedd Dŵr

NRA-Wales 189

NRA WELSH REGION - SOUTH WEST AREA

MINEWATERS WORKSHOP - 23 MAY 1995

SUMMARY REPORT

NRA - WELSH REGION

SOUTH WEST AREA - MINEWATERS WORKSHOP

23rd MAY 1995 - COUNCIL CHAMBER, COUNTY HALL, SWANSEA

Organised by the South West Area Minewaters Project PR Team

Chaired by Niall Reynolds, District Pollution Control Manager, NRA, Swansea

Introduced by Dave Walker, Area Manager, NRA, Haverfordwest

Objectives

To enable Welsh Region and other staff to gain an appreciation of the issues and problems relating to the remediation of abandoned minewater discharges, with particular emphasis on reporting of progress and future work of the River Pelenna and Blaenant/Ynysarwed minewater remediation projects.

Programme/contents

1. Regional Minewaters Project (David Williams, District Pollution Control Manager, NRA, St.Mellons)

2. The River Pelenna Minewater Treatment Project - a local solution to a European problem (Chris Bolton, Area Pollution Control Officer, NRA, Swansea)

3. Environmental assessment studies in the River Pelenna catchment (Paul Edwards, Minewaters Project Officer, NRA, Swansea)

4. River Pelenna Minewaters Project - wetland design and construction (Allan Archer & Kevin Price, West Glamorgan County Council)

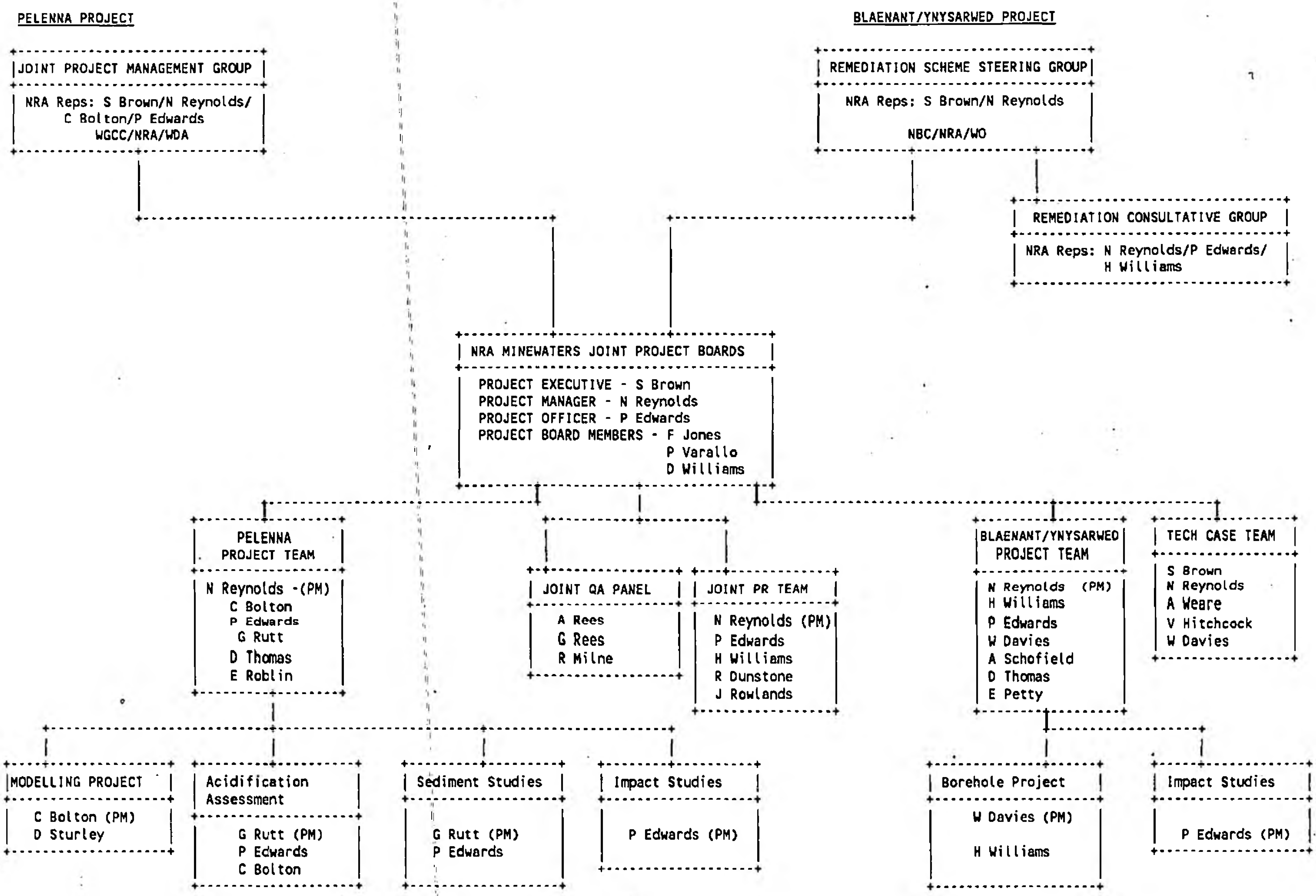
5. Blaenant/Ynysarwed Project overview (Helen Williams, Area Pollution Control Officer, NRA, Swansea)

6. Blaenant/Ynysarwed Technical Case - the cause of problem (Wayne Davies, Regional Hydrogeologist, NRA, St.Mellons)

7. Remediation options (Robert Rees & Arthur Davies, Neath Borough Council).

8. Summary (Steve Brown, Area Environmental Quality Manager, NRA, Haverfordwest)

NRA, WELSH REGION, SOUTH WEST AREA - MINEWATERS PROJECT MANAGEMENT STRUCTURE



PM = Project Manager

1. REGIONAL MINEWATERS PROJECT

DAVID WILLIAMS, District Pollution Control Manager, NRA, St.Mellons

Background

The Welsh Region of the NRA gave evidence to the Welsh Affairs Committee's Inquiry into this subject in March 1992. Following this a Phase I survey was undertaken of all abandoned coal mine discharges in Wales. This work was jointly funded by the Welsh Office (£34K) and the NRA (£25K) and carried out in-house. The brief conclusions of this survey were that 90 discharges were located and 64kms of river were affected.

Phase 2 study

Thirty-three of the discharges identified in Phase I were also subjected to a more detailed impact assessment. From these, 16 discharges were selected for further investigation in Phase 2 of the project. The objectives of Phase 2 were to identify the underlying causes of the discharges, to propose the most favourable remedial options and to provide budget costings.

This work was put out to consultants in 1994 and funded jointly again by the Welsh Office (£20K) and the NRA (£20K). Stephen, Robertson and Kirsten (UK) Ltd, an international mining and engineering consultancy, won the contract.

The list of discharges considered in Phase 2 is shown in table 1.

The consultants visited each site and carried out a desk study of all the available information. Their approach included development of a conceptual model of the underlying process causing each discharge. River quality objectives were developed in consultation with the NRA and potential remedial options for achieving these objectives were considered for each discharge. A probabilistic approach was used to decide on the option most likely to be successful. Finally, using standard unit costs and an allowance for contingencies, budget costings were produced. The results of this work are summarised in Table 2.

Conclusions

i) A wide range of remedial options is available, depending on individual site specific circumstances.

ii) Capital costs ranged from £17.5K for £730K and annual operating costs from £1.2K to £830K.

iii) The work was based on conceptual models therefore a degree of uncertainty is inherent in the conclusions.

iv) In some cases the costs of the remedial work would appear likely to outweigh the benefits to be gained.

v) Costs are approximate and should be used for comparative purposes only.

The Future

Clearly, remedial schemes should only be considered where a proper cost benefit analysis demonstrates that the benefit outweighs the cost. To this end the authority is developing cost benefit analysis techniques and is trialling a system at the moment on the minewater discharge at Hengoed on the Rhymney. At the time of writing this work is incomplete.

The Pelenna minewater discharges were not included in Phase 2 as a major remedial scheme is already underway to deal with these. This project was the subject of an earlier report to Committee. The Pelenna project will provide a full scale demonstration of the use of anoxic limestone drains, lagoons and reed beds as an integrated remedial package. The Ynysarwed minewater discharge, which continues to cause serious pollution of the Neath Canal, was included in Phase 2 of the regional project.

The Phase 2 report included other remedial techniques and one in particular, better dispersion, is relatively cheap and shows promise at a number of sites. Unfortunately, no money is available this year to trial this option but the opportunity should be grasped as soon as possible.

Reference

Steffen, Robertson & Kirsten (UK) Ltd. (1994) Study of ferruginous minewater impacts in Wales: Phase 2a Determination of remedial options

Table 1

MINEWATERS INVESTIGATED

	PLACE	RIVER
1.	Blackwood	Sirhowy
2.	Pontllanfraith	Sirhowy
3.	Hengoed	Rhymney
4.	Llanwonno	Y Ffrwd
5.	Bettws	Llynfi
6.	Aberbaiden	Nant Craig yr Aber
7.	Glyncorrwg	Corrwg
8.	Glyncorrwg	Corrwg Fechan
9.	Blaengwynfi	Nant Gwynfi
10.	Garnswllt	Cathan
11.	Morlais	Morlais
12.	Llechart	Lower Clydach
13.	Dunvant	Clyne
14.	Blaenavon	Afon Llwyd
15a.	Ynysarwed	Neath Canal
15b.	Blaenant	Dulais

Table 2

SUMMARY OF COSTS FOR PREFERRED REMEDIAL OPTIONS

Site No	Site Name	Remedial Option	% Confidence	Capital Cost	Operating cost/annum
5	Blackwood	Diffuser	90%	£20,000	£2,500
6	Pontllanfraith	Hydraulic balance & diffuser	70%	£37,000	£4,700
7	Rhymney	Hydraulic balance Sulphate reduction Wetland	60% 40% 90%	£130,000 £126,000 £730,000	£13,500 £52,600 £74,500
10	Blaenavon	Hydraulic balance Wetland	70% 90%	£28,000 £50,000	- £6,500
12	Y Ffrwd/Llanwonno	Dam and spillway	75%	£25,000	£4,000
15	Llynfi	Oxygen plugs, wetland	80%	£55,000	£5,000
16	Craig yr Aber	ALD, aeration & wetland	80%	£264,000	£28,900
17	Afon Corrwg	Oxygen plugs, ALD, aeration & wetland	90%	£125,000	£14,000
18	Afon Corrwg Fechan	Bulkhead, wetland	80%	£36,000	£5,100
19	Gwynfi	Oxygen exclusion/wetland	80%	£50,000	£6,500
29	Cathan	Oxygen exclusion/wetland Sulphate reduction	70% 30%	£74,500 £210,000	£8,950 £33,000
30	Morlais	ALD/wetland Pipeline Sulphate reduction	70% 90% 50%	£525,000 £100,000 £160,000	£54,000 £11,500 £816,000
31	Dunvant	Plugging, wetland	90%	£17,500	£1,250
31A	Dunvant Square	Hydraulic balance, ALD, wetland	70%	£61,000	£6,600
33	Clydach Tawe	Oxygen exclusion/wetland	80%	£50,000	£5,500
62	Ynysarwed	Oxygen exclusion, ALD, wetland	80%	£604,000	£62,200
62A	Blaenant	Hydraulic balance, wetland	80%	£225,000	£24,000

NB: Wetlands costings include land purchase price. Wetlands are costed for 10 years and costs do not include sludge disposal but the operating costs at 10% of capital allows for replacement or sludge disposal. The above costs do not include for engineering design.

2. THE RIVER PELENNA MINEWATER TREATMENT PROJECT - A 1OCAL SOLUTION TO A EUROPEAN PROBLEM

CHRIS BOLTON, Pollution Control Officer, NRA, Swansea

Summary

This talk described the River Pelenna Minewater Treatment Project which is currently ongoing in the River Afan catchment North East of Port Talbot, South Wales.

The National Rivers Authority (NRA), in collaboration with West Glamorgan County Council (WGCC) (lead partner) and the Welsh Development Agency (WDA) is developing a series of constructed wetlands to treat the drainage from five abandoned mineworkings in the valley. The main aims of the project are to reduce iron concentrations in the watercourse to a level that will allow recolonisation by salmonid fish and reduce the aesthetic impact of the discharges. The problems of water pollution associated with drainage from abandoned mineworkings are common not only throughout the UK coalfields but also in Europe and further afield, wherever mineral exploitation has led to the generation of Acid Rock Drainage. The relatively low technology and low maintenance solutions being developed could have very wide ranging benefits and also provide a demonstration of current technology, which is a requirement of one of the funding organisations, the EC LIFE Programme. The other funding organisations are WDA, WGCC, NRA and The BOC Foundation for The Environment.

Introduction

The River Pelenna, a tributary of the River Afan is situated to the North East of Port Talbot in the county of West Glamorgan, South Wales. It rises 300m above sea level and flows approximately 16 Km into Swansea Bay at Port Talbot. The landscape and topography of the area is typical of the South Wales valleys, comprising upland moors and steep sided river valleys, with coniferous forest plantations being dominant in parts. The River Pelenna has two main tributaries, the Nant Gwenffrwdd and the Nant Blaenpelenna, which meet in the former mining village of Tonmawr, which developed as a consequence of coal mining in the area.

Records indicate that coal exploitation began in the valley as early as the 1850's with approximately 15 small drift mines and adits developing over the next 100 years working a number of seams including the Wenallt, Glyngwylim and Wenallt Rider. Following the First World War two larger collieries; the Garth Tonmawr Drift Mine in the Nant Blaenpelenna Valley and Whitworth Colliery, a deep mine in the Gwenffrwdd Valley, developed employing approximately 500 men between them. These are detailed in Figure 1. Coal mining had however ceased in the area by the early 1960's leaving behind the industrial dereliction and the spoil tips which were common in much of South Wales.

However, probably the most startling legacy of the coal mining past in the Pelenna catchment is the aesthetic impact of the highly polluting discharges from many of the abandoned mines in the area. These are startlingly evident due to the characteristic orange-yellow staining of the receiving watercourses frequently associated with the discharges from abandoned coal mines. This is due to the precipitation of iron hydroxide as the dissolved metal becomes oxidised on entering local watercourses. On occasions, the minewater discharges can be directly toxic to aquatic life due to low pH and elevated concentrations of heavy metals, particularly iron but also aluminium. The blanketing of the substrata with the metal oxides also has more chronic effects by destroying invertebrate habitat and fish spawning areas. The effects of and the chemistry of drainage from abandoned coal mines have been well documented elsewhere. It has been estimated that approximately 17Km of watercourse has been adversely affected in the Pelenna catchment, as far downstream as it's confluence with the main River Afan at Pontrhydyfen. From the social and economic perspective the gross aesthetic impact is considered by the District and County Councils to be a barrier to the redevelopment of the area.

The Pelenna Discharges

Of the numerous abandoned minewater discharges in the Pelenna catchment, five have been identified as being the most polluting, and are the subject of this remediation project. These are Whitworth A and B which discharge to the Whitworth Lagoon, Gwenffrwdd, Whitworth No.1 and the discharge from the former Garth Tonmawr Drift Mine. Although these mines have been closed for over thirty years, the polluting effects are still very severe as illustrated by the following table of the mean daily iron loadings from each discharge.

Table 1. Mean daily iron loadings, Pelenna minewater discharges.

	Mean Iron (mg/l)	Mean Flow (l/s)	Daily Load (Kg Fe/day)
Whitworth Lagoon	40.3	14.1	49.1
Garth Tonmawr	25.4	26.0	57.1
Whitworth No.1	22.3	4.6	8.9
Gwenffrwdd	10.6	16.0	14.6

The Origins of the Project

Following closure of the two largest mines, Whitworth and Garth Tonmawr, predecessors of the NRA were collecting information to characterise the discharges and their impact on the receiving watercourses. During the reclamation of the Whitworth Colliery site in the mid 1970's, West Glamorgan County Council constructed the Whitworth Lagoon in an attempt to treat two of the discharges, also the local angling club, Afan Anglers, put forward detailed proposals to deal with the Garth Tonmawr discharge. Local concern over the problem had always been an issue but the situation gained wider attention during the late 1980's as the South Wales Coalfield was being run down, creating the potential for more widespread problems to occur.

In 1992, The BOC Foundation for the Environment funded an investigation into the water quality of the catchment to identify the levels of treatment necessary at each minewater discharge to achieve acceptable standards downstream. This work, managed by the NRA, engaged the Institute of Hydrology to run their QUASAR (QUality ASsesment Along Rivers) which measured the iron and pH concentrations in the river and each of the discharges and predicted the reductions required to meet EIFAC standards downstream. The study recommended that the iron concentrations in the Nant Gwenffrwdd and Nant Blaenpelenna be reduced by 95% and 50% respectively to achieve EIFAC standards and make the watercourse suitable for recolonisation by salmonid fish.

Following on from this work, a contract was let by the NRA in spring 1993 to consultants Richards, Moorehead and Laing Ltd. (RML) to undertake a feasibility study of the most suitable and cost effective methods of achieving these reductions. The report concluded that this could be achieved by treating the Whitworth A and B, Gwenffrwdd, Garth Tonmawr and Whitworth No.1 discharges by a combination of anoxic limestone drains, settlement ponds, aerobic and anerobic wetlands. A schematic diagram of the proposals for the

Nant Gwenffrwdd valleys is illustrated in Figure 2. It should be noted that the design of passive wetland treatment systems is highly dependent on the minewater chemistry and as a consequence the detailed designs of the Whitworth No.1 and Garth Tonmawr wetlands does vary from the original proposals.

This report was then used by West Glamorgan County Council (WGCC) as the basis of a bid to the EC LIFE Programme for funding for the project on behalf of the project partners WGCC, NRA and the WDA. Funding of £505 K was confirmed by the EU in November 1993, with the WDA matching this money, WGCC bearing significant project management costs as lead partner and the NRA carrying costs of all environmental monitoring associated with the project. Work on the project started in earnest in January 1994, with a programme to construct five wetlands over a five year period.

Project Aims and Objectives

The application to the EC LIFE Programme stated four objectives which have become the primary objectives of the project;

1. To create a large scale demonstration wetland treatment system capable of improving sites contaminated by coal mine water discharges.

2. To evaluate water purification and therefore rehabilitation of contaminated sites.

3. To assess and develop opportunities to enhance the conservation aspects of such treatment systems.

4. To produce comprehensive data to contribute to the information base on treatment of the problem and its applicability to the European Community including the dissemination of that information.

Achieving the Aims and Objectives

To date, the Whitworth No.1 wetland has been constructed and incorporates a number of demonstration features which will partly fulfil one of the project objectives. The system includes both anerobic and aerobic wetlands, utilising subsurface and surface flow, differing substrate types (mushroom compost and wood bark mulch) and differing plant species (nursery grown *Typha sp*. and the locally occurring *Juncus sp*) The Garth Tonmawr wetland will extend the scale of demonstration by including Anerobic Contact Beds to remove oxygen from the minewaters, Anoxic Limestone Drains, Aeration Cascades and Settlement Ponds.

As these and the future wetlands become established, monitoring work by the NRA will be carried out to determine the success of the wetlands in removing iron from the discharges and increasing their pH prior to discharge to the river.

In terms of collecting data and disseminating information, WGCC has established links with The Coalfields Community Campaign, EURACOM and EURADA, and has undertaken work to establish areas throughout Europe where problems of drainage from working and abandoned mines exist. This will assist in the exchange of information and allow the right audience for circulars and papers to be targeted. A publicity leaflet and a video about the project have been produced and circulated widely, and there has been both local and regional coverage in the press and on television and radio. Dissemination through the scientific press is encouraged and a paper on the early water quality modelling work was recently published in the CIWEM Journal.

Additional Work

In addition to this work the NRA has become involved in a number of other associated projects, principally:

Fisheries, Biology, Water Quality Studies.
Acidification Studies.
Sediment Studies.
Investigations into Natural Wetlands.
Ecological/Conservation Studies.
Minewater Treatment Computer Aided Design Package (MTCADPak).

Briefly, each of these projects covers the following areas:

1. **Fisheries, Biology, Water Quality Studies.** Detailed work has been carried out to quantify the status of the catchment and determine the impact of the abandoned mine discharges. This will provide baseline data so that any future changes due to the wetlands can be assessed.

2. **Acidification Studies.** The above studies identified that surface water acidification in the catchment is a severe problem, to the extent that if the minewater discharges were successfully treated recolonisation by salmonid fish would only have limited success. A feasibility study into methods of addressing this problem has been carried out.

3. **Sediment Studies.** As part of the work to measure the impact of the minewater discharges, methods of quantifying the aesthetic impact and the sediment load of iron hydroxide compounds in the watercourse have been carried out.

4. **Investigations into Natural Wetlands.** Work by an MSc placement student has recently been carried out to investigate the iron removal processes in 'natural' wetlands associated with abandoned minewater discharges and to assess their remediation capabilities.

5. **Ecological/Conservation Studies.** As part fulfilment of one of the project objectives, baseline surveys into the ecological status of the catchment have been carried out, including a bird survey. These will be repeated as the wetlands develop to identify any benefits.

6. **Minewater Treatment Computer Aided Design Package (MTCADPak).** This project has been funded by The BOC Foundation for The Environment and follows on from work that they funded during 1992 which involved water quality modelling on the catchment. The aim of this project is to produce a freely available piece of computer software which will allow people with abandoned minewater problems to assess them and develop a solution based on the experiences of the Pelenna Project using construced wetlands. The contract has been awarded to Environmental Technology Consultants Ltd (ETC) of Newcastle, and will cover four main areas: (i) Background information and environmental data gathering needs, (ii) treatment level definition (catchment water quality modelling), (iii) treatment system design and (iv) treatment system process model, which will act as a management tool.

The Future

The design and construction for the remaining four phases of the project will proceed up to 1988. During this time there will be continuous monitoring and evaluation of the earlier phases, with lessons being incorporated into the later phases. Alongside this, the additional works and projects mentioned earlier will be progressing and producing information which will add to the data bank and assist in the dissemination process. Ultimately it should be possible to demonstrate an improvement in the water quality of the River Pelenna and a reduction in the aesthetic impact of the discharges and wider conservation and environmental benefits of the project.

Conclusion. As previously mentioned, the problem of pollution from abandoned coal mines is common throughout Europe. Mining areas in Germany (Ruhr and East Germany), Spain (Bilbao), France (Lorraine), Luxembourg, Belgium (South), Poland and Greece are all known to suffer from polluting abandoned coal mine drainage. To date the majority of the work to address the problem has been carried out in the Eastern USA and South Africa. . The Pelenna project represents one of only a small number of projects developing this technology in Northern Europe. If successful the project will have applications not only in South Wales and the rest of Britain and as such it will also be "a local solution to a European problem".

References

Ishemo, C.A.L., Whitehead P.G.(1992) Acid mine drainage in the River Pelenna: modelling and pollution control. Wallingford: Institute of Hydrology.

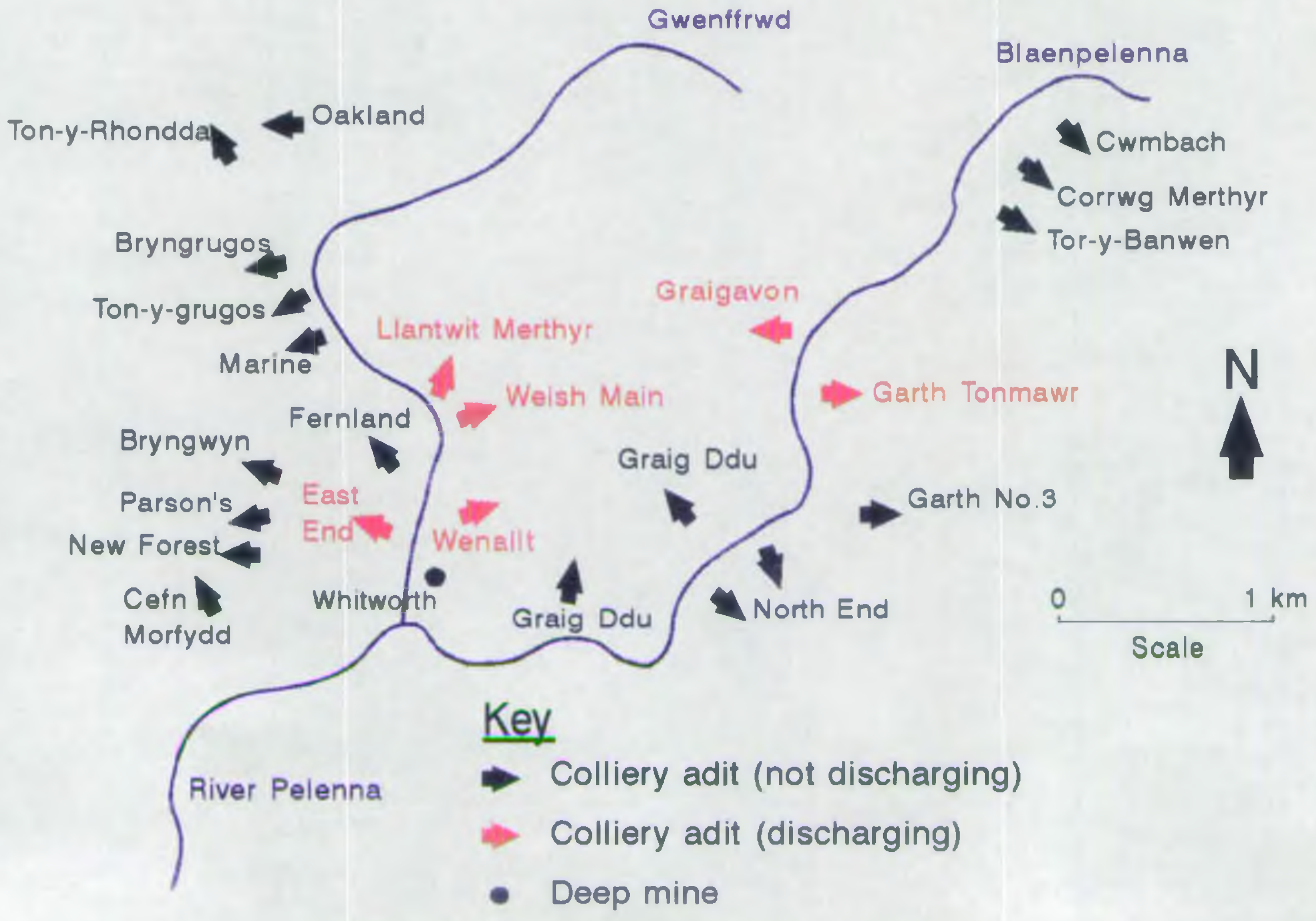
Richards, Moorehead and Laing Ltd. Feasibility & Costing Study for a Constructed Wetland Treatment System (for NRA Welsh Region) February 1993.

SRK (UK) LTD. Passive treatment of minewater discharges in South Wales with specific reference to Garth Tonmawr discharge. (for West Glamorgan County Council) February 1995.

Thomas,G., Neath and District (not dated) - A Symposium, pages 166-196.

West Glamorgan County Council.(1993) Application to LIFE. Under The European Communitiy's Fifth Action Programme For The Environment.

Fig.1. Abandoned collieries in the Pelenna catchment



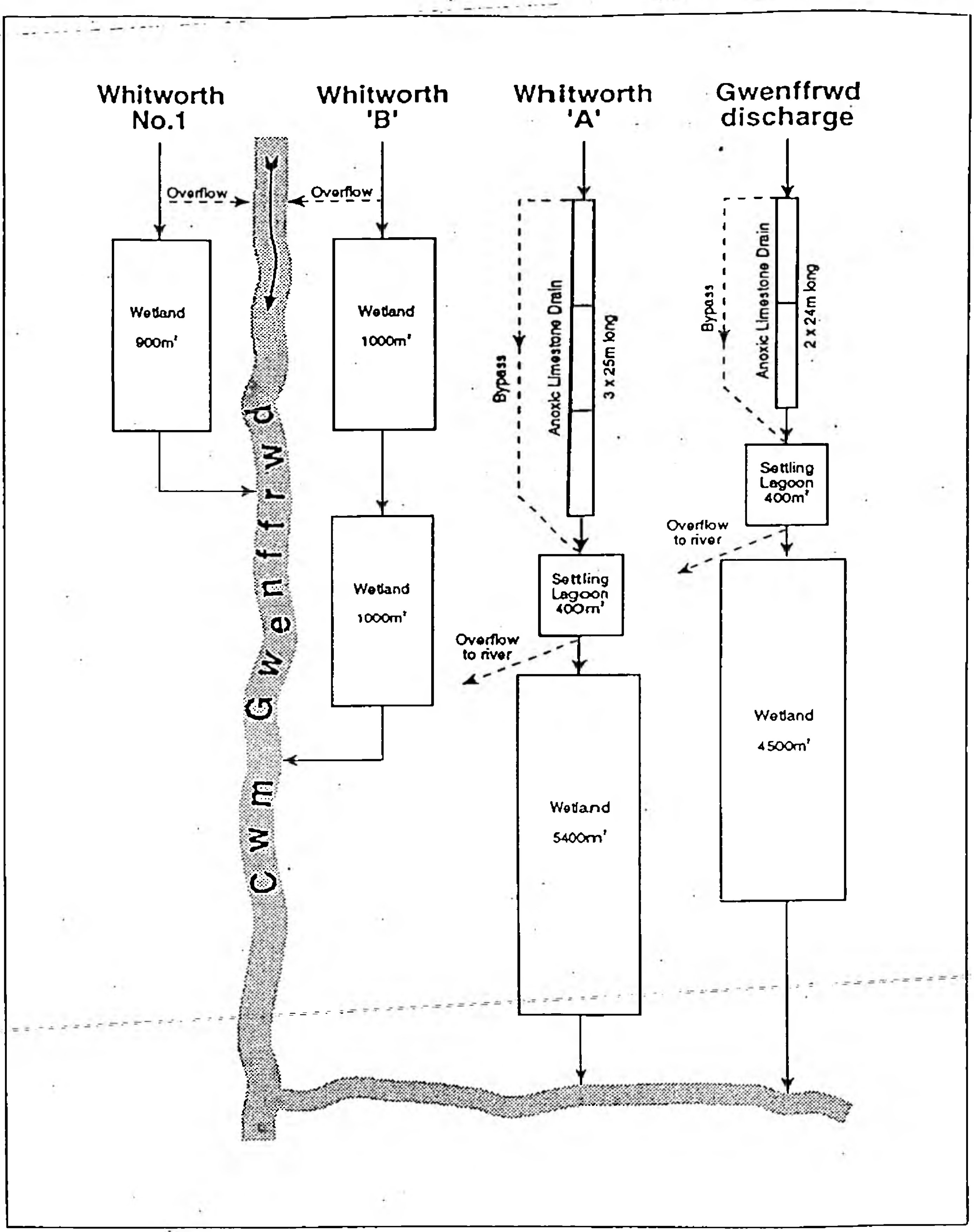


Figure 2. Schematic diagram of the Cwm Gwenffrwd treatment system

3. ENVIRONMENTAL ASSESSMENT STUDIES IN THE RIVER PELENNA CATCHMENT

PAUL EDWARDS, Minewaters Project Officer, NRA, Swansea

Introduction

Extensive investigations have been carried out by the NRA in the last three years to provide baseline information on the status of fish and macroinvertebrate populations and water quality in the Pelenna catchment. This information will provide a basis for monitoring improvements resulting from the installation of treatment systems.

Methods

Water quality sampling was carried out on a regular basis from seven minewater discharges, as well as their receiving rivers (Fig.1), using spot sampling techniques involving the use of hand-held meters and laboratory analyses. Automatic water samplers and continuous water quality loggers have also been deployed for limited periods to monitor the influence of rainfall episodes.

Extensive biological surveys were carried out in 1993 and 1994, in spring and summer, to assess the status of macroinvertebrate communities in the Pelenna catchment. Routine biological monitoring has also been carried out at four sites in the catchment since 1990. Samples were processed to determine Biological Monitoring Working Party (BMWP) scores and taxon richness. The RIVPACS (River inVertebrate Prediction and Classification System) computer model was used to compare observed macroinvertebrate assemblages with those which may be expected under pristine water quality conditions.

An acid indicator key was used to assess the impact of acidification on macroinvertebrate assemblages in the headwaters of the catchment.

Quantitative electrofishing surveys were carried out in the summers of 1993 and 1994. Densities of trout fry and parr were calculated, and classified according to the Regional Juvenile Salmonid Monitoring Programme (RJSMP) system. The HABSCORE computer model was used to determine whether available habitats were being fully utilised by salmonids.

Fish and egg survival experiments were carried out in the winter and early spring of 1994. Brown trout eggs were buried in mesh boxes to monitor egg and alevin survival, while parr survival was assessed by keeping fish in submerged cages.

Results/discussion

Minewater discharges entering the Gwenffrwd and Blaenpelenna were found to cause elevated concentrations of iron in their receiving rivers. A water quality and aesthetic impact was identified on the River Pelenna as far downstream as its confluence with the River Afan.

Upstream of the minewater discharges on both the Gwenffrwd and Blaenpelenna, an additional water quality problem was identified. The headwaters of the catchment were found to be subject to episodes of extreme acidity (low pH) corresponding with high flow conditions (Fig.2). High concentrations of aluminium, which is known to have harmful effects on fish and macroinvertebrates in acidic streams, were also observed. The acidification problem is attributable to atmospheric deposition of airborne pollutants, the effects of which are exacerbated by conifer afforestation, base-poor underlying geology and fast catchment run-off rates.

Juvenile trout populations and macroinvertebrate assemblages were found to be impoverished both upstream and downstream of the minewater discharges on the Gwenffrwd and Blaenpelenna, and to a lesser extent on the River Pelenna (figs. 3 & 4). Macroinvertebrate assemblages in the headwaters of the catchment were typical of acidified streams, while communities downstream of the major minewater discharges appeared to be even more impoverished. Poor survival rates of brown trout eggs, alevins and parr (Fig.5) were observed in the Blaenpelenna and Gwenffrwd, particularly downstream of the minewater discharges.

The combined toxic effects of low pH and high aluminium concentrations may be responsible for the poor status of fish and invertebrate communities upstream of the minewater discharges. An additional impact may have occurred downstream of these discharges, as a result of toxic effects of metals contained in the minewater and smothering effects of precipitated iron hydroxide. Salmonid eggs in particular may suffocate if excessive sedimentation occurs on the gravel in which they are laid.

The effects of acidification and minewater pollution became less pronounced further downstream on the River Pelenna, due to increased dilution of toxic metals, scouring of sediments and buffering of acidity. No significant impacts on fish or invertebrate populations or water quality, from either acidification or minewater pollution, were identified on the Fforch-dwm, a tributary of the Blaenpelenna, or on the River Afan.

A feasibility study was carried out for the NRA earlier this year, by ACER Environmental, to investigate possible methods of combating the problem of surface water acidification in the Pelenna catchment. Catchment liming was considered the least favourable liming option on grounds of cost, likely effectiveness and environmental impact. Of the two stream liming methods considered, dosing is the more favourable as it is a well tested method known to provide significant improvements in water quality. The alternative method, lime wells, requires less maintenance and uses cheaper lime. The use of lime wells would require initial investment in a pilot scheme to optimise their design and performance; the benefits of such research may however offset the initial cost of the pilot scheme. The findings and recommendations of this report will be considered as part of the Afan/Kenfig Catchment Management Plan.

Reference

Edwards, P.J. (1995) Investigations into the status of fisheries, biological & water quality in the River Pelenna catchment, prior to the treatment of discharges from abandoned coal mines. NRA report no. PL/EAW/95/3.

Fig.1. Locations of sampling sites in the Pelenna catchment

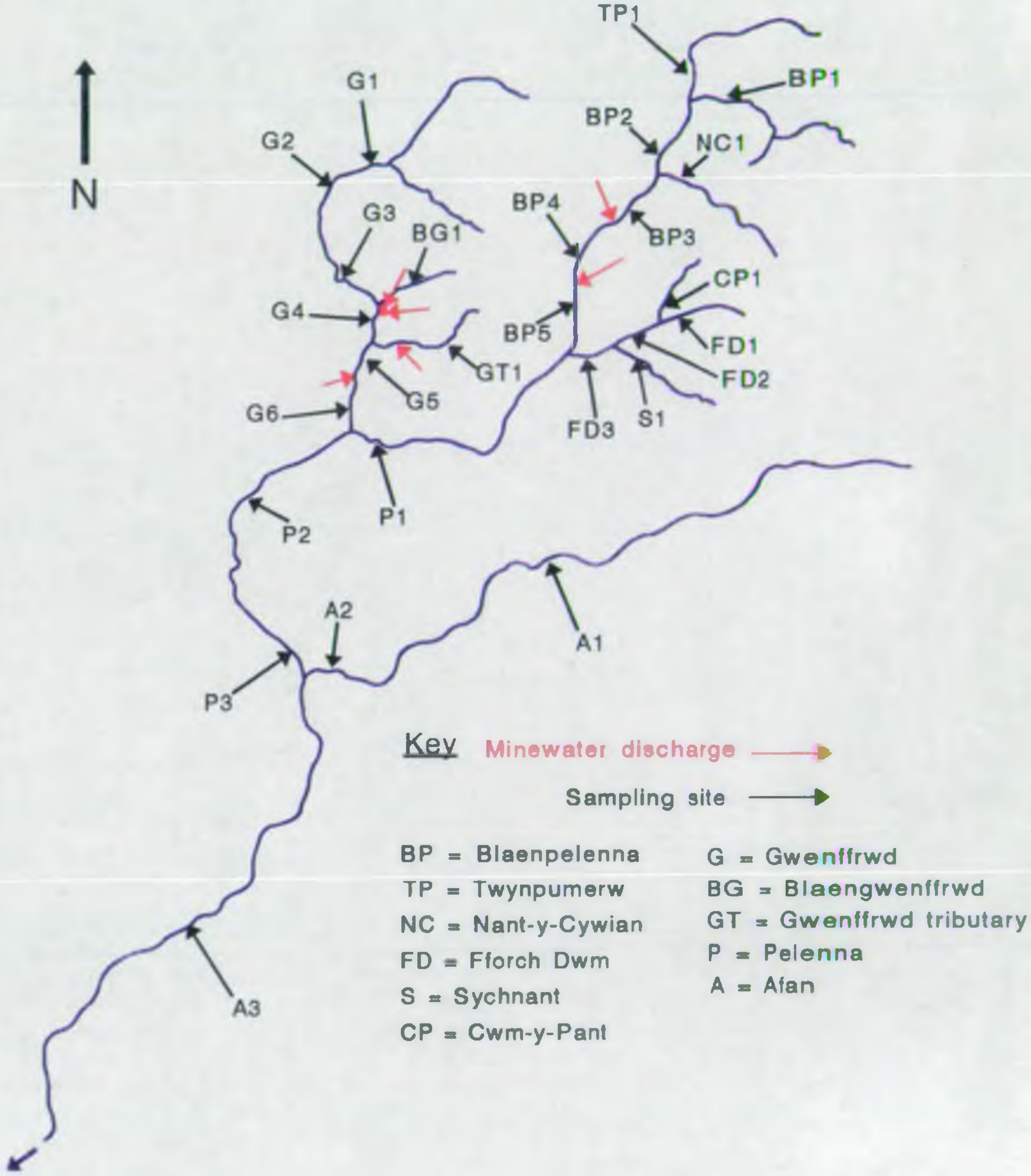


Fig.2. Variations in pH and conductivity in the Pelenna Catchment in February and March 1994

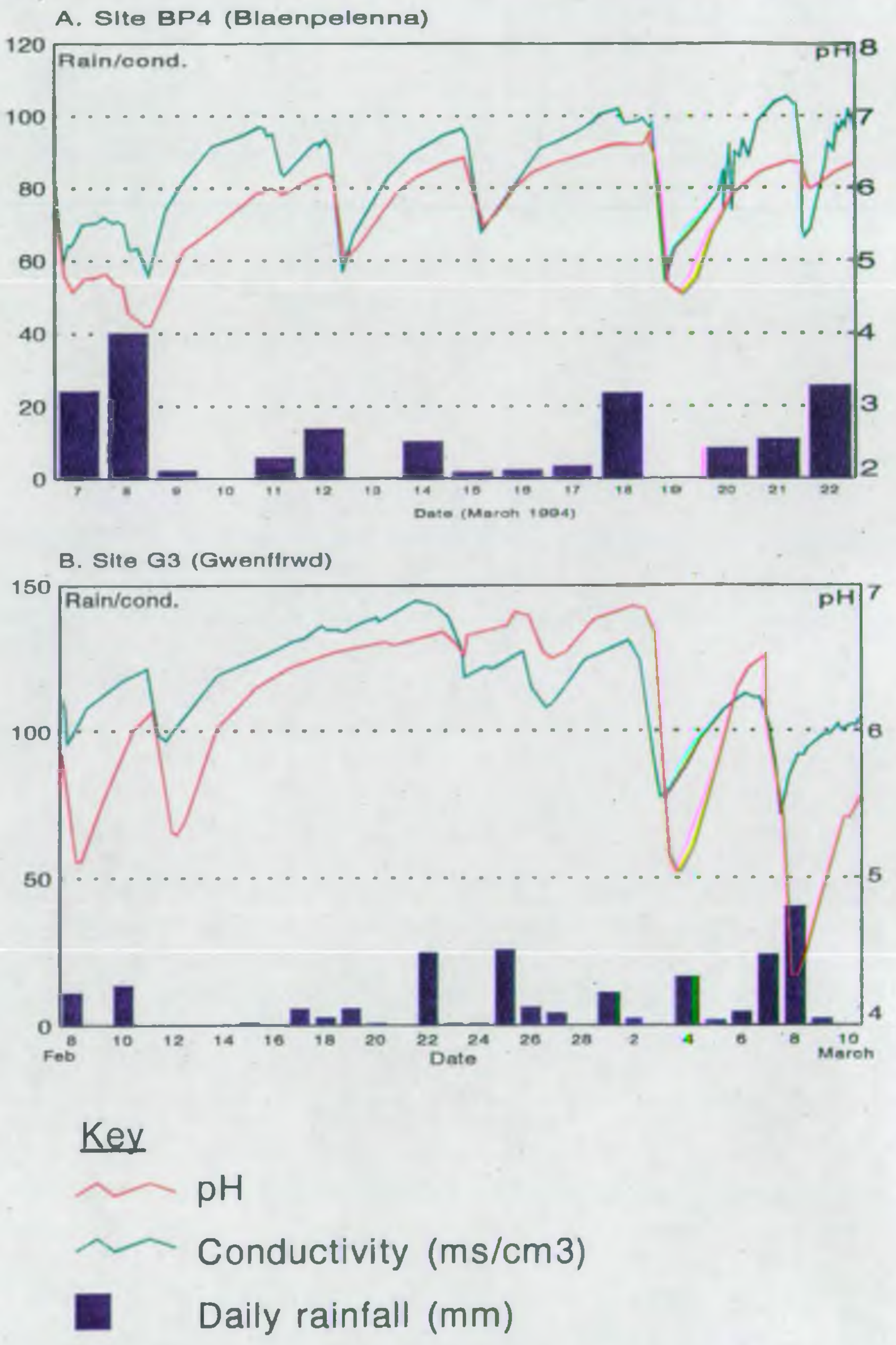


Fig.3. Observed numbers of invertebrate taxa in summer 1994 expressed as percentages of predicted no.taxa (summer 1993 results in brackets)

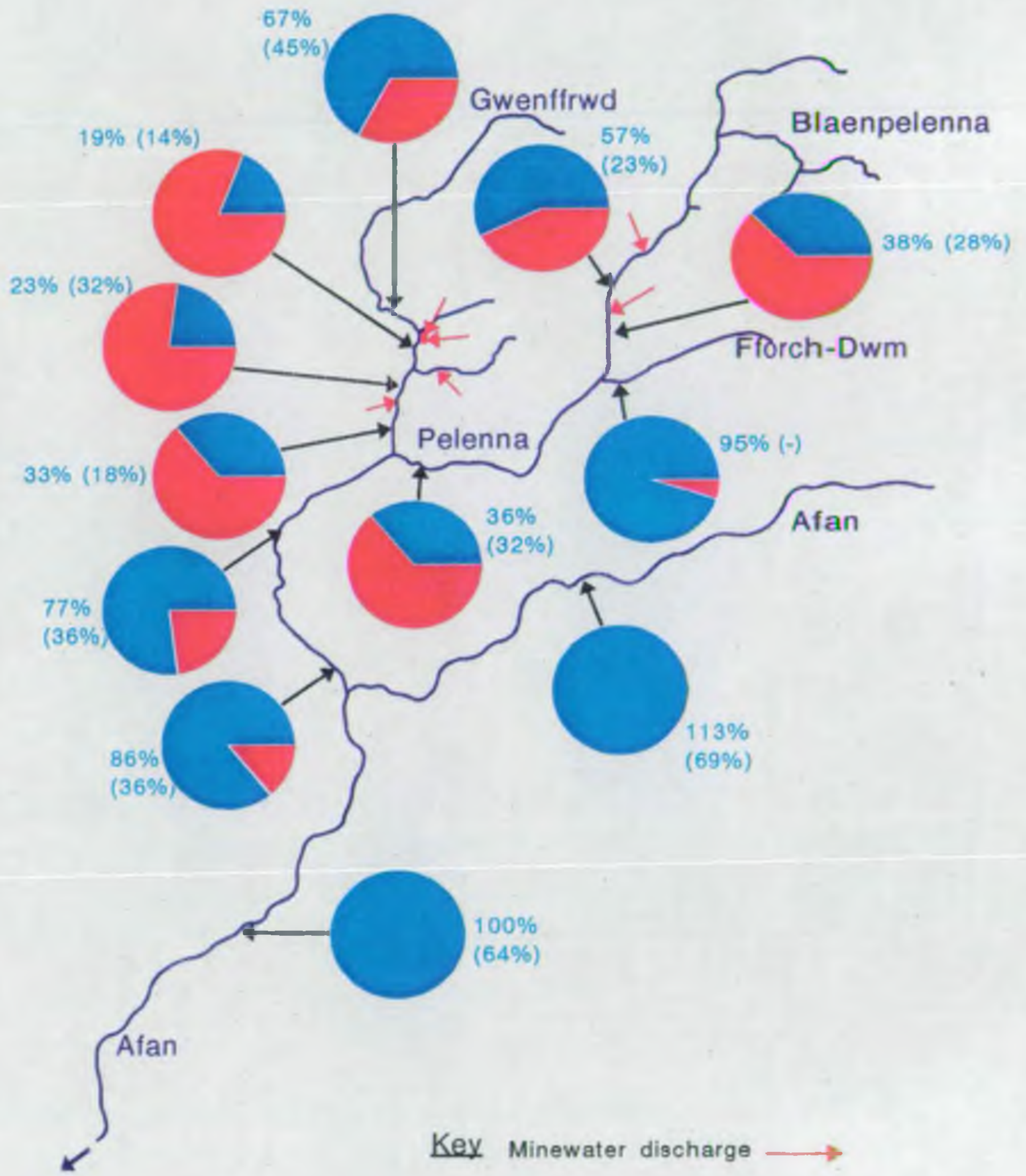


Fig.4. Observed trout parr densities in 1994 expressed as percentages of HABSCORE predicted parr densities (1993 results in brackets)

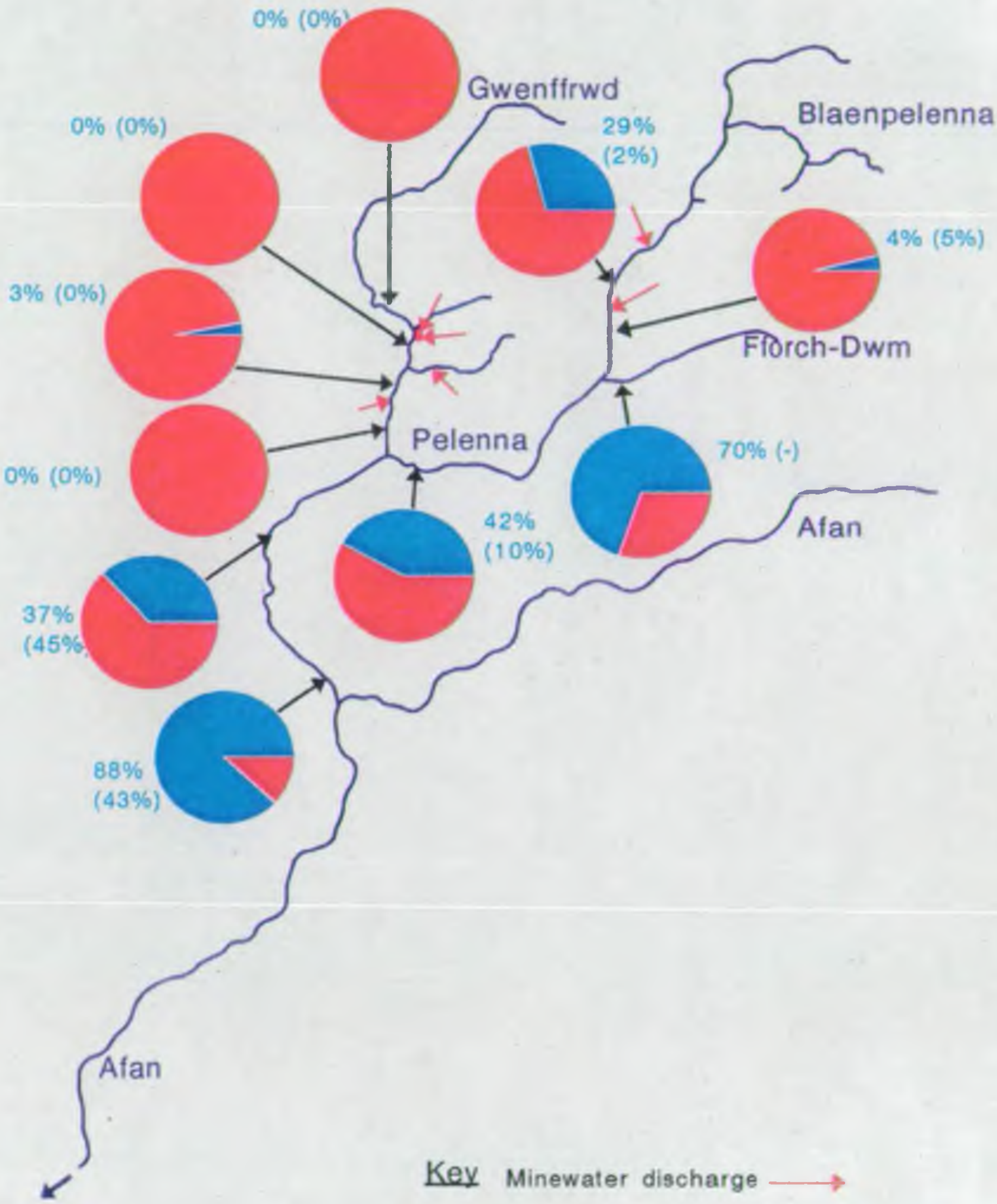
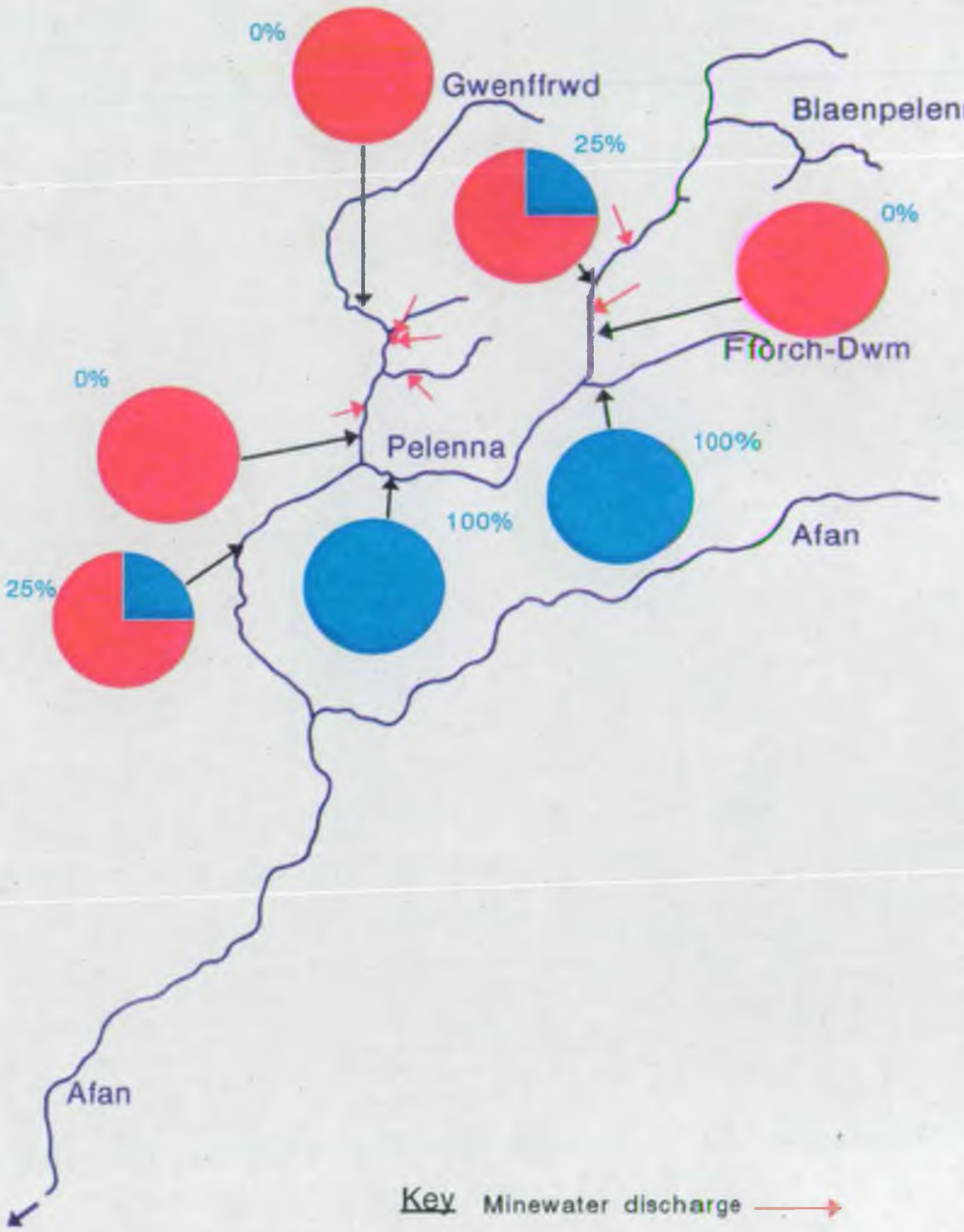


Fig.5. Percentage survival of brown trout parr after 24 hours in cages (Feb-March 1994)



4. RIVER PELENNA MINEWATER PROJECT - WETLAND DESIGN AND CONSTRUCTION

ALLAN ARCHER, Acting Assistant Director, Environment and Highways (Environment & Planning), West Glamorgan County Council

KEVIN PRICE, Resident Engineer, Design and Construction Consultancy, Environment and Highways Dept, West Glamorgan County Council

Allan introduced this session by setting out the funding context for the project together with the management structure showing the roles of the contributing bodies and the project partners (see Figure 1). The successful bid for LIFE funding (The European Community's Fifth Action Programme for the Environment) had been based on the feasibility report produced by Richards, Moorehead and Laing in February 1993.

Crucially important to the successful award of funding has been the demonstration element of the scheme to other areas in Europe and it has been particularly important to test out alternative procedures and to in-build monitoring to enable comprehensive analysis of the system.

Funding partners are the NRA and WGCC with additional grant aid from the WDA as well as from LIFE.

In fulfilling the demonstration commitment, it had proved more costly than originally envisaged to in build treatment options for comparison and to provide the additional monitoring required to be able to fully analyse the process.

The wetland currently under construction, the Whitworth No. 1 would be divided into 4 cells and would permit comparison of the effectiveness of treatment mechanisms (surface and sub-surface flow), substrate type, (mulch and spent mushroom compost) and plant selection (2 separate monocultures: *Typha* and *Juncus*).

Kevin presented the detailed design and construction issued arising in the 1st phase of the project, the Whitworth No. 1.

The main problem had been the topography of the site, perched on a ledge over the valley floor below and with a very constrained surface area within which to construct the wetland. Other constraints included the spoil tip on the hillside above the site and the nearby National Grid cables, construction access to the site and the temporary closure/re-routing of the cycle track.

The influent would drain via headworks at the adit mouth into a monitoring chamber with v-notch, then through a distribution chamber with decanting weir into the 4 cells. Flow distribution across the bed would be achieved by perforated pipes discharging onto highly permeable gabions across/through the bed to the outlet pipe. The outlet pipe would feed through an NRA water quality monitoring outlet to discharge into the river (Figure 2).

Prior to the construction phase, site clearance had been undertaken with some 700 cubic metres of iron sludge taken to a controlled tip. To facilitate this the adit flow had been over piped for several months to partially dry the sludge.

The adit headworks had needed to be constructed on solid ground, and clearing the locality had proved problematic as this was the location of the bund/wall actually in the adit mouth. The wall had been lowered to reduce water levels, but the lagoon had been incapable of coping with the flow of sludge which had been stirred up. A larger lagoon had been cut with a capacity sufficient for 3 days flow and contingency pumping was made available. A temporary wall had been constructed out of concrete and rockfill sandbags inside the adit entrance and the headworks had been constructed in front of this.

A key concern in the planning consent had been to minimise journeys to/from the site during school arrival and departure times. This had been achieved.

The gabions had been placed on top of a goesynthetic liner (bentonite sandwich) and a sand layer had been included to protect the liner and to allow for maintenance of the cell, including replacement of the substrate. The contract was likely to be substantially complete (i.e. ready for commissioning and planting) in June 1995.

Allan concluded this session by describing the design criteria for the second phase, at Garth Tonmawr, programmed for construction in Autumn this year.

Steffen, Robertson & Kirsten had been appointed as specialist consultants to the project to provide design criteria for and to oversee preparation of the detailed design.

Given the different parameters of the discharge at Garth Tonmawr to that at Whitworth No. 1, the scheme proposed here, it will be necessary to incorporate ponds, cascades anaerobic cells and anoxic limestone drains as well as aerobic cells (Figure 3).

It is likely that subsequent phases of the project will focus on those methods shown to be most effective in phases 1 and 2.

References

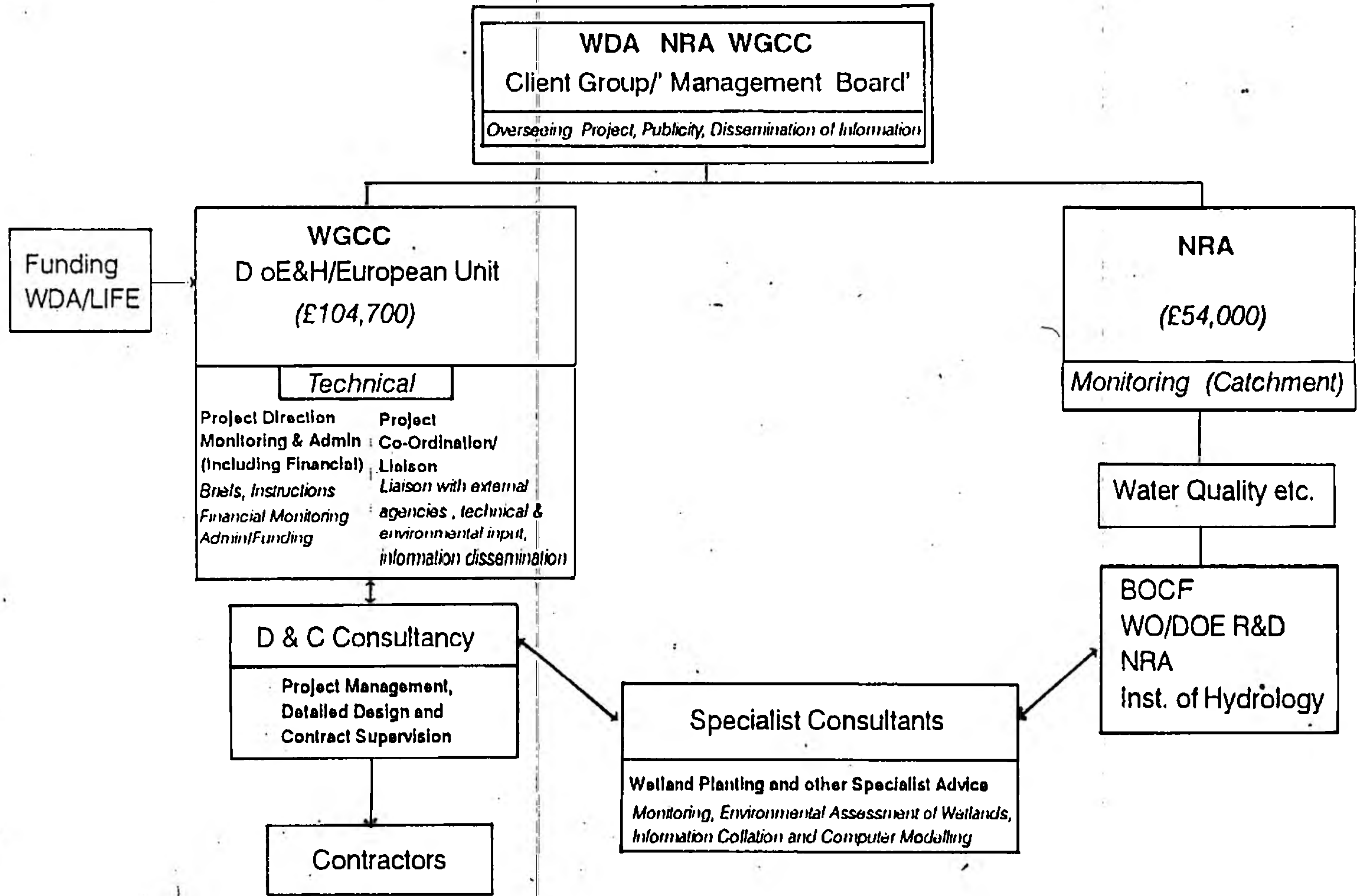
Richards, Moorehead and Laing Ltd. (1993) Feasibility and costing study for a constructed Wetland Treatment System.

WGCC/NRA/WDA (1993) Application to LIFE under the European Community's Fifth Action Programme for the Environment.

Steffen, Robertson & Kirsten (1995) Passive Treatment of Minewater Discharges of the Pelenna River Catchment of South Wales.

Figure 1. **Wetland Treatment System - Tonmawr**

Management Structure



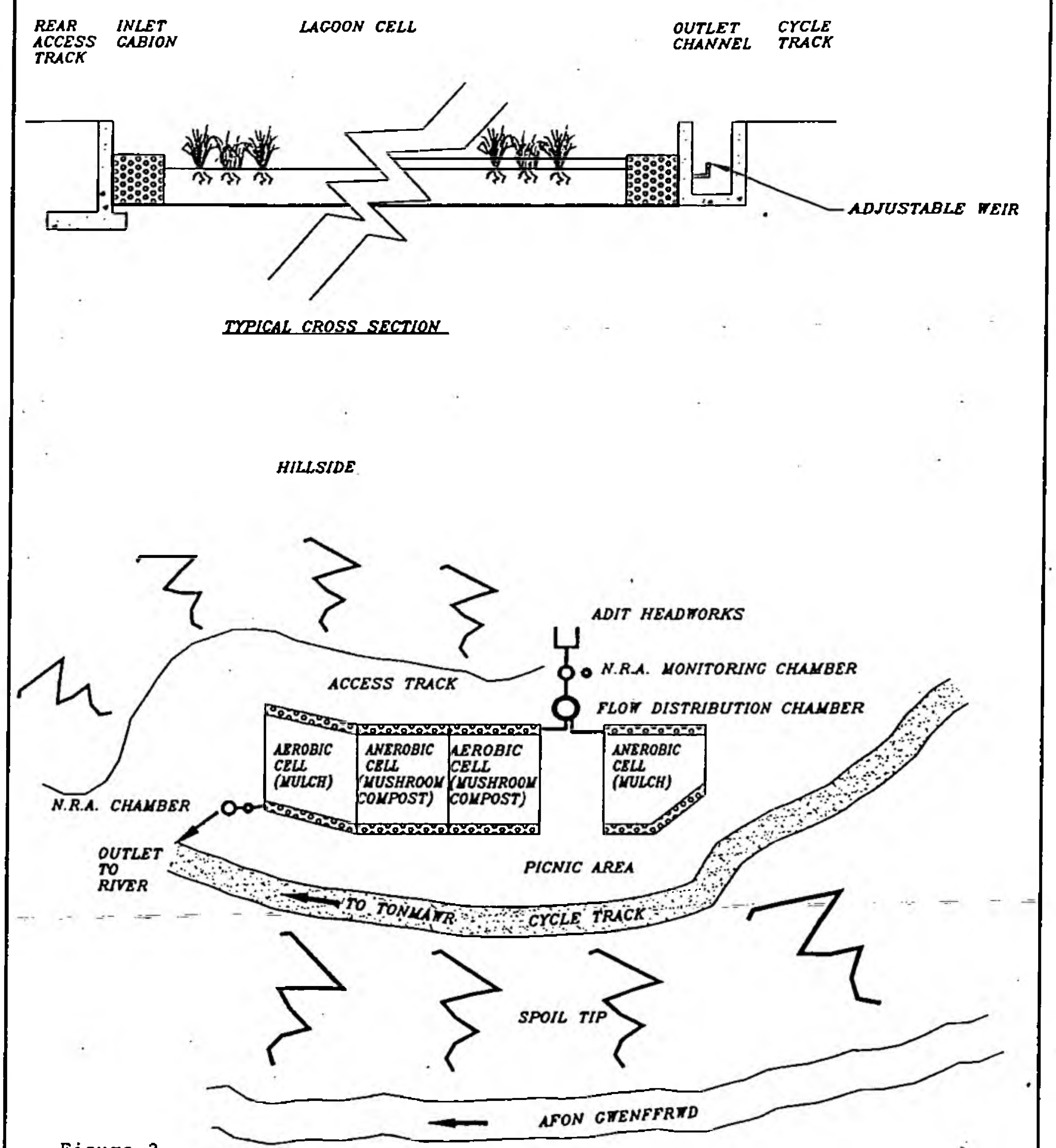
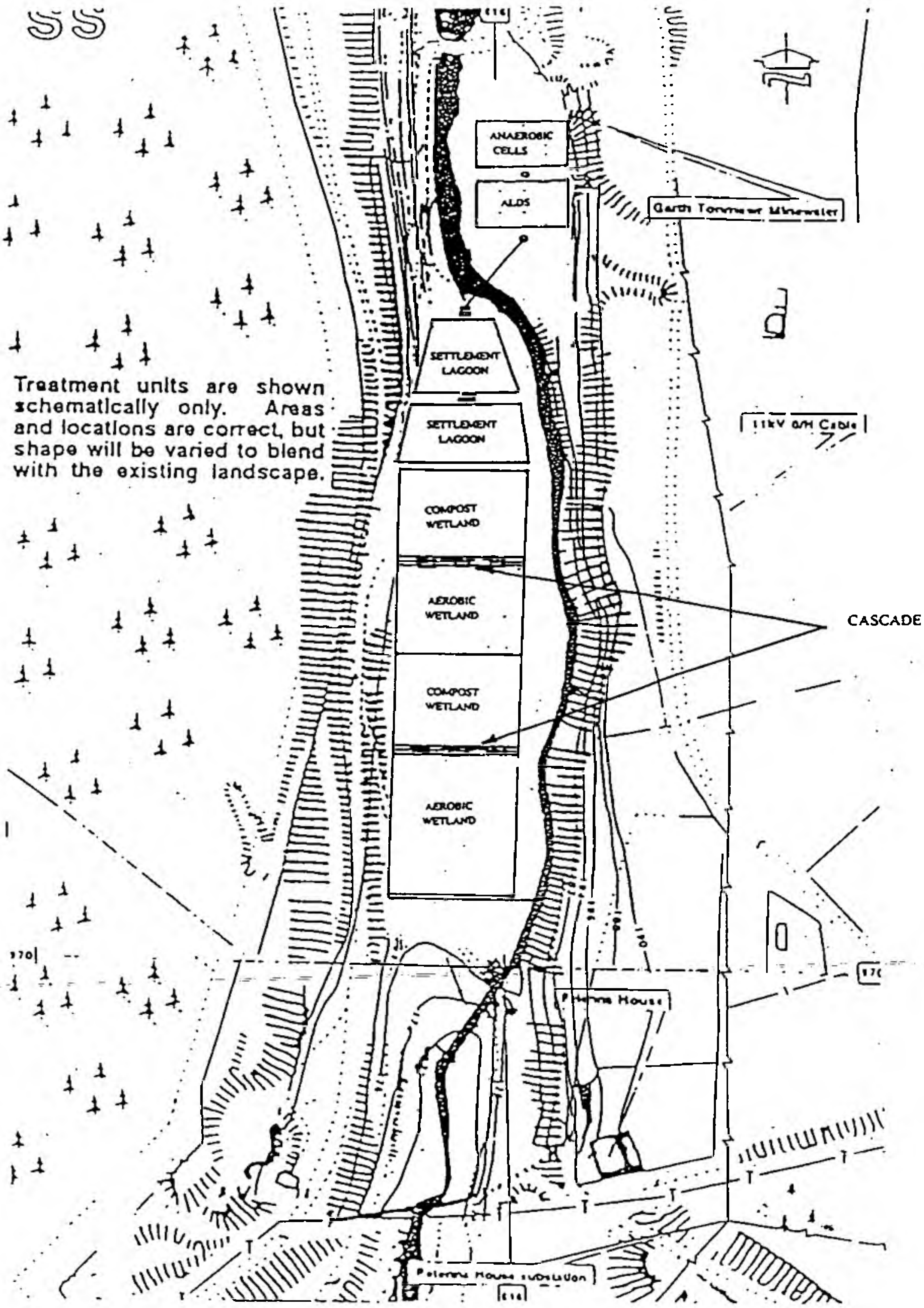


Figure 2

RIVER PELENNA MINEWATER PROJECT – PHASE 1
WHITWORTH No1 GENERAL ARRANGEMENT



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DATE: 7/4/95	PROJ. No: U497	PELENNA	
SRK		GENERAL ARRANGEMENT OF GARTH TONMAWR WETLAND AND AREA OF INTEREST	Figure 3

5. BLAENANT/YNYSARWED PROJECT OVERVIEW

HELEN WILLIAMS, Pollution Control Officer, NRA, Swansea

Introduction

There are currently major minewater problems in the Neath area of West Glamorgan which it is believed have arisen from the closure in 1991 of Blaenant Colliery. To date two discharges of minewater to watercourses have commenced since the closure, the more serious of which is via the Ynysarwed adit to the Neath Canal. The impact of this discharge has been considerable and has attracted extensive press and media coverage as well as the concerns of water users, local people and organisations. The second discharge occurs directly into the bed of the River Dulais approximately 200 metres downstream of the Blaenant Colliery shaft entrance (See Fig.1).

The purpose of this talk was to briefly describe the nature and impact of the two discharges, to provide information on short term remedial measures taken so far to alleviate the impact of the Ynysarwed discharge and plans for longer term mitigation measures.

Ynysarwed discharge

Ynysarwed adit is located adjacent to the A465 and is associated with the working of the Lower Ynysarwed Mine which closed in the 1930's.

Since closure of the mine, the adit has been known to discharge a small volume of minewater under extreme weather conditions although no regular discharges were recorded prior to 1993. During the Spring of 1993, it was noticed that a discharge was occurring which increased steadily, reaching a peak in the autumn of the same year to about 36 litres per second.

Sampling of the discharge has shown the quality initially to be variable, with pH ranging from a very acidic pH 3.2 to just under pH 6, and iron concentrations from a low of 10 mg/l to over 300 mg/l. More recently the quality has stabilised although remains very poor with iron levels consistently above 300 mg/l. Dissolved oxygen is virtually absent.

The sudden and continuing steady increase in the volume of the discharge is thought to correspond to the closure of the Blaenant Colliery in the adjacent Dulais Valley in 1991 when pumping also ceased. The Blaenant Colliery worked the same seam (No. 2 Rhondda) as the Lower Ynysarwed Colliery and although a 90 metre barrier of coal was maintained between the two mine workings, it is thought that hydrological continuity exists between the two areas.

Effect on the Neath Canal

The effect of the discharge on the Neath Canal in particular has been devastating. Prior to 1993 the canal supported a healthy brown trout and coarse fish population. However, a survey carried out in December 1993 showed that fish populations downstream of the minewater input were severely reduced. This reduction in fish populations was due partly to a reduction of invertebrate food supply caused by acidity and the deposition of iron on the bed of the canal, and also as a direct consequence of the deterioration in water quality. Dissolved and particulate iron is directly toxic to fish and monitoring of the canal has shown that the Environmental Quality Standard (EQS) for iron was significantly breached throughout its 12 kms length, with concentrations up to 100 mg/l in places. Acidity in the canal also increased and pH levels as low as 3.5 were recorded in the lower reaches.

Due to deteriorating quality conditions, a fish rescue was carried out in March 1994 by the NRA with funding from Neath Borough Council. The fish recovered were in poor condition and were relocated to an unaffected stretch of the canal. In spite of these efforts a number of mortalities occurred subsequently.

A large industrial abstraction, the single largest source of revenue for the Neath Canal Company, was affected by deteriorating water quality. BP Chemicals, the major abstractor, had to reduce their abstraction and purchase more expensive water from alternative sources pending resolution of the problems. In addition, a £13 million investment by Neath BC on urban renewal that has the canal as a focal point is threatened by a long term visual nuisance problem.

Effect on the River Neath

The canal now overflows to the River Neath in the tidal reaches of the river. This overflow is causing visible staining of the river gravels with orange-coloured iron hydroxide, although it does not appear to be causing water quality problems in the estuary at present.

Blaenant discharge

The minewater at Blaenant now appears to have reached a stable level. British Coal sealed the drift entrance which is within 10 metres of the River Dulais.

British Coal also installed pipework to discharge any minewater overflowing from the shaft direct to the river and have given a verbal commitment to undertake treatment should the discharge be of unacceptable quality. No direct overflows have occurred and now seem unlikely as the level of water in the shaft has stabilised. However, investigations by the NRA in February 1994 found that iron contaminated water was welling up through the strata directly into the stream bed some 200 metres downstream of the Blaenant shaft entrance. This discharge is also causing staining of the river gravels.

The National Trust site at Aberdulais is just 4.5 kms downstream from the point of contamination and there is particular concern because the site is based on the Aberdulais Falls hydroelectric generator and fish pass which attracts 30,000 visitors a year. The Trust are currently undertaking a 10 year conservation programme and have invested over £1 million at the site which is expected to increase the number visiting the site to over 70,000.

Emergency remedial measures

Because of the deterioration in quality of the Neath Canal, the NRA took emergency action in collaboration with a number of other organisations, including Neath BC, West Glamorgan CC, Neath Canal Navigation, BP Chemicals (abstractor), CMB Packaging (abstractor), Neath and Dulais Angling Club and The National Trust. These remedial measures included the installation of aeration equipment, addition of lime at various points along the canal and revised management of flow regimes (Fig.2). The aeration and liming measures proved largely ineffective although management of the flow regime of the canal has successfully stabilised the situation, with pollution in the canal being confined to the 7 km between the discharge and Tonna Lock (See Fig. 3). Nevertheless, iron-rich sludge continues to accumulate in the canal and a solution to the problem remains a high priority.

Profiles of water quality in the Neath Canal following emergency remediation are shown in figs 4 & 5.

Long Term Remedial solutions

The Ynysarwed and Blaenant discharges are included in the Regional list of 15 priority discharges studied as part of a jointly funded NRA/Welsh Office programme. This work, which has recently been reported, has identified possible long term treatment/engineering options, made recommendations on the best practical options, and estimated anticipated costs and achievable benefits. A more detailed feasibility study was commissioned with external consultants in November 1994 and this work has recently been reported. Alternative schemes have been proposed to undertake within mine works and minewater treatment and for "end of pipe" treatment in the form of a constructed wetland. The feasibility study provided supporting information for an application by Neath Borough Council to the Welsh Office for a grant under the Strategic Development Scheme (SDS) which was succesfully obtained in December 1994. A total of £1.4 million will be provided for remedial works over a 3 year period commencing in April 1995. A summary of costs for the project to date, with a forecast for the next three years, is shown in Table 1. A management structure is shown in Fig.6.

A report has also recently been received from consultants following a contract placed by the NRA to determine the technical case for taking legal action against the Coal Authority on the basis of the closure of Blaenant Colliery having a direct causative link with both discharges. If a robust technical case can be developed, the NRA will consider taking legal action, in default of any acceptance of liability and contribution to the costs of the problem by the Coal Authority.

Further work was commissioned by the NRA arising from the recommendations contained in the feasibility study. Contracts were placed for construction of deep boreholes into the mine workings to provide supporting information to the technical case and also to assist with the design and implementation of within-mine mitigation measures.

Table 1. Costs

	1994	1995	1996	1997
NRA Emergency Work	£ 8K			
NRA Feasibility Study	£10K			
NRA Boreholes	£44K			
NBC Pumping (/week)	£ 29K	£ 19.5K		
BP Alternative supply	£ 1,000K	£ 1,000K	£ 1,000K	£ 1,000K
SDS Grant		£ 250K	£ 250K	£ 1,000K
NRA		£ 30K	?	?
NRA Virement		£ 12K		

Fig. 1. Map of Lower River Neath and Neath Canal, showing impacted areas in spring 1994

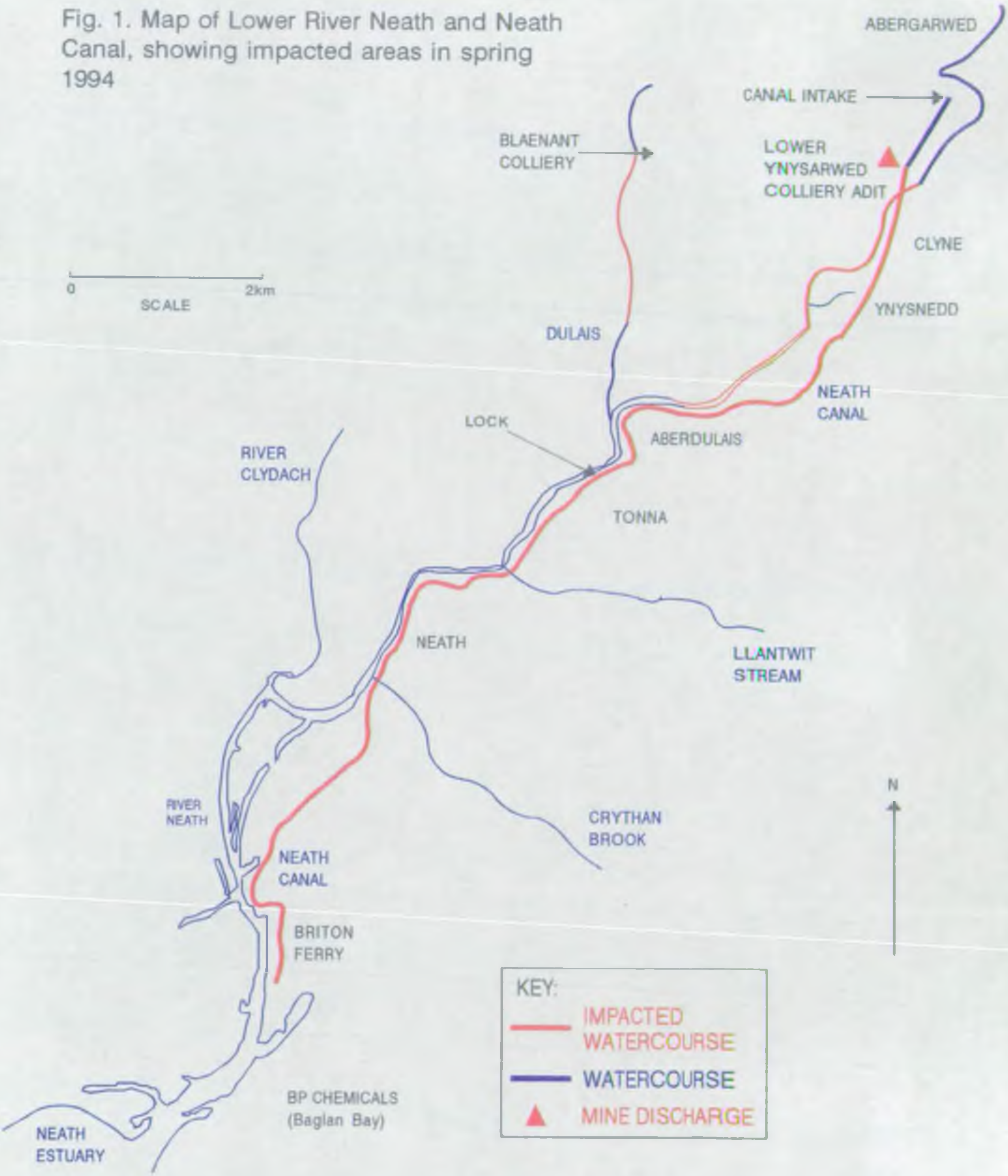


Fig. 2. Map of Lower River Neath and Neath Canal, showing remediation measures in May 1994

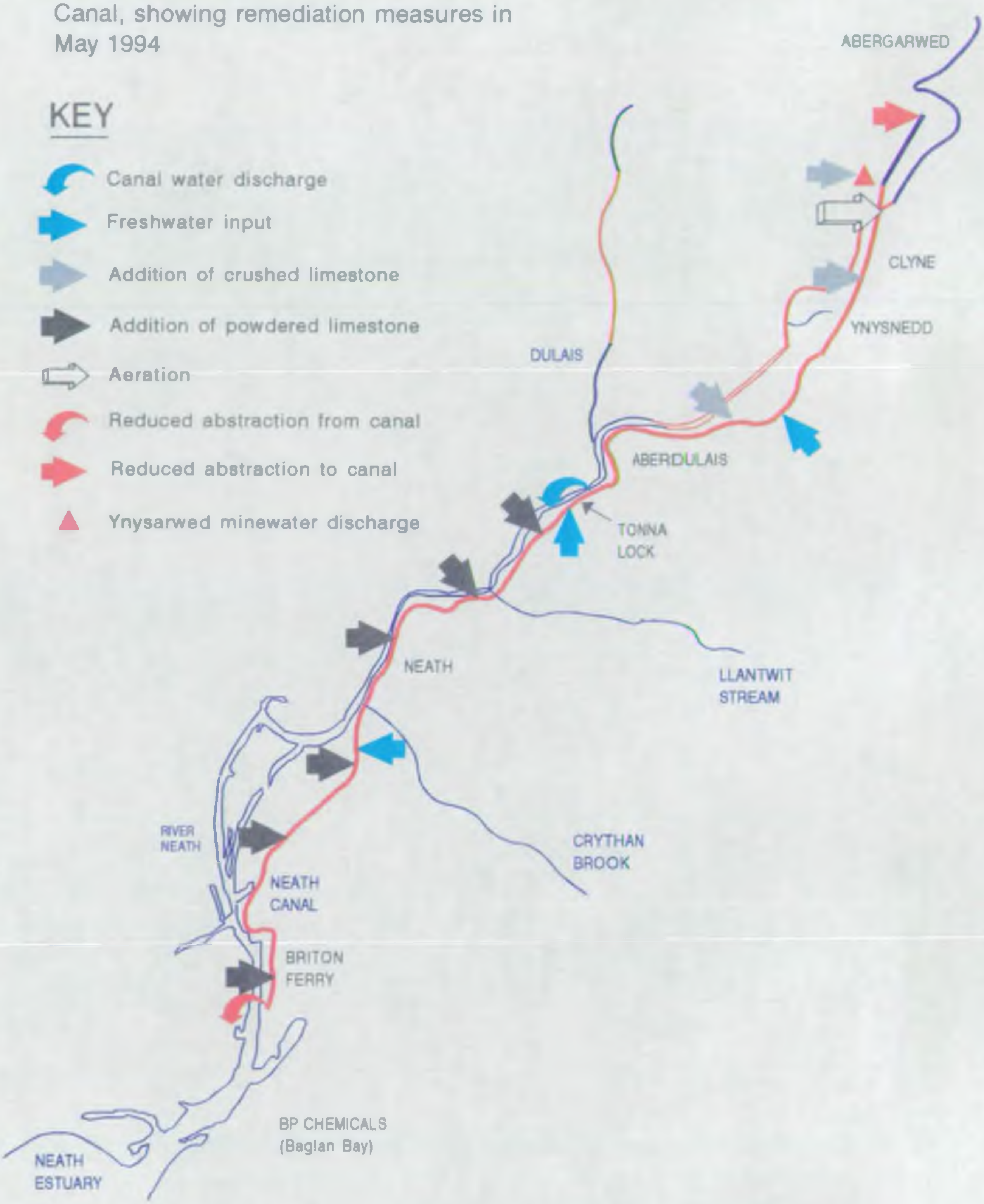


Fig. 3. Map of Lower River Neath and Neath Canal, showing impacted areas following emergency remediation

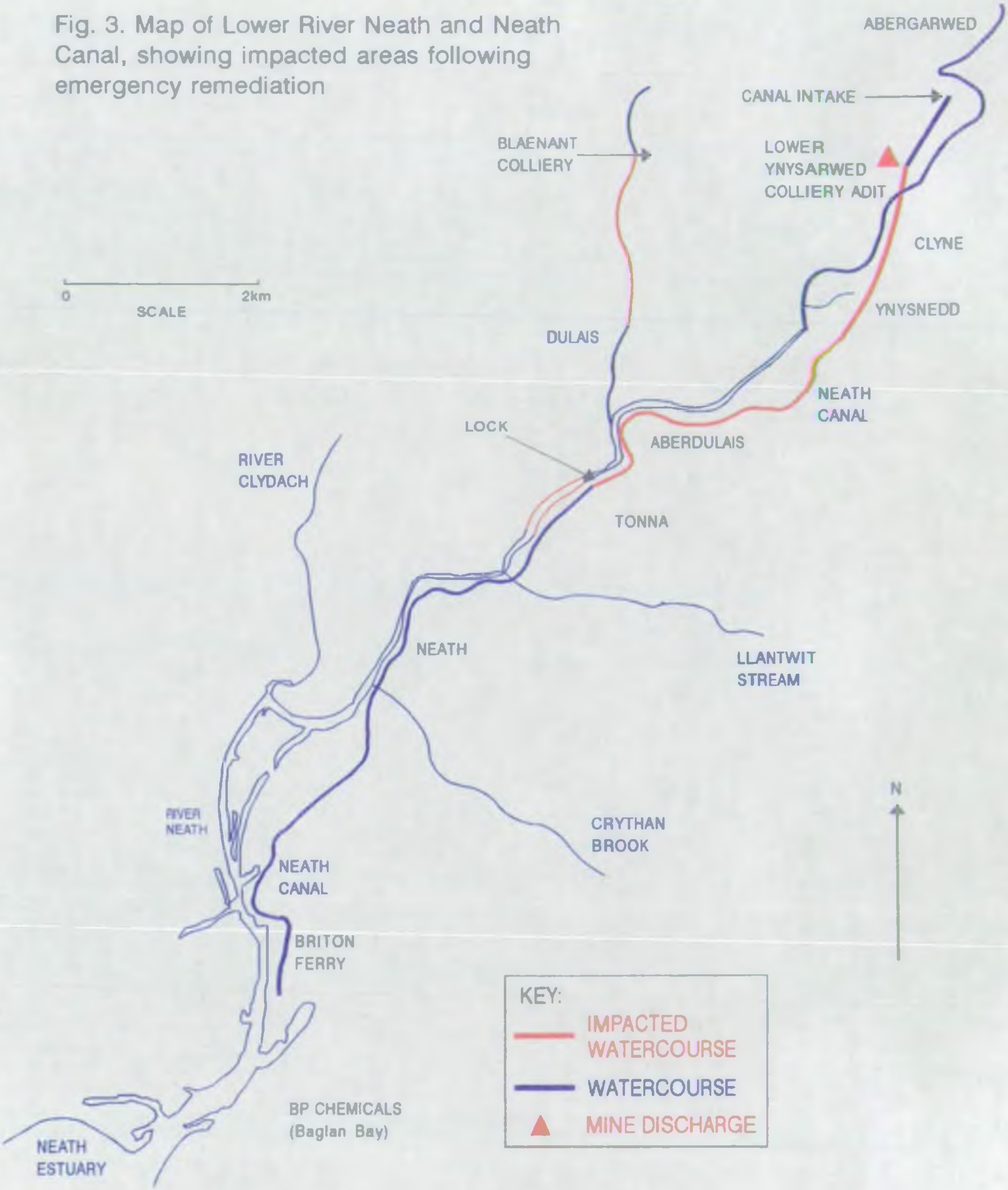


Fig.4. Neath Canal pH profile

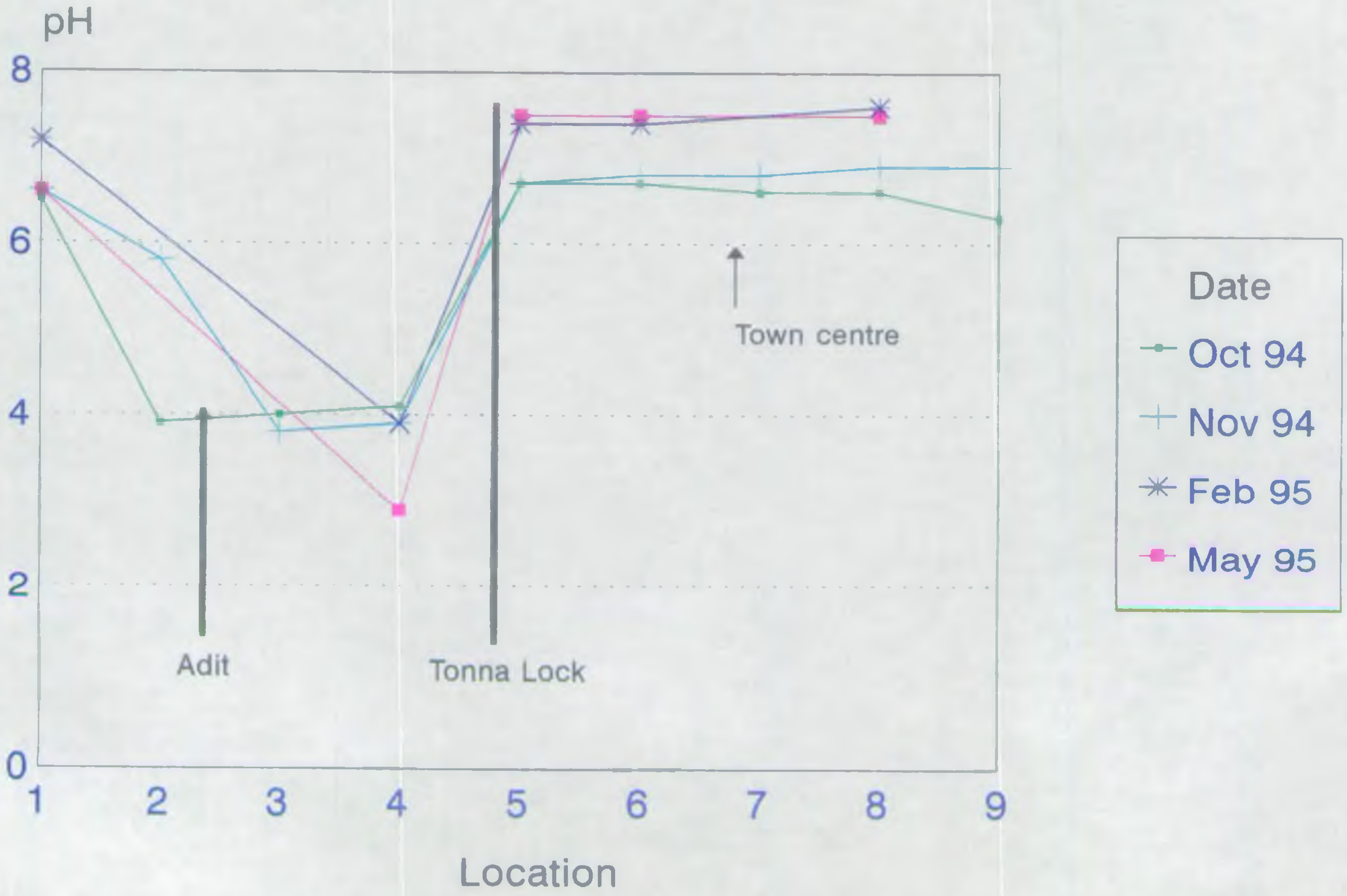


Fig.5. Neath Canal iron profile

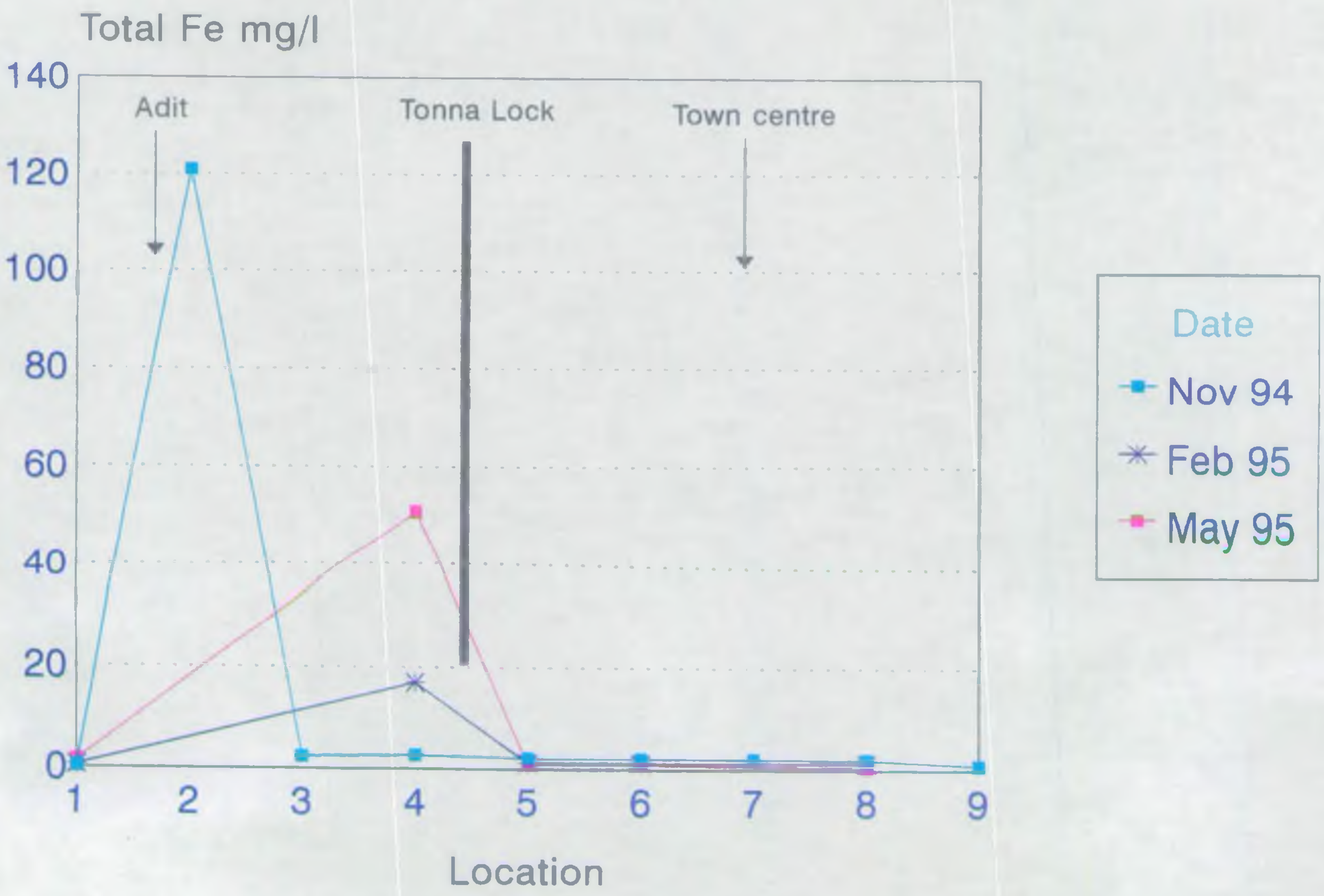
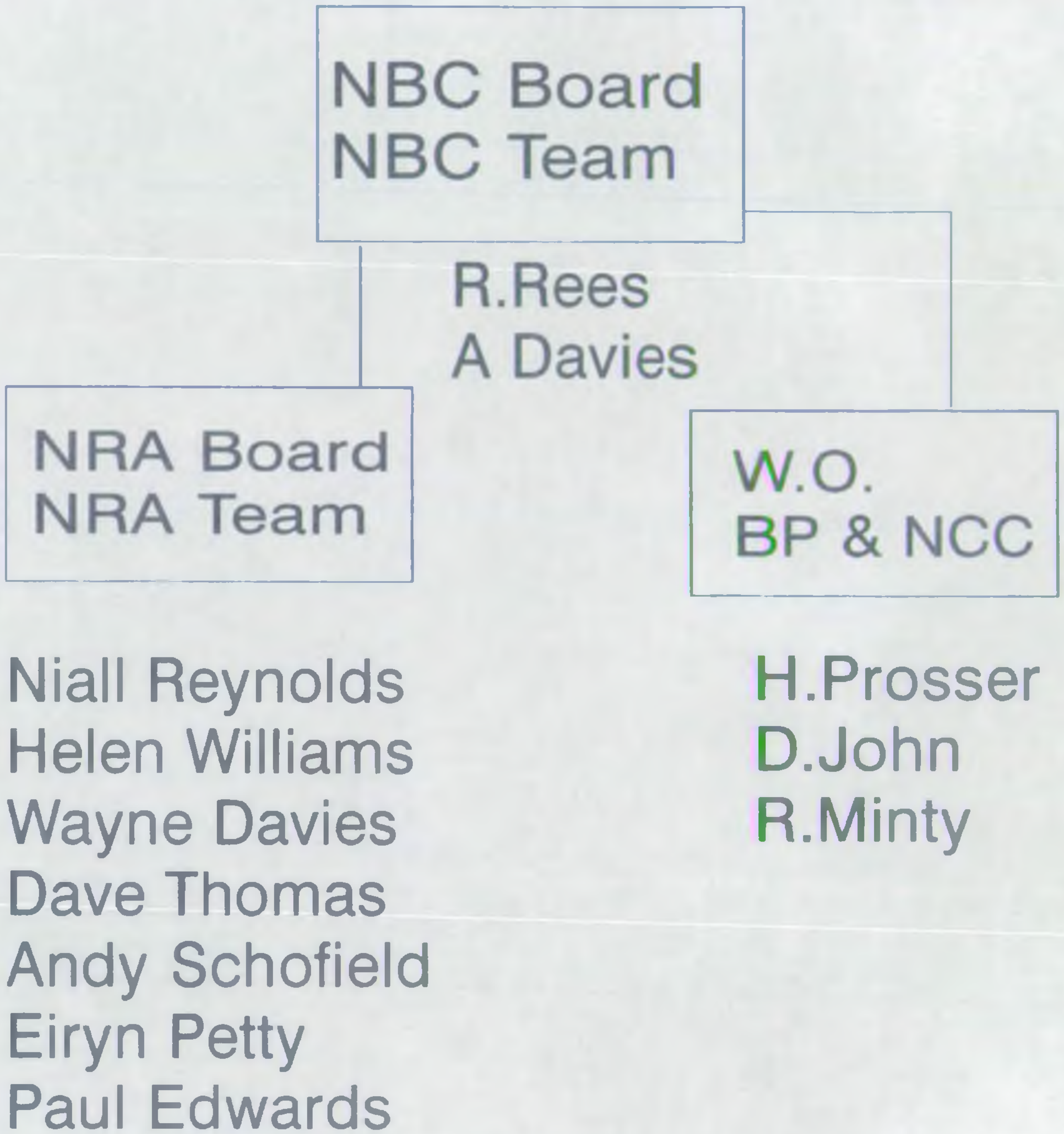


Fig.6. Blaenant/Ynysarwed project management structure



6. BLAENANT/YNYSARWED TECHNICAL CASE - THE CAUSE OF THE PROBLEM

WAYNE DAVIES, Regional hydrogeologist, NRA, St.Mellons

Wayne Davies explained what is happening to groundwaters in the Neath and Dulais valleys to cause minewater to discharge into the Neath Canal and River Dulais.

Hydrogeology

The main aquifers of the area are the Pennant Sandstones of the Upper Coal Measures. These are inherently porous and can store and transmit water. It is likely however, that much of the water movement in the sandstones occurs within fractures in the rock, which often result from faulting. Under natural conditions, the thin mudstones and coals within the Upper Coal Measures may form aquitards through which ground water movement is limited. The Middle Coal Measures are mainly of mudstone and siltstone, with minor sandstones. These strata can be considered an aquitard through which there is no significant ground water movement on a local scale.

The overall regional ground water flow direction in the Upper Coal Measures is from north-east to south-west. However, precipitation infiltrating the main aquifer units in outcrop areas on hill tops is likely to flow across the direction of regional ground water flow towards watercourses such as the rivers Neath and Dulais.

The mine workings in the upper coal measures provide preferential flow paths which have two main impacts on the hydrological regime:

(i) interception of infiltrating recharge water

(ii) drainage of overlying and underlying saturated aquifers

Mine workings act as unsaturated drains above the water table, in which case the flow direction is controlled by the dip of the workings, or as preferential ground water flow paths below the water table, in which case the flow direction is controlled by the hydraulic gradient. Mine water drainage will ultimately discharge from the mining system, either direct to the surface via adits or shafts, or as diffuse ground water discharges to rivers and streams or springs.

The hydraulic connection between mines which are not directly connected is dependent on the permeability of the unworked coal pillar and strata above and below the pillar, and the hydraulic gradient across the pillar.

Mining related subsidence is likely to have created flow paths across thin aquitards close to the workings thus enhancing drainage from the overlying strata.

Under natural conditions infiltrating rainfall would recharge the ground water body and flow down the ground water gradient to discharge points which are likely to be springs occurring along river and stream beds, particularly at the junction between sandstones and lower permeability strata. It could be expected that between 15 and 25 % of rainfall would recharge the Upper Coal Measures in the area.

Conceptual Hydraulic Model

Calculations were made by SRK (UK) Ltd. to evaluate the proportion of water discharging at lower Ynysarwed originating in the various parts of the

Blaenant/Ynysarwed system. The results were assessed and used to make judgements which were presented in the form of a conceptual hydraulic model. The model forms the basis for predictions of hydraulic impacts of potential remedial measures, and will be developed as the investigation proceeds and understanding of the system improves.

The water inputs and outputs to and from the Blaenant-Lower Ynysarwed system are shown conceptually with the estimated flow rates on Fig.1. Recharge refers to infiltrating water intercepted by unsaturated workings. Groundwater flows are those flows which occur between the saturated aquifer and both the saturated and unsaturated workings.

With the exception of the small area of workings in the exteme northwest of East Blaenant adjacent to the Crynant workings, all the workings in Blaenant are permanently flooded.

The flooded workings are likely to drain the overlying and underlying saturated aquifer, except in the region directly below the Dulais valley, where there is an upward ground water gradient, from the workings to the overlying aquifer. The unflooded workings are likely to intercept a small amount of ground water flowing from the north and to intercept recharge. There is likely to be drainage of water from the Crynant workings to the north, but the amount of flow from this area is likely to be small..

The mine workings in East and West Blaenant are likely to drain water at similar rates per unit area. West Blaenant therefore supplies between 60 and 70 % of the total input to Blaenant, the remainder being supplied by East Blaenant.

Outflow from the Blaenant workings is made up of regional ground water outflow to the south west, flow to the Dulais river, and flow through the barrier between Blaenant and Ynysarwed. The regional ground water outflow element is likely to be small as the workings are likely to drain water from all directions. The up flow to the Dulais is likely to fall in the range 0 - 2 l/sec, and the flow to Lower Ynysarwed is likely to fall in the range 23 - 28 l/sec.

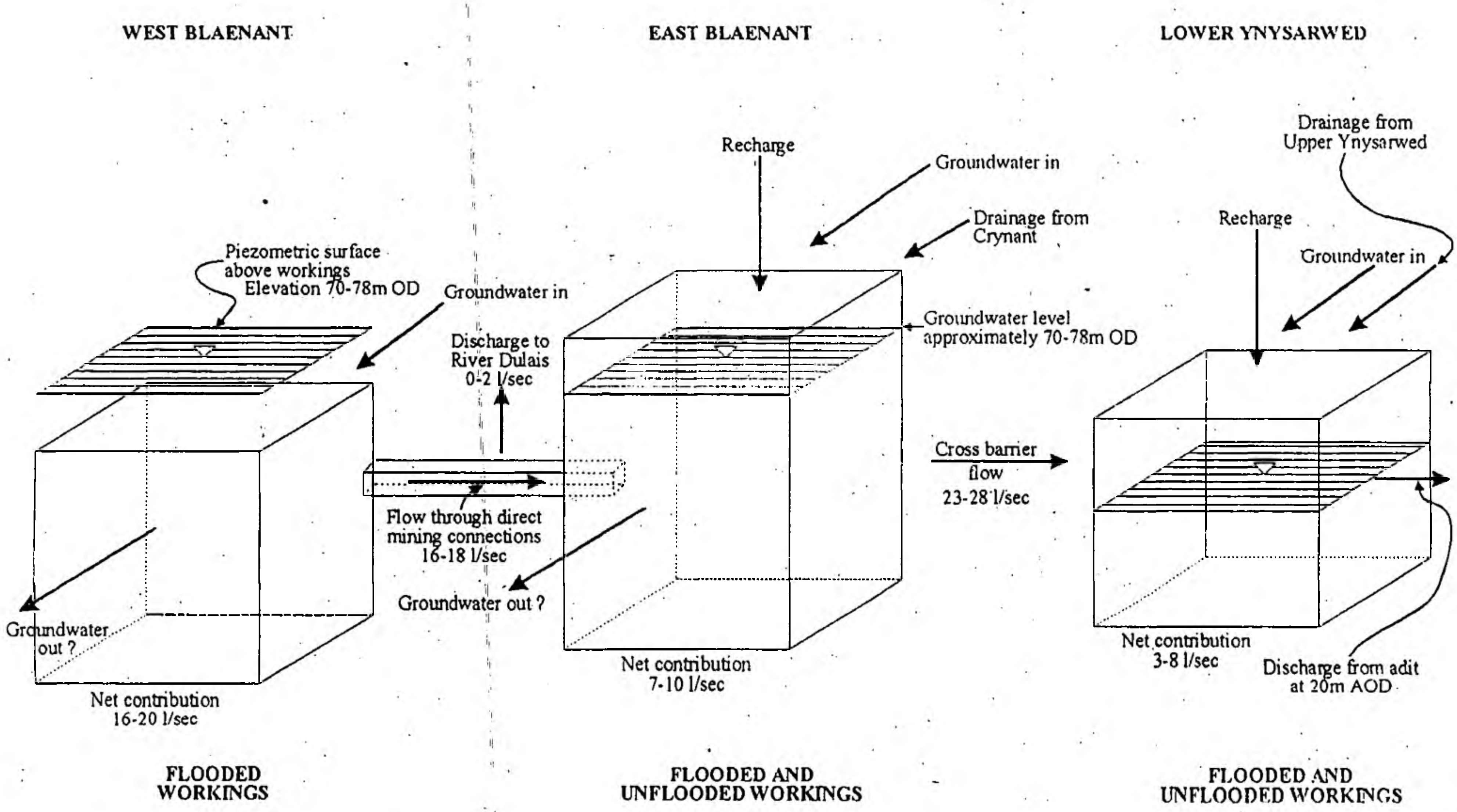
The southern part of the Lower Ynysarwed workings is flooded to approximately 20 m OD. The area to the north is unflooded. The proportion of flooded to unflooded workings is approximately 60:40. Inflows to the flooded portion comprise cross barrier flow from Blaenant and ground water inflow. Inflows to the unflooded area comprise direct recharge and flow across the pillar from Blaenant.

Ground water outflow from Lower Ynysarwed under present conditions is likely to be negligible as the water level in the workings is likely to be at a similar elevation to the down gradient ground water level, and the workings are likely to act as a drain to ground water flowing to the discharge.

The flow through the pillar is likely to vary seasonally between 23 - 28 l/sec, and the contribution from within Lower Ynysarwed is likely to be 3 - 8 l/sec. The resultant flow from the Lower Ynysarwed discharge generally varies between 26 and 36 l/sec.

Reference

Steffen, Robertson & Kirsten (UK) Ltd. (1995) Short and long term remediation of the Neath Canal and River Dulais minewater discharges. Ref:PJKS/534PS001.REP.



DATE: 16/1/95	PROJ. No: U534	REMEDIATION OF THE NEATH CANAL AND RIVER DULAIS MINEWATER DISCHARGES	
SRK		FLOW COMPONENTS OF THE BLAENANT/ YNYSARWED SYSTEM	Figure 1

7. REMEDIATION OPTIONS

ROBERT REES, Director of Housing and Leisure, Neath Borough Council
ARTHUR DAVIES, Assistant Director of Engineering and Operations, Neath Borough Council

Robert Rees introduced this session, highlighting the implications of the minewater problem and the importance of finding a long term solution. Arthur Davies concluded the session by summarising the options available for long term remediation.

A number of long term remediation options were identified, and assessed in terms of cost-effectiveness in a feasibility study carried out by consulting engineers Steffen, Robertson and Kirsten (UK) Ltd. These options can be categorised as source control, migration control and "end of pipe" treatment. The following options are currently being considered:

(i) Chemical treatment

Alkali treatment would be an effective way of neutralisating acidity and precipitating metal hydroxides. However, the annual operating costs would be prohibitive.

(ii) Anaerobic wetland treatment

This is the most appropriate passive treatment option available, due to the high iron loading in the discharge. It is anticipated that a well designed wetland of 6 hectares with good hydraulic control could reduce the iron concentration in the discharge to less than 50 mg/l. The wetland would be designed on a modular basis so that it could be expanded if necessary.

(iii) In situ sulphate reduction

This involves the addition of a carbon substrate to the Lower Ynysarwed mine workings via boreholes to create conditions ideal for the bacterial mediated reduction of sulphate to sulphide, and the precipitation of ferrous iron sulphide. It is anticipated that the iron concentration could be reduced by more than 90%, but this is dependent on the kinetics of the dissolution of secondary minerals. Further studies, including laboratory experiments and a within-mine tracer test, as well as a pilot scheme, would be necessary to ensure that risks are minimised.

(iv) Isolation of West Blaenant

By sealing the direct hydraulic link between West and East Blaenant it is anticipated that the discharge flow, and therefore the iron loading, could be reduced by 25%. However, the risk of increasing ferruginous discharges to the River Dulais would need to be fully assessed prior to implementation. This option would be implemented either with in situ sulphate reduction, to reduce the requirement for the chosen carbon substrate, or with a wetland, to reduce the risk of non-compliance.

Predicted discharge characteristics with combinations of remedial options are shown in Table 1. The strengths and weaknesses of the various options are shown in Table 2.

Reference

Steffen,Robertson & Kirsten (UK) Ltd.(1995) Short and long term remediation of the Neath Canal and River Dulais minewater discharges.Ref:PJKS/534PS001.REP.

Option	'End of Pipe' Treatment Options		Source and Migration Controls					Predicted discharge characteristics			Wetland Treatment (source and migration controls only)
	Baseline Chemical Treatment	Baseline Anaerobic Wetland Treatment	Isolation of West Blaenant	Ynysarwed Internal Diversion	*In situ* Sulphate Reduction	Ventilation Control	Flooding of Ynysarwed	Flow (l/sec)	Discharge iron concentration (mg/l)	Overall reduction (%)	
1	x							26 - 36	50	85	NA
2	x							26 - 36	1	100	NA
3		x						26 -36	50	85	NA
4			x					17 - 27	375	25	Full
5				x				26 -36	335 - 360	4 - 11	Full
6					x	x		26 - 36	50	85	None
7						x	x	14 - 26	285 - 340	40 - 50	Partial
8			x			x	x	3 - 13	285 - 340	67 - 73	Polishing
9			X		X	X		17 -27	50	90	None

Table 1: **Predicted Discharge Characteristics with Combinations of Remedial Options**

Option	STRENGTHS	WEAKNESSES
1 (Baseline chemical)	High level of control, could be implemented in 6 months	Very high revenue costs
2 (Baseline chemical and sell water)	As above but reduced revenue costs	No customer identified, lack of security associated with water markets
3 (Baseline wetland)	Passive treatment, relatively low revenue costs	Purchase of land, risk of excessive iron load in effluent
4 (Isolation of W Blaenant and wetland)	As for option 3, and isolation has no maintenance or operating costs, isolation could be implemented within 6 months, risk of poor quality effluent reduced relative to 3	As for option 3 but considerably reduced risk of excessive iron load, difficulty of sealing West Blaenant, risk of contaminating River Dulais
5 (Internal diversion and wetland)	Entry to mine would increase understanding of the system	Capital costs very high for limited benefit
6 (In situ sulphate reduction)	Low capital and operating costs, no wetland, research and development value, sewage disposal with environmental benefits	Untested method, risk that pilot scheme fails and therefore expenditure partly wasted, time to implement will be 2-3 years, public perception, planning process may cause problems
7 (Flooding of Ynysarwed and wetland)	As option 5, low operating costs, reduced wetland size	High capital cost, risk associated with uncontrolled discharges, difficulty of implementation
8 (Isolation of W Blaenant and flooding)	As option 7, very small wetland, at times flow may cease	As for option 7, difficulty of sealing West Blaenant, risk of contaminating River Dulais
9 (Isolation of W Blaenant and sulphate reduction)	As option 6, reduced sewage requirement	As option 6, difficulty of sealing West Blaenant, risk of contaminating River Dulais

Table 2: **Strengths and Weaknesses of Options**

8. SUMMARY

STEVE BROWN, Area Environmental Quality Manager, NRA, Haverfordwest

Steve Brown concluded the workshop by summarising the main issues arising from the presentations and discussions. These were as follows:

A. Pelenna Project

1. Acidification is a major issue that needs further consideration. Further funding will be necessary for the amelioration of this problem, which may need to involve controls over local emissions of acid-forming compounds.

2. The timing of the assessment of effectiveness of the wetland treatment systems is important to the Blaenant/Ynysarwed project.

3. The scheme is essentially a full scale project, with many uncertainties.

4. Compromises are inevitable, eg. visual impact of treatment areas.

5. Overall we must be able to demonstrate improvements and benefits.

B. Blaenant/Ynysarwed Project

1. This project arose from a major acute incident, with no "do nothing" option.

2. A collaborative emergency response was successful in limiting the damage caused by the pollution.

3. The Welsh Office supported an urgent application from Neath Borough Council under the 1995/96 Strategic Development Scheme (SDS).

4. The cost/benefit of possible options looks very favourable.

5. The conceptual model for long-term remediation needs further confirmation. Further investigations are needed to assess risks and benefits.

6. Source control is favoured but risks must be quantified.

7. The role of the Coal Authority needs to be clarified. The technical case needs further development and liabilities need to be confirmed.