NRA - Wales 188

# STUDY OF FERRUGINOUS MINEWATER IMPACTS IN WALES:

## PHASE 2a DETERMINATION OF REMEDIAL OPTIONS

## VOLUME 2 - SITE REPORTS

ADM/489AC001.REP

SEPTEMBER 1994


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# STUDY OF FERRUGINOUS MINE WATER IMPACTS IN WALES

## Phase 2a DETERMINATION OF REMEDIAL OPTIONS

## VOLUME 2 - SITE REPORTS

**This report was prepared under contract to the National Rivers Authority and the Welsh Office. The results of this work will be used in the formulation of Government Policy, but views expressed in this report do not necessarily represent Government Policy.**

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**Project Number U489** **September 1994**

## VOLUME 2 - SITE ASSESSMENTS

### SITE ASSESSMENTS (RIVER NAME FOLLOWED BY SITE NAME)

| | | |
|---|---|---|
| 1 | Site 5 | Sirhowy, Blackwood |
| 2 | Site 6 | Sirhowy, Pontllanfraith |
| 3 | Site 7 | Rhymney, Tir-y-Birth |
| 4 | Site 10 | Lwyd, Blaenavon |
| 5 | Site 12 | Clydach, Y Ffrwd (Llanwonno) |
| 6 | Site 15 | Llynfi, Llynfi |
| 7 | Site 16 | Cynffig, Craig yr Aber (Aberbaiden) |
| 8 | Site 17 | |
| | Site 17A | Corrwg, Afan Corrwg |
| 9 | Site 18 | Corrwg, Afan Corrwg Fechan |
| 10 | Site 19 | Afan, Gwynfi |
| 11 | Site 29 | Loughor, Cathan |
| 12 | Site 30 | Morlais, Morlais |
| 13 | Site 31 | |
| | Site 31A | Clyne, Dunvant |
| 14 | Site 33 | Lower Clydach Llechart |
| 15 | Site 62 | Neath, Ynysarwed |
| | Site 62A | Dulais, Blaenant |

For each site the following sections are presented:

1 Geology and Mining
2 Contamination Sources
3 Hydrogeological model
4 Discharge Water Quality and Load Assessment
5 Environmental Costs and Benefits
6 Options for Remediation and Costs

# SITE 5 - BLACKWOOD

## 5.1 GEOLOGY AND MINING

Site 5 is a discharge on the right bank of the Sirhowy River just downstream of a footbridge in Blackwood, Gwent as shown on Fig 5.1. The discharge almost directly overlies the Old Rock Colliery Shaft. The discharge flow combines with clean run-off before entering the main stream of the river. A number of small diffuse seeps were also observed upstream from the site.

The discharge is situated near to the axis of the Blackwood Syncline, this being a gentle west-east striking structure which plunges at a shallow angle to the east. The Mynyddislwyn seam of the Upper Coal Measures underlies the area at shallow depth and outcrops a short distance to the north. The area is also underlain at a depth of about 300 m by the Brithdir Seam and by other seams at greater depth.

The collar elevation of the Old Rock Colliery shaft is at 147m AOD. The shaft is 23m deep and intersects the Mynyddislwyn Seam at 133m AOD. The Old shaft was at some time superseded by the New Rock Shaft (collar 181 m AOD), which is on the northern (southerly dipping) limb of the syncline. The Old Shaft appears to have been used for pumping. It is recorded that very little water was pumped in summer, but about 1.0Ml per day was pumped in winter. Another pumping station in the old workings some 800m to the west appears to have been pumping about 0.45Ml per day to surface at the same time.

There is also an entrance to a level between the two shafts. The entrance to this is at the same elevation as the old shaft and it appears to be linked to the newer shaft. The Old Rock Shaft and the level entrance are at a lower elevation than any other entrance to the Rock Colliery workings in the Sirhowy valley. However, there is at least one entrance to the Rock Colliery workings at a lower level in the Rhymney Valley to the west. This is the Upper Gwaunborfa Level which is shown on the mine plan to have an entrance elevation of 144m AOD. However, there is a rise in elevation between the adit entrance and the workings which would prevent a discharge. The Lower Gwaunborfa Level does not have a marked elevation. Both appear to be associated with shafts, though the depths of these is unknown.

No discharge is recorded at the entrances to the levels in the Rhymney Valley or the one in the Sirhowy Valley, but not all of these sites have been checked. The west-east section, Fig 5.1b/c shows the strata between the Old Shaft in the Sirhowy Valley and the level entrances in the Rhymney Valley.

Figure 5.1e shows the extent of the workings in the Mynyddislwyn and Brithdir Seams and the relative positions of the shafts and adits.

Rock Colliery has been worked sporadically for more than 100 years, but finally ceased operations in 1957.

## 5.2 CONTAMINATION SOURCES

The discharge is almost certainly from the Old Rock Colliery Shaft. The flow is primarily from active recharge, flowing down through the Mynyddislwyn workings. From examination of the mine plans, it would seem that there is a large area of unsaturated workings above the 148m elevation to the North. Staining on the walls of the culvert above the current level of flow suggests a significant variation in flow; suggesting rapid response to rainfall. The iron concentration is low and sulphate high, suggesting there is active oxidation but probably the water has found defined channels through the unsaturated workings and there may be ongoing deposition in the workings.

## 5.3 HYDROGEOLOGICAL MODEL

Both this and the Pontllanfraith discharge (Site 6) were first noted after the closure of the Oakdale complex. The workings in the Mynyddislwyn Seam would have remained largely dry and unsaturated, but in an oxidising state, while the ground water was pumped by Oakdale and associated collieries.

There is no mined direct connection between the more recently worked deep collieries in the area and Rock Colliery. The discharge is likely to be the result of the recovery of the level of regional groundwater with the main sources of water being active recharge through the strata overlying the Mynyddislwyn Seam and the mine workings responding as a lateral drain.

No discharge has been noted at either of the two Rock Colliery level entrances in the Rhymney Valley or the one in the Sirhowy Valley. These are at similar elevations to the shaft collar although there are higher elevations in the actual workings. Any significant rise in water level could result in discharge from these.

## 5.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

At the time of the site visit, the discharge flow rate was estimated to be 4.3Ml/day. The discharge water is characterized by a near neutral pH, a total iron concentration ranging from 1.6 to 5.1 mg/l, and a relatively elevated sulphate concentration in the order of 700 mg/l. There is evidence that the iron concentration may be directly proportional to the flow. This suggests that ongoing oxidation is the primary mechanism for iron generation and the release of sulphate.
However, under the oxidizing but neutralizing conditions and considering the sulphate to iron ratio in the mine water, iron is being precipitated prior to discharge. It is considered that the sources for iron release comprise flooded as well as unflooded underground mine workings.

It is estimated that annually a total iron load of about 2.8 tonnes and about 600 tonnes of sulphate are released at the site.

As shown in Section 7 of Volume 1, it is estimated that the iron concentration in the receiving water downstream from the site should not exceed the 1.0mg/l set criterion. However, the impact as a result of the accumulation of iron hydroxides on the river beds is significant.

Whilst approximately 690kg aluminium is being released annually, its concentration is low and does not pose a concern with respect to its EQS of 1mg/l.

## 5.5 ENVIRONMENTAL COSTS AND BENEFITS

The character and value of the fishery on the River Sirhowy is very similar to that of the River Rhymney. The main angling club is the Islwyn and District Angling Club and about half the sport is based on put and take fishing for trout.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 5 | 50% loss of fish stocks |
| Accessibility - footpaths | 5 | Path within 10 m |
| Accessibility - roads | 3 | Road within 100 m |
| Visual impact downstream | 2 | Significant plume of colour |
| Proximity to built up area | 3 | Houses and factories 100-300 m away |
| Proximity to recreation area | 1 | Any recreation area >500 m away |

Site specific details: The discharge is not likely to be seen by casual visitors to the area. There are considerable amounts of rubbish in the trees along the banks.

The relatively high scoring means that the site would benefit from remediation in terms of fisheries and aesthetic impacts on those living in the area.

## 5.6 OPTIONS FOR REMEDIATION AND COSTS

It is considered that the primary source for iron release is unflooded underground workings. A large contribution of the total loading is active oxidation, therefore the potential for source control by oxygen exclusion is high. It is also anticipated that the discharge concentration would remain at present values in the long term.

Active treatment of the discharge would be technically feasible and would yield a high performance, the associated long term costs are probably not warranted by the relatively low loading and the estimated downstream receiving water concentration.

A wetland approach, comprising an aeration-oxidation stage followed by a settling basin, is anticipated to reduce the iron concentration in the discharge to an acceptable level. No anoxic limestone drain (ALD) would be required for pH adjustment.

It is estimated that a settling basin of about 0.1 Ha would provide adequate retention time to allow removal of iron. The annual sludge build-up would be about 0.005m.

The wetland approach would work although little land is available in the immediate vicinity. A pipe would be required to move the discharge to where a wetland could be developed.

Based on the estimated total iron concentration in the receiving water and the probability distribution (Fig 5.4), it is considered that if the iron loading is introduced to receiving water as a diffuse rather than a point loading, the adverse impact of accumulated ferric precipitates on the river bed may be prevented. The mechanism for introducing such a diffuse loading will have to be designed with great care to prevent plugging through accumulation of iron hydroxide precipitates at the point of discharge. It will be necessary to provide a hydraulic head to prevent back-washing of neutral, aerated waters into the diffusing mechanism. Point flows from the diffuser should be low enough to limit the formation of precipitates by virtue of dilution at the point of discharge.

It is anticipated that a hydraulic head sufficient for the purpose of discharge could be generated by plugging of the discharge culvert. It is considered that the control objective may be achieved with a controlled, diffuse discharge system.

The high probability of success of a controlled diffuse discharge make this the preferred option.

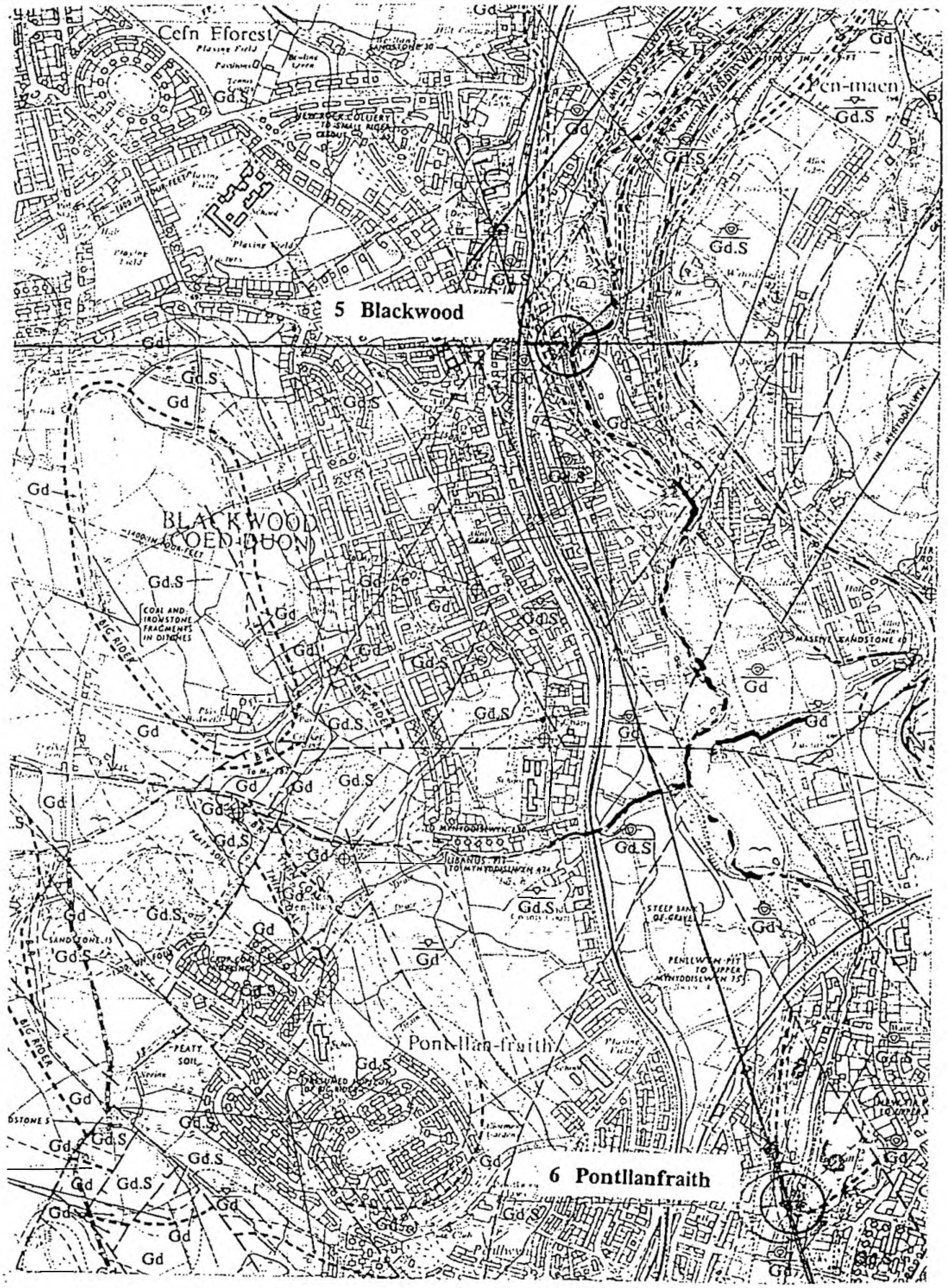
Estimated Costs:

**Capital**

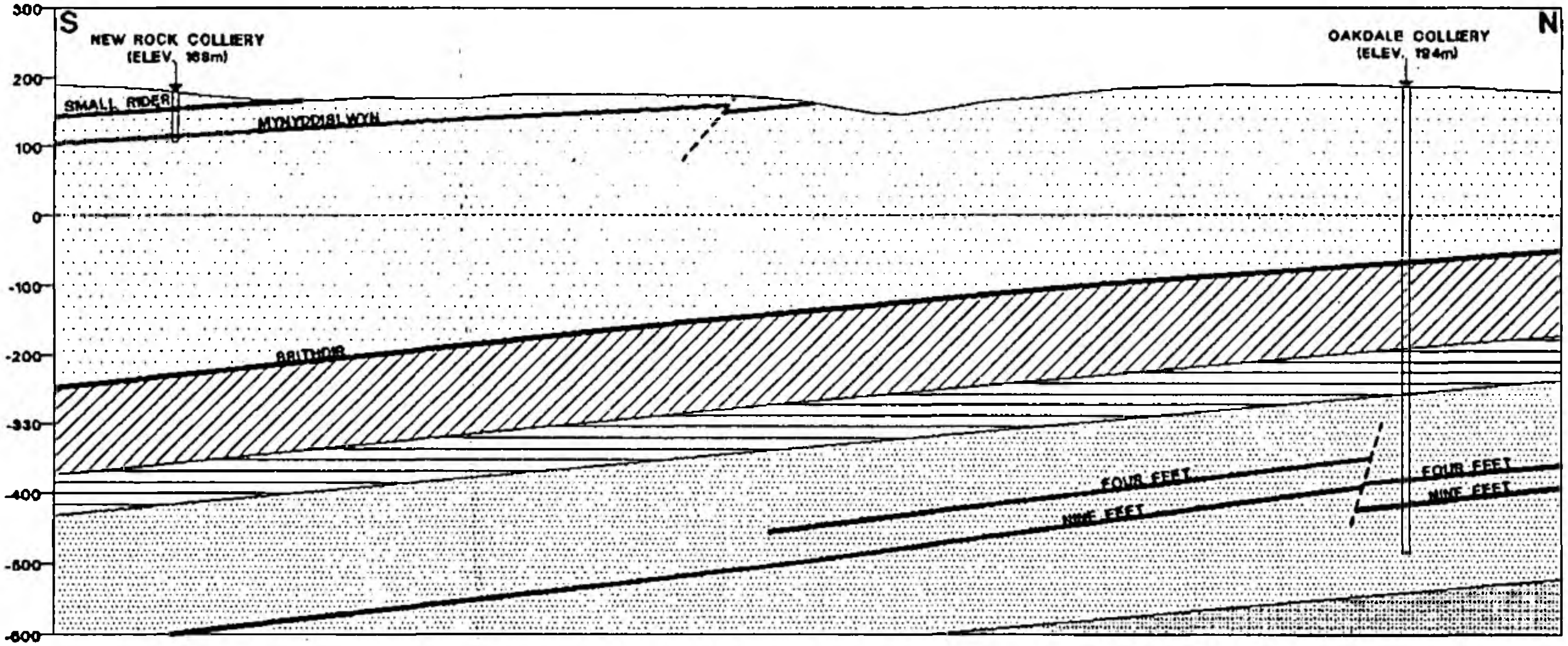
| | |
|---|---|
| Block discharge entrance to provide hydraulic head | £ 5,000 |
| Installation of diffuser system (150 m pipe) | £10,000 |
| Risk of new discharge emergence from adit upstream - contingency to block this adit | £ 5,000 |
| | £20,000 |

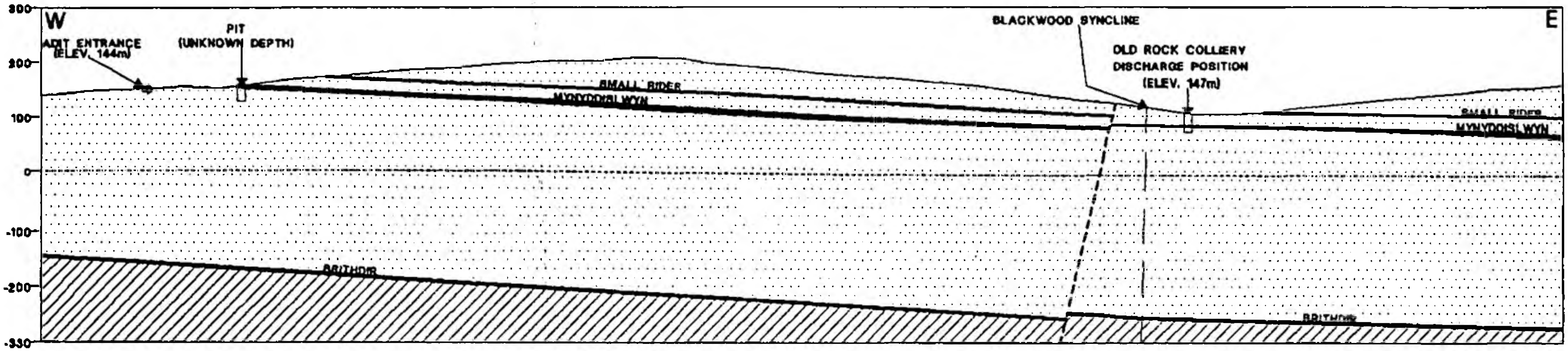
**Operating/Maintenance Costs**

| | |
|---|---|
| 2 man days/yr @ £250 | £500 |
| Maintenance/depreciation @ 10% of capital costs | £2,000 |
| | £2,500 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure |
|---|---|---|---|
| SRK | | SITE 5: BLACKWOOD | 5.1 |



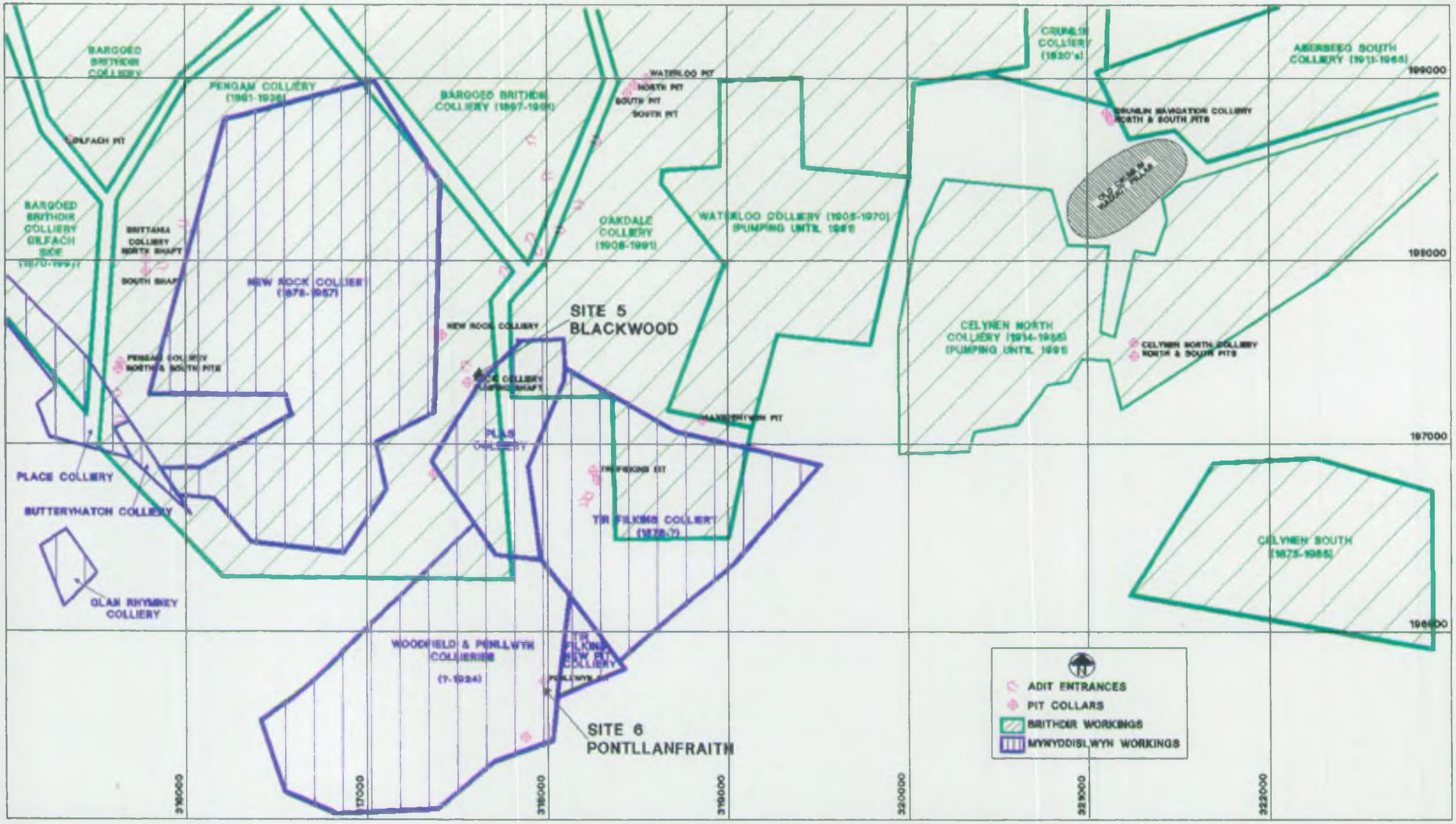

BRITHDIR, HUGHES & GROVESEND BEDS
RHONDDA BEDS
LLYNFI BEDS
MIDDLE COAL MEASURES
LOWER COAL MEASURES

| DATE: 7/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 5: BLACKWOOD<br>SOUTH-NORTH & WEST-EAST SECTIONS | Figure<br>5.1b/c |

DISCHARGE INTO RIVER

ADIT/ SHAFT ENTRANCE

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | **SITE 5: BLACKWOOD** | Figure 5.1 D |




DATE: 13/4/94 | PROJ. No: U489

SRK/NRA ACID ROCK DRAINAGE

STEFFEN, ROBERTSON & KIRSTEN
CONSULTING ENGINEERS

# DOCUMENTED BRITHDIR & MYNYDDISLWYN SEAM WORKINGS, ADIT ENTRANCES & SHAFTS

Figure 5.1e

# Site 5, Section 4. Discharge Water Quality and Load Assessment.

Synthesized flow distribution

| | Discharge | River |
|---|---|---|
| Jul | | 4.8 |
| Aug | | 4.6 |
| Sep | | 4.1 |
| Oct | | 8.9 |
| Nov | | 15.0 |
| Dec | | 16.5 |
| Jan | | 13.4 |
| Feb | | 10.4 |
| Mar | | 6.8 |
| Apr | | 5.8 |
| May | | 4.7 |
| Jun | | 8.0 |

Site #: 5
Site : Blackwood

Receiving water

Site #: 5
Site : Blackwood
Discharge

| | Discharge (m3/s) | U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | pH | Alkalinity (mg CaCO3/l | SO4 (mg/l) U/S | D/S | pH | Alkalinity (mg CaCO3/l | Fe(T) Concentration (mg/L) Discharge | Calculated Receiving | Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.018 | 1.320 | 41 | 3487 | 0.012 | | | | | | | 3.0 | 0.035 | | 0.123 | 2.3 | 0.002 | 9.5 | 0.7 | 0.028 | 693 | 29 |
| Aug | 0.008 | 1.269 | 20 | 3334 | 0.006 | | | | | | | 3.0 | 0.018 | | 0.059 | 1.1 | 0.001 | 19.7 | 0.7 | 0.014 | 693 | 14 |
| Sep | 0.004 | 1.118 | 11 | 2937 | 0.004 | 7.4 | 87 | 64 | 62 | 6.6 | 151 | 1.6 | 0.006 | 0.230 | 0.018 | 0.3 | 0.000 | 34.5 | 0.12 | 0.001 | 668 | 8 |
| Oct | 0.010 | 2.458 | 26 | 6457 | 0.004 | | | | | | | 3.0 | 0.012 | | 0.076 | 1.5 | 0.001 | 15.4 | 0.7 | 0.018 | 693 | 18 |
| Nov | 0.017 | 4.126 | 46 | 10838 | 0.004 | | | | | | | 3.0 | 0.012 | | 0.136 | 2.6 | 0.003 | 8.6 | 0.7 | 0.031 | 693 | 32 |
| Dec | 0.025 | 4.538 | 66 | 11920 | 0.006 | | | | | | | 3.0 | 0.016 | | 0.196 | 3.7 | 0.004 | 6.0 | 0.7 | 0.045 | 693 | 46 |
| Jan | 0.053 | 3.673 | 138 | 9649 | 0.014 | | | | | | | 3.0 | 0.042 | | 0.409 | 7.8 | 0.008 | 2.9 | 0.7 | 0.095 | 693 | 96 |
| Feb | 0.060 | 2.852 | 158 | 7491 | 0.021 | | | | | | | 3.0 | 0.061 | | 0.468 | 8.9 | 0.009 | 2.5 | 0.7 | 0.108 | 693 | 109 |
| Mar | 0.058 | 1.880 | 152 | 4939 | 0.030 | 8.0 | 95 | 72.8 | 269.6 | 6.8 | 100 | 5.1 | 0.152 | 1.400 | 0.775 | 14.8 | 0.015 | 2.6 | 1.5 | 0.228 | 796 | 121 |
| Apr | 0.038 | 1.582 | 100 | 4154 | 0.024 | | | | | | | 3.0 | 0.070 | | 0.297 | 5.7 | 0.006 | 3.9 | 0.7 | 0.069 | 693 | 69 |
| May | 0.021 | 1.283 | 54 | 3369 | 0.016 | | | | | | | 3.0 | 0.047 | | 0.160 | 3.1 | 0.003 | 7.3 | 0.7 | 0.037 | 693 | 37 |
| Jun | 0.018 | 1.371 | 48 | 3601 | 0.013 | 8.1 | 109 | 50.9 | 52.6 | 6.7 | 117 | 2.2 | 0.029 | 0.065 | 0.105 | 2.0 | 0.002 | 8.2 | 0.437 | 0.021 | 614 | 29 |
| mean | 0.027 | 2.289 | 859 | 72155 | 0.013 | | | | | | | 3.0 | 0.042 | | 2.821 | 54.0 | 0.054 | 10.1 | 0.7 | 0.694 | 693 | 607 |
| min. | 0.004 | 1.118 | | | 0.004 | | | | | | | | 0.006 | | | | | 2.5 | | | | |
| max. | 0.060 | 4.538 | | | 0.030 | | | | | | | | 0.152 | | | | | 34.5 | | | | |

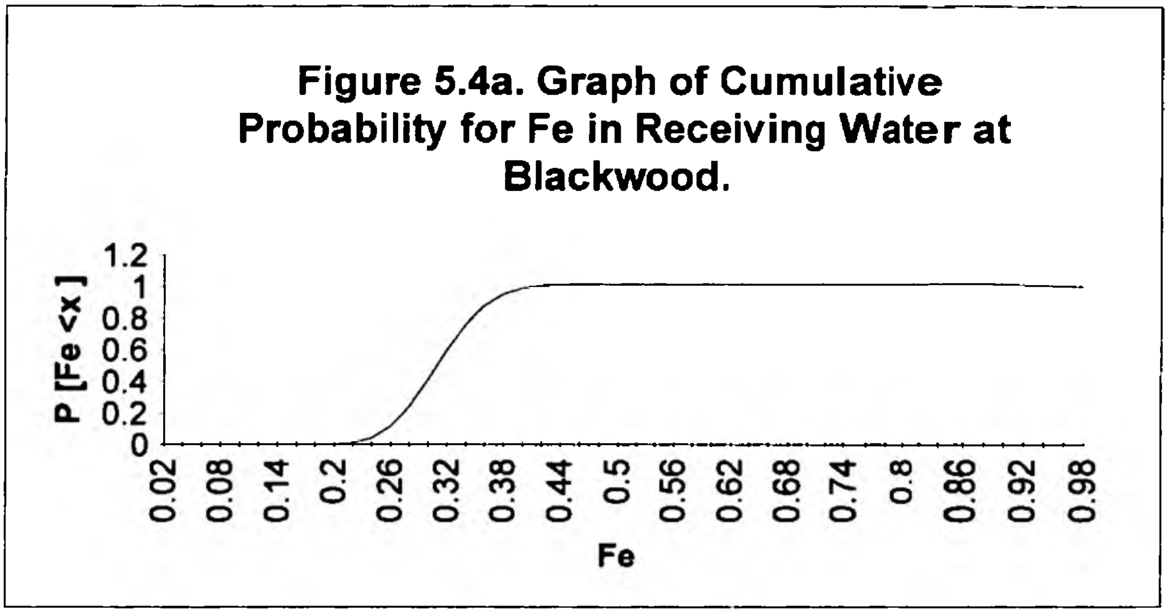


Figure 5.4a. Graph of Cumulative Probability for Fe in Receiving Water at Blackwood.
P [Fe <x ]
1.2
1
0.8
0.6
0.4
0.2
0
0.02
0.08
0.14
0.2
0.26
0.32
0.38
0.44
0.5
0.56
0.62
0.68
0.74
0.8
0.86
0.92
0.98
Fe

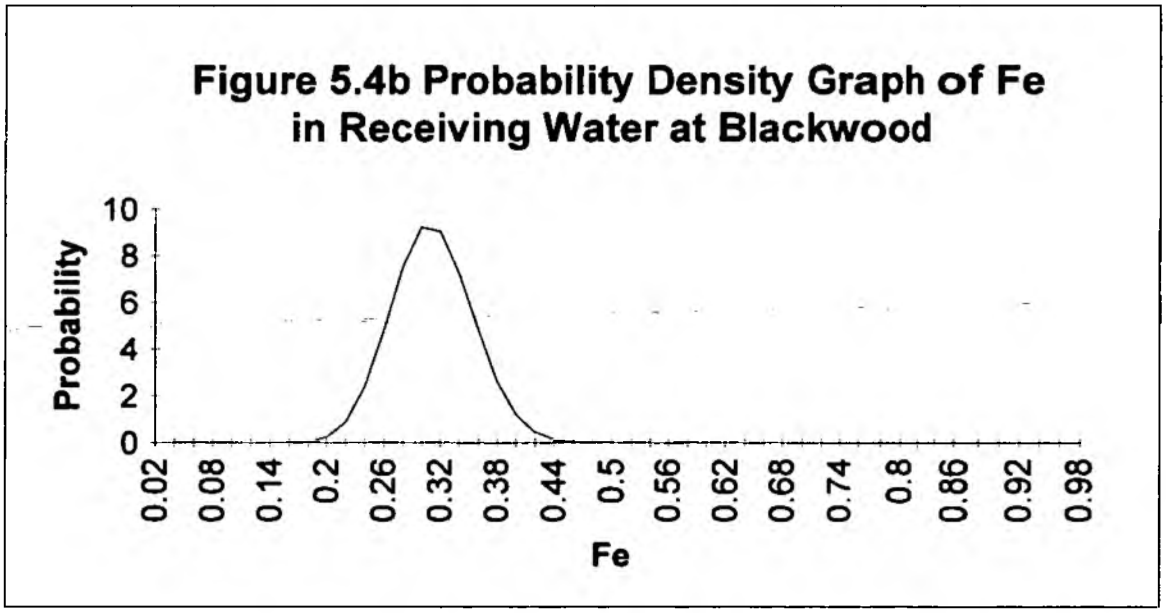



Figure 5.4b Probability Density Graph of Fe in Receiving Water at Blackwood
Probability
10
8
6
4
2
0
0.02
0.08
0.14
0.2
0.26
0.32
0.38
0.44
0.5
0.56
0.62
0.68
0.74
0.8
0.86
0.92
0.98
Fe

# SITE 6 - PONTLLANFRAITH

## 6.1 GEOLOGY AND MINING

Site 6 is a discharge on the right bank of the Sirhowy River in Pontllanfraith, some 2km downstream from Site 5 as shown in Fig 6.1. Mine water enters the Sirhowy River from a culvert which passes under a nearby road. The culvert is fed by clean run-off and a number of upwelling mine water flows at the inlet side of the culvert. Mine water is also observed as upwelling flows at the nearby RMC site, as well as at a number of smaller, diffuse seeps in close proximity. The discharge source is the old Penllwyn Colliery New Shaft, within the area of the RMC site.

There are five other, unnumbered, discharge points into the Sirhowy River between Site 5 and Site 6. Two of the other discharge points directly overlie shaft collars, New Penmaen Pits and Woodfield Pits respectively, while the other three are where fault outcrops intersect the river.

The area is underlain at shallow depth (between 15 and 30m) by the Mynyddislwyn Seam of the Upper Coal Measures. The mine entrances noted are all associated with old workings on this seam. The Penllwyn New Shaft is the lowest entrance to the Penllwyn workings - there are some other shafts but these are higher up the river banks.

The north-south section, Fig 6.1b, shows the geology between Rock Colliery and Penllwyn Colliery. The two collieries are separated by the Pontypridd Anticline. The main discharge and one unnumbered discharge are on the southern limb while the remainder are on the northern.

The Mynyddislwyn seam has been virtually mined out in the area. Operations on this seam had been largely completed by the end of the 19th century. The Small Rider Seam has generally not been worked as it is too thin.

Figure 5.1e (previous section) shows the extent of the workings in the Mynyddislwyn and Brithdir seams and the relative positions of the shafts and adits.

## 6.2 CONTAMINATION SOURCES

The immediate source of the minewater discharged at site 6 is the Mynyddislwyn Seam workings of the Penllwyn Colliery. The other discharges upstream are thought to emanate from the Mynyddislwyn workings of the Penmaen and Woodfield Collieries. The catchment area for the discharge comprises mainly flooded workings (release of stored products) and to a lesser extent unflooded (active oxidation) areas.

## 6.3 HYDROGEOLOGICAL MODEL

The discharge is related to the regional recovery of the groundwater and flow through the workings in the Mynyddislwyn Seam after cessation of pumping from the Oakdale system. The discharge points observed are in each case the lowest point of entrance to a colliery. It appears that Penllwyn, Woodfield and Penmaen collieries are connected and so it is assumed that water within them will preferentially flow to the lowest discharge point. The source of water and contamination would be a combination of recharge downwards to the workings as well as upward seepage from the sandstones underlying the Mynyddislwyn Seam.

The existence of minor discharges which are apparently related to faults suggests that to attempt to stop the discharge by some form of capping or blocking of adits/shafts would cause discharge at geologically controlled points.

## 6.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge flow rate at the point of entry to the River Sirhowy was estimated to be 3.9Ml/day at the time of the site visit. The discharge water is neutral in pH and characteristically has a high alkalinity. This would suggest that the shaft from which the discharge is occurring has been backfilled with a calcareous material such as limestone. The discharge contains about 7mg/l total iron, which appears to be independent of flow. This would suggest that the iron concentration is controlled by equilibrium chemistry, probably within the backfilled zone of the shaft immediately prior to discharge. The elevated concentration of sulphate would suggest that ongoing oxidation is probably occurring within the catchment of the discharge.

It is considered that the sources for iron release comprise flooded as well as unflooded underground mine workings.

The total load of iron released annually from the site is estimated to be in the order of 11.8 tonnes, together with 1077 tonnes of sulphate. It is estimated that the iron concentration in the receiving water downstream from the site would comply with the 1.0mg/l criterion. However, the impact as a result of the accumulation of iron hydroxides on the river bed is significant.

It is estimated that less than 50kg aluminium is being generated annually at this site and consequently does not represent a concern.

## 6.5 ENVIRONMENTAL COSTS AND BENEFITS

The character and value of the fishery on the River Sirhowy is very similar to that on the River Rhymney. The main angling club is the Islwyn and District Angling Club and about half the sport is based on put and take fishing for trout.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 5 | 50% loss of fish stocks |
| Accessibility - footpaths | 5 | Path within 10m |
| Accessibility - roads | 3 | Road within 100m |
| Visual impact downstream | 3 | Banks wooded, litter present |
| Proximity to built up area | 5 | Houses within 100m |
| Proximity to recreation area | 5 | Sports field within 100m |

Site specific details: The discharge is not likely to be seen by casual visitors to the area, there is considerable rubbish in trees along banks and in stream bed .

The high ranking means that the site would benefit from remediation in terms of fisheries and aesthetic impacts to people living in the area, particularly due to its proximity to footpaths and recreation areas.

## 6.6 OPTIONS FOR REMEDIATION AND COSTS

It is considered that the primary source for iron release is flooded underground workings. The potential for source control by oxygen exclusion is small. There is also no opportunity for migration control. It is anticipated that the discharge concentration will decrease in the long term. Treatment of the discharge therefore appears to be the most feasible solution.

While active treatment of the discharge may be technically very feasible, and would yield a high performance, the associated costs are probably not warranted by the relatively low loading and downstream receiving water concentration.

A wetland approach, comprising an aeration-oxidation stage, followed by a settling basin is anticipated to effectively reduce the iron concentration in the discharge to an acceptable level. No anoxic limestone drain (ALD) would be required for pH adjustment. It is estimated that a settling basin of about 0.3Ha with a pond depth of about 1m would provide adequate retention time to allow removal of iron to a level acceptable for direct discharge to the receiving environment. The annual sludge build-up would be about 0.01m.

Based on the estimated total iron concentration in the receiving water, it is considered that if the iron loading is introduced to receiving water as a diffuse rather than a point loading, the adverse impact of accumulated ferric precipitates on the river bed may be eliminated. The mechanism for introducing such a diffuse loading will have to be designed with great care to prevent plugging through accumulation of iron hydroxide precipitates at the point of discharge. It will be necessary to provide a hydraulic head to prevent back-washing of neutral, aerated waters into the diffusion mechanism. Point flows from the diffuser should be low enough to limit the formation of precipitates by virtue of dilution at the point of discharge.

While the control objective may be achieved with a controlled, diffuse discharge system, it is recommended that the wetland approach be followed for the abatement of the ferruginous discharge.

It is considered that at the 7mg/l iron observed for the discharge, a diffuser mechanism would be prone to plugging as a result of precipitate accumulation and localized staining of the river bed gravels may result. To implement a wetland system it may be necessary to install a drillhole at an angle to intercept and manage the flow, thus preventing the multiple discharges currently being observed.

A form of hydraulic balancing could also be used, which would increase the flow at one of the other identified (but not ranked) discharge points between Blackwood and Pontllanfraith.

This should serve to decrease the iron loading at Pontllanfraith so that a diffusion system can be utilised. The discharge points identified coincide with either faults or shaft/adit entrances and flow should be increased by installing a borehole to intersect the old workings and a diffuser to dispose of this flow in the stream bed.

**Capital Cost**

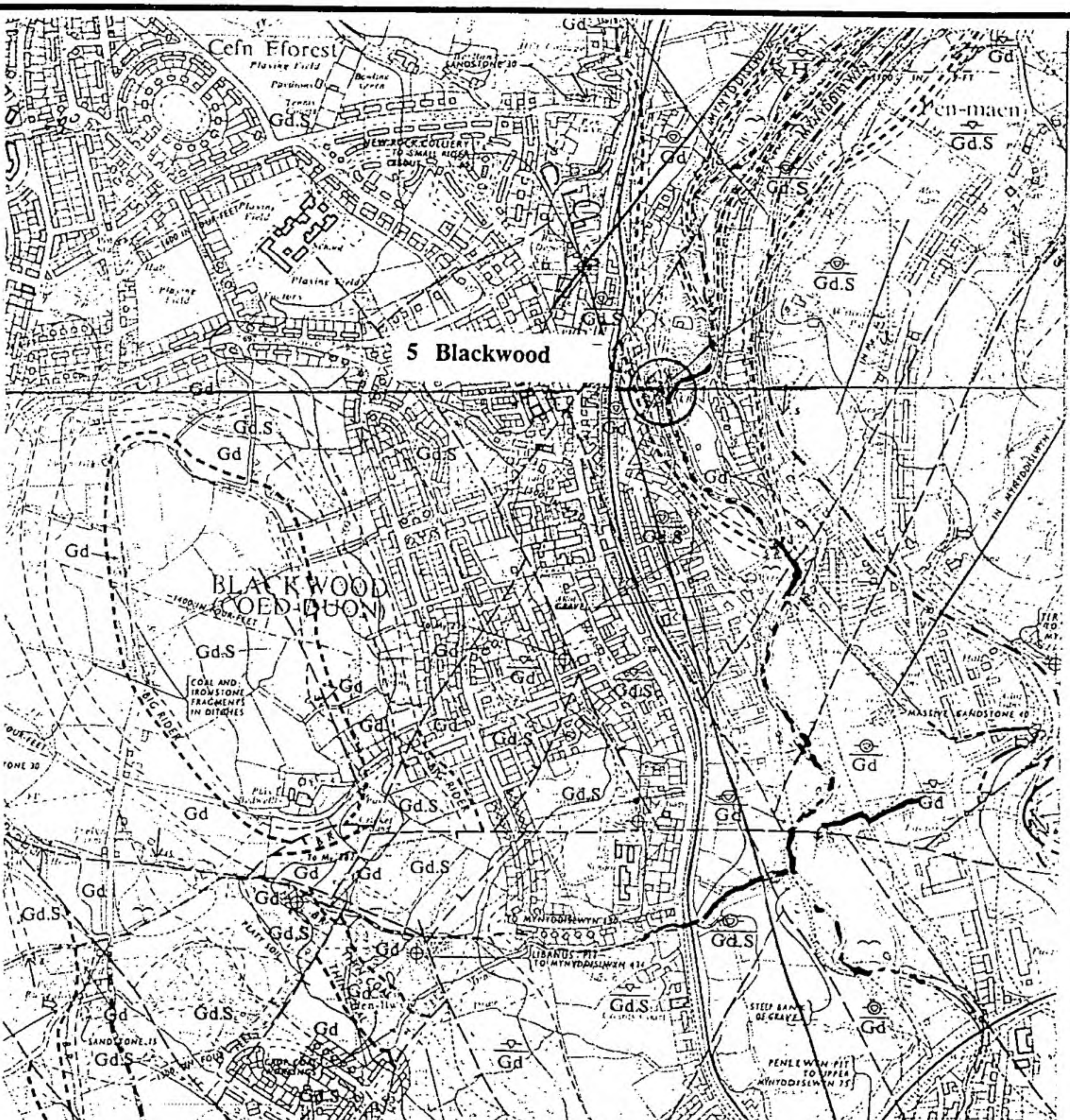
| | |
|---|---|
| 2 x Boreholes for investigation and production at upstream site (± 1km) @ | £12,000 |
| Headworks for boreholes | £ 5,000 |
| 2 x diffusers | £20,000 |
| | £37,000 |

**Operating and Maintenance Costs**

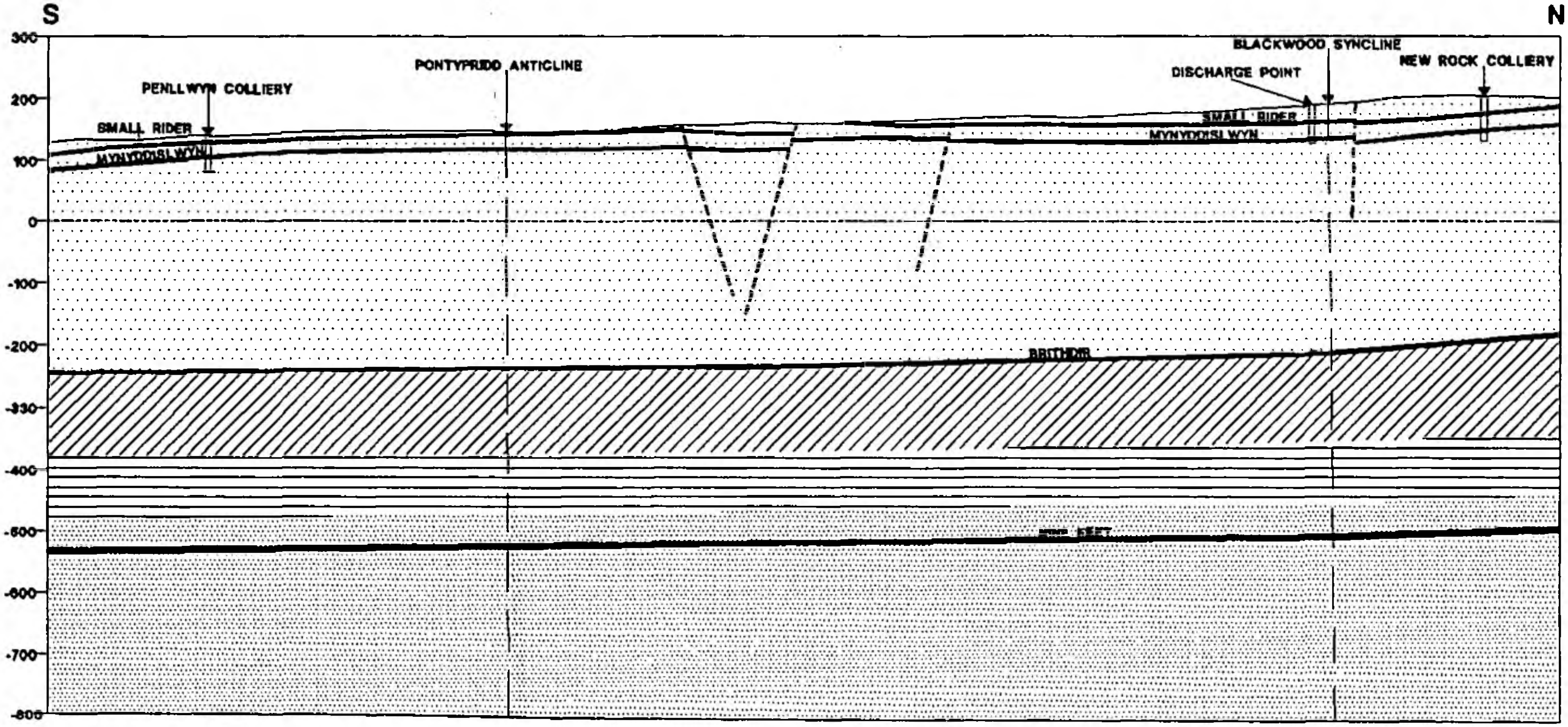
| | |
|---|---|
| 4 man days/year | £1,000 |
| Depreciation/maintenance 10% of capital | £3,700 |
| | £4,700 |

During the study the actual source of the discharge, the Penllwyn Shaft within the RMC site was inspected. The remedial measures proposed will have little effect on this discharge, which will continue. Alternative remedial measures may be taken to reduce this problem as well as the discharge to the river, but these have not been considered here and would be more complex.

It may be possible from information on the mine plans to locate a source of water on the fault between the two main discharges (Blackwood and Pontllanfraith) which could be extracted to reduce the drainage path length and the quantity of water to be treated at the current discharge point.




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure |
|---|---|---|---|
| SRK | | SITE 6: PONTLLANFRAITH | 6.1 |




- BRITHDIR, HUGHES & GROVESEND BEDS
- RHONDDA BEDS
- LLYNFI BEDS
- MIDDLE COAL MEASURES

| DATE: 5/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 6: PONTLLANFRAITH<br>SOUTH-NORTH SECTION | Figure<br>6.1b |

DISCHARGE TO RIVER

DISCHARGE TO CULVERT-CLEAN WATER & FERRUGINOUS SPRING

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 6: PONTLLANFRAITH | Figure 6.1 D |

DISCHARGE FROM SHAFT LOCATION AT R.M.C. PLANT

EMERGENCE POINT OF DISCHARGE

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 6: PONTLLANFRAITH | Figure 6.1 D |

Site 6, Section 4. Discharge Water Quality and Load Assessment.

Site #: 6
Site : Pontlanfraith

Receiving water

Site #: 6
Site : Pontlanfraith
Discharge

| | Disch distr. | River | | Discharge (m3/s) | U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | Receiving water: pH | Receiving water: Alkalinity (mg CaCO3/l | Receiving water: SO4 (mg/l) U/S | Receiving water: SO4 (mg/l) D/S | Discharge: pH | Discharge: Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L): Discharge | Fe(T) Concentration (mg/L): Calculated Receiving | Fe(T) Concentration (mg/L): Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | | 4.8 | Jul | 0.048 | 1.598 | 125 | 4192 | 0.029 | | | | | | | 7.0 | 0.20 | | 0.878 | 16.8 | 0.017 | 13.1 | 0.02 | 0.003 | 640 | 80.095 |
| Aug | | 4.6 | Aug | 0.041 | 1.534 | 107 | 4030 | 0.026 | | | | | | | 7.0 | 0.18 | | 0.752 | 14.4 | 0.014 | 15.3 | 0.02 | 0.002 | 640 | 68.581 |
| Sep | | 4.1 | Sep | 0.050 | 1.352 | 132 | 3551 | 0.036 | 7.3 | 83 | 69 | - | 6.9 | 221 | 7.6 | 0.27 | - | 1.000 | 19.1 | 0.019 | 12.5 | 0.026 | 0.003 | 657 | 86.455 |
| Oct | | 8.9 | Oct | 0.048 | 2.972 | 125 | 7807 | 0.016 | | | | | | | 7.0 | 0.11 | | 0.877 | 16.8 | 0.017 | 13.1 | 0.02 | 0.003 | 640 | 80.011 |
| Nov | | 15.0 | Nov | 0.058 | 4.988 | 152 | 13102 | 0.011 | | | | | | | 7.0 | 0.08 | | 1.063 | 20.3 | 0.020 | 10.8 | 0.02 | 0.003 | 640 | 89.989 |
| Dec | | 16.5 | Dec | 0.069 | 5.487 | 181 | 14412 | 0.012 | | | | | | | 7.0 | 0.09 | | 1.270 | 24.3 | 0.024 | 9.1 | 0.02 | 0.004 | 640 | ###### |
| Jan | | 13.4 | Jan | 0.059 | 4.441 | 155 | 11665 | 0.013 | | | | | | | 7.0 | 0.09 | | 1.087 | 20.8 | 0.021 | 10.6 | 0.02 | 0.003 | 640 | 99.174 |
| Feb | | 10.4 | Feb | 0.073 | 3.448 | 192 | 9056 | 0.021 | 7.7 | 87.19 | 125 | 258 | 7 | 227 | 6.1 | 0.13 | 0.174 | 1.177 | 22.5 | 0.023 | 8.6 | 0.013 | 0.002 | 616.7 | ###### |
| Mar | | 6.8 | Mar | 0.051 | 2.273 | 133 | 5971 | 0.022 | | | | | | | 7.0 | 0.15 | | 0.933 | 17.8 | 0.018 | 12.4 | 0.02 | 0.003 | 640 | 83.054 |
| Apr | | 5.8 | Apr | 0.049 | 1.912 | 129 | 5022 | 0.025 | | | | | | | 7.0 | 0.18 | | 0.904 | 17.3 | 0.017 | 12.8 | 0.02 | 0.003 | 640 | 82.449 |
| May | | 4.7 | May | 0.049 | 1.551 | 129 | 4074 | 0.031 | | | | | | | 7.0 | 0.22 | | 0.908 | 17.4 | 0.017 | 12.7 | 0.02 | 0.003 | 640 | 82.785 |
| Jun | | 5.0 | Jun | 0.048 | 1.657 | 126 | 4353 | 0.026 | 7.9 | 81 | 71.6 | 230 | 7 | 213 | 7.3 | 0.21 | 1.160 | 0.922 | 17.6 | 0.018 | 13.0 | 0.026 | 0.003 | 646.2 | 81.470 |
| | | | mean | 0.053 | 2.768 | 1685.3 | 87234.1 | 0.022 | | | | | | | 7.0 | 0.159 | | 11.8 | 225.2 | 0.225 | 12.0 | 0.02 | 0.036 | 640 | 1077.1 |
| | | | min. | 0.041 | 1.352 | | | 0.011 | | | | | | | | 0.080 | | | | | 8.6 | | | | |
| | | | max | 0.073 | 5.487 | | | 0.036 | | | | | | | | 0.272 | | | | | 15.3 | | | | |

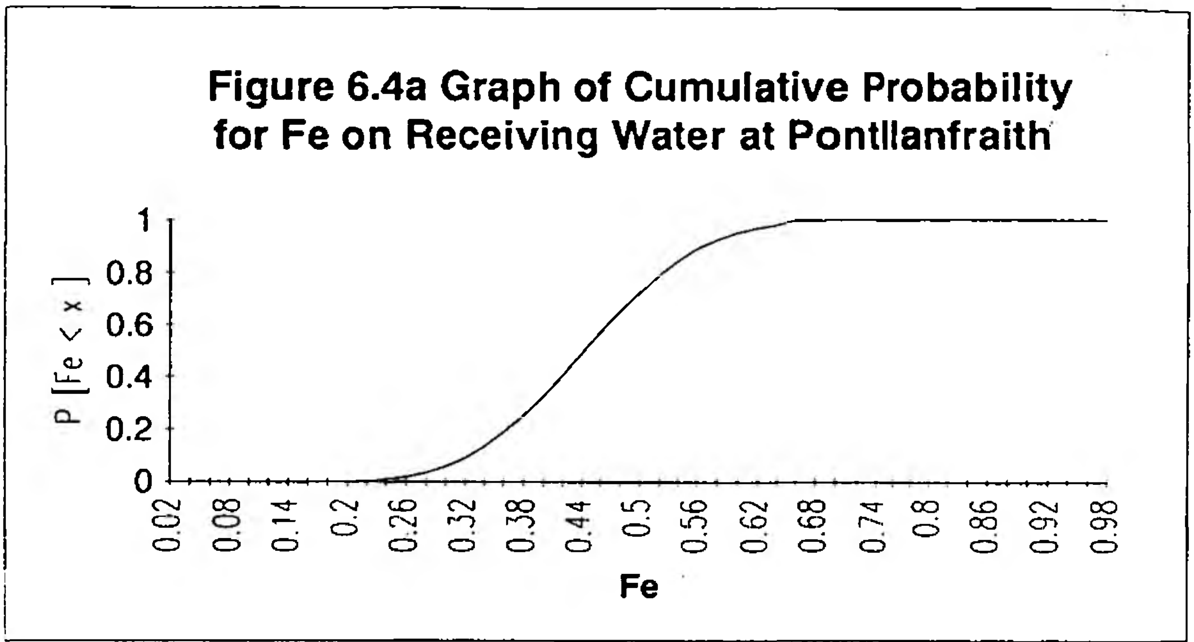


Figure 6.4a Graph of Cumulative Probability for Fe on Receiving Water at Pontllanfraith
P [Fe < x ]
1
0.8
0.6
0.4
0.2
0
0.02
0.08
0.14
0.2
0.26
0.32
0.38
0.44
0.5
0.56
0.62
0.68
0.74
0.8
0.86
0.92
0.98
Fe

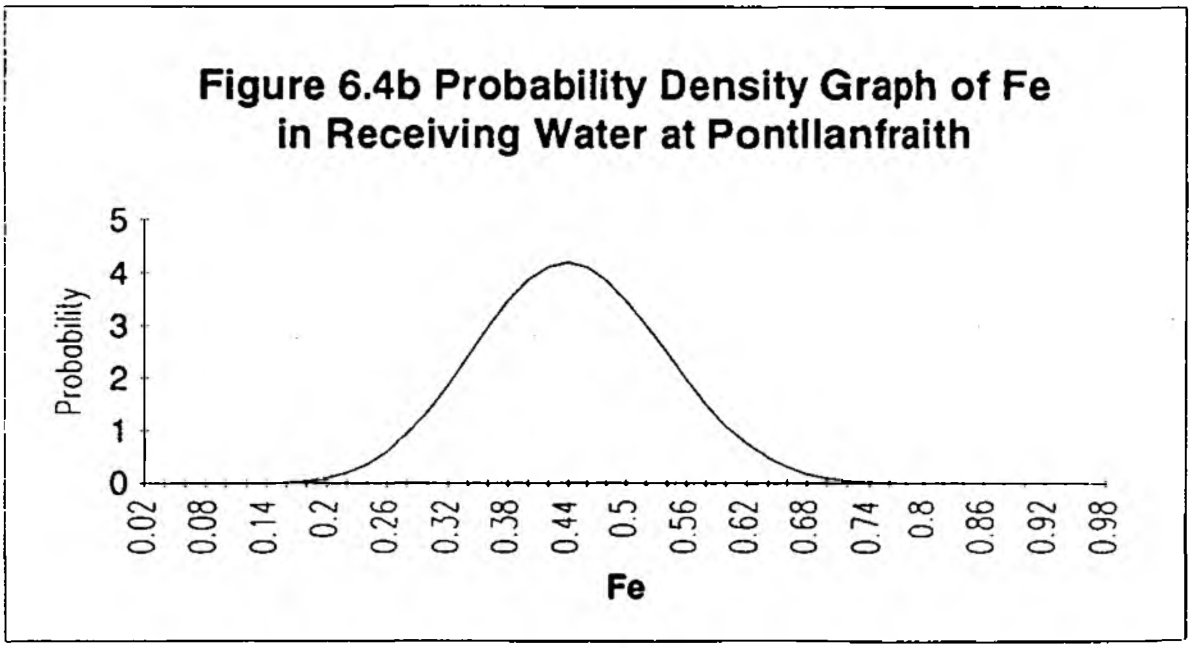



Figure 6.4b Probability Density Graph of Fe in Receiving Water at Pontllanfraith
Probability
5
4
3
2
1
0
0.02
0.08
0.14
0.2
0.26
0.32
0.38
0.44
0.5
0.56
0.62
0.68
0.74
0.8
0.86
0.92
0.98
Fe

3

3

# SITE 7 - TIR-Y-BERTH

## 7.1 GEOLOGY AND MINING

A series of upwelling flows enter the River Rhymney near to Tir-y-Berth. The attached photograph illustrates the discharge which exhibits the highest flow rate.

Coal mining in the area is first recorded from the 13th century; early workings were limited to mining seams close to surface from small shafts and drifts. Virtually all mining prior to the mid 19th Century was confined to the Mynyddislwyn Seam, and plans from then show that most of the coal was in the process of being or had been mined out. The principal collieries working then were Buttery Hatch, Place Pits, Pengam Pits and Glanravon. The last of these to close was Glanravon in 1880. An attempt in the 1940s to work coal near the outcrop at Glan Rhymney Colliery was abandoned when the mine flooded, possibly because it intersected old unrecorded workings. The present discharges are from six adjacent adits into the Glan Rhymney and Glanavon Mines.

The Brithdir Seam, 300m below the Mynyddislwyn Seam, was worked from the 1880's at collieries further north and subsequently workings began in the Middle and Lower Coal Measures below the Brithdir Seam. When workings in the Brithdir seam ceased in 1956, pumping was maintained to protect the workings in the seams beneath which were worked from Britannia Colliery. Britannia Colliery closed for production in 1983 but remained open as a pumping station and as a training centre until Oakdale Colliery closed in 1989. Pumping ceased in February 1990 and the discharge was first noticed in February 1991.

## 7.2 CONTAMINATION SOURCES

The iron in the discharge water is most likely to be from the workings in the Mynyddislywn Seam as well as remobilised material in the Mynyddislywn and Brithdir Seams and the intervening sandstones. The discharge is related to the cessation of pumping at Britannia Colliery when recovering ground water intersected and drained from the Mynyddislywn Seam. Areas of the workings remain unflooded so oxygenation is continuing.

## 7.3 HYDROGEOLOGICAL MODEL

The flows at Tir-y-Berth issue from old adits in the Mynyddislwyn Seam which accessed Glan Rhymney and Glanravon Collieries. The volume of the flows shows a relationship to the river flows with a delay of about a month and the river flow is closely correlated to rainfall. The relationship of the discharge flows to river flows indicates a significant contribution from direct active recharge rather than from stored groundwater. The primary source of water under mining conditions were the Mynyddislwyn and Brithdir Seams. Now that ground water has recovered, the main source will be from the Mynyddislwyn Seam.

Following cessation of pumping, the ground water levels recovered to pre-mining levels, except where interfered with by near-surface mining activities. The interruption in ground water recovery means there will be a flow contribution from upward seepage in the floor of the Mynyddislwyn Seam from the Brithdir sandstones as well as from recharge from above. Although the area is faulted, breaking the continuity of workings, the sandstone and faults are permeable and provide hydraulic continuity.

The discharge sites are south of the synclinal basin. Therefore, immediately north of the discharges the workings will be fully flooded. Further to the north as shown on Fig 7.1c, the workings will behave as unflooded drains.

The discharge at Tir-y-Berth represents the lowest access point to the Mynyddislwyn Seam (at outcrop) in the Rhymney Valley. The water level in the shaft at Britannia indicates the driving head for the discharge; this is approximately 34m above the level of the adits.

## 7.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

Recent data suggest that the iron concentration in the discharge has stabilized at about 6 to 8mg/l. For the purpose of estimating the total iron load, an average concentration of 6mg/l was used. The discharge has a neutral pH and shows an elevated alkalinity which suggests the flow passes through a calcareous zone prior to discharge. Sulphate concentrations are elevated, at 600 to 700mg/l. The discharge water quality conditions are very similar to those observed at Site 6. This would suggest that the iron concentration is controlled by equilibrium chemistry, prior to discharge. The elevated concentration of sulphate would suggest that ongoing oxidation is probably occurring elsewhere within the catchment of the discharge. It is considered that the sources for iron release comprise flooded as well as unflooded underground mine workings.

The flows and discharge adits have been monitored regularly by the NRA. The present flows are 15 to 20Ml/day. The total load of iron released annually from the site is estimated at about 45.3 tonnes, and the corresponding sulphate load at about 5000 tonnes. Based on this assessment and observed downstream water quality data, a reduction in the total iron loading would be required to meet the 1.0mg/l criterion.

The aluminium loading for this site is estimated at about 0.5 tonnes per year. Discharge and receiving water concentrations are below 1mg/l.

## 7.5 ENVIRONMENTAL COSTS AND BENEFITS

The ferruginous springs emerged at Tir-y-Berth in February 1991 following cessation of pumping at Britannia Mine in 1990. The electrofishery survey indicates that populations of fish downstream of the springs were about half the numbers upstream.

| | July 1991 | Winter 1992-93 |
|---|---|---|
| Upstream | 1.7 | 4.7 |
| Downstream | 0.9 | 3.3 |

**Table 7.1 Trout Density per 100m$^2$**

The Royal Oak Angling Club has fishing rights in the river from the springs to Ystrad Mynach.

Lower down the river, the Maesycymmer Angling Club and Llanbradach Angling Club did not suffer any biological impact but they did suffer loss of amenity due to iron deposition.

The river, in general, is recovering from past pollution and salmon and sea trout populations had been gradually improving year by year. The 1.5km downstream of the springs is unlikely to provide suitable conditions for spawning migratory fish. Therefore, part of the potential for recovery has been lost for all anglers in the river system.

Impact scores

| | | |
|---|---|---|
| Fisheries value | 5 | 50% loss of fish stocks |
| Accessibility - footpaths | 5 | Path within 10m |
| Accessibility - roads | 3 | Road within 100m |
| Visual impact downstream | 4 | Banks wooded, litter present |
| Proximity to built up area | 2 | Factories/industrial areas 100-300m |
| Proximity to recreation area | 1 | Any recreation area >500m |

Site specific details: There is rubbish in trees along banks and in stream bed. The pollution is not likely to be seen by casual visitors to the area. The site is opposite a scrap yard. The high ranking means that the site would benefit from remediation in terms of fisheries and aesthetic impacts.

## 7.6 OPTIONS FOR REMEDIATION AND COSTS

The total iron loading observed at this site is considerable. Consequently, source control should take precedence. However, it is perceived that technically, implementation of source control options would be difficult.

Flooding of the mine workings which remain above the water table will not be feasible as the host rock appears to be relatively permeable, as indicated by the spread of the associated discharges. It may be possible to reduce oxygen entry by closing off openings to surface.

The effectiveness of such an option is considered to be low as it is unlikely that all possible openings would be identified and closed off.

Hydraulic balancing, in the context of lowering the water table to below the current elevation of discharge in order to achieve a controlled single point outlet, may be possible. In addition, identification, and interception of the primary recharge water sources should be investigated. It may be possible that a large proportion of the discharge may be drawn directly from the 'clean' recharge water source, thus reducing the flow through the mine workings and consequently the loading.

Sulphate reduction may be considered for implementation within the flooded workings. It will be necessary to establish the hydrology or flow within the underground mine workings. Such a system will be most effective if the flow passes directly through the anoxic reducing zone and if an inorganic substrate can be provided upstream from this zone. This would require introducing an organic substrata which could be sewage sludge, through boreholes into the syncline area of the workings.

The discharge water quality currently shows a high alkalinity content and thus there is no need for a anoxic limestone trench. However, the high iron loading would require a relatively large surface area for a wetland system to be effective. Land is at a premium within the immediate vicinity of the discharge and it may be necessary to intercept and reroute the discharge to a more suitable location.

The greatest impact to the river is anticipated to be during the low flow season. Because of the dilution available in the River Rhymney during high flow periods, it may be possible that a smaller, less effective, wetland system may provide sufficient iron removal during the low flow period of the year to allow continuous discharge. Under the same terms of reference, a small water treatment plant operated for only part of the year might be considered.

The nearby Britannia Shaft could be considered as a sludge disposal facility in the long term.

Civil works at the Tir-y-Berth site will be necessary to collect the diffuse discharges whatever treatment option is considered. The scale of these will vary according to the option but costs are likely to be in the order of £30,000.

The most appropriate options or combination of options for remediation are as follows:

**Hydraulic Balancing**

A horizontal borehole from the side of the River Rhymney into the Britannia Shaft at 10-15m below the level of the shaft cap is required. This will reduce the driving head on the existing discharges and therefore reduce flows by approximately 50%. The iron concentrate is not expected to be reduced significantly. The balance of the discharge from the shaft intersection may be at a reduced iron concentration as it is closer to the original inflow and will not have passed through the Mynyddislywn workings. The total loading to the system should be slightly reduced. The existing discharge would show a reduced load due primarily to the reduced flows making diffusion of the flow a more feasible option.

**Capital Costs**

| | |
|---|---|
| Horizontal borehole 100 m | £40,000 |
| Headworks, pipe and diffuser | £20,000 |
| Civil works at Tir-y-Berth | £30,000 |
| Diffuser | £15,000 |
| Test pumping from shaft to test intersection | £25,000 |
| | £130,000 |

**Operating Costs**

| | |
|---|---|
| 2 man days/yr @ £250 | £500 |
| Maintenance/depreciation @ 10% of capital costs | £13,000 |
| | £13,500 |

**Sulphate Reduction**

**Capital**

| | |
|---|---|
| 4 x boreholes to Mynyddislwyn Seam x 75 m x 250 mm @ £9,000 | £ 36,000 |
| 4 x headworks | £ 20,000 |
| Civil works at Tir-y-Berth | £ 30,000 |
| Substrate feed system | £ 40,000 |
| | £126,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| £2,000/t for iron removed (20 t) | £ 40,000 |
| Depreciation/maintenance 10% of capital | £ 12,600 |
| | £ 52,600 |

**Wetlands**

Adits at Tir-y-Berth must be sealed to exclude oxygen and collect the discharge water before it becomes oxygenated and the hydroxide precipitates.

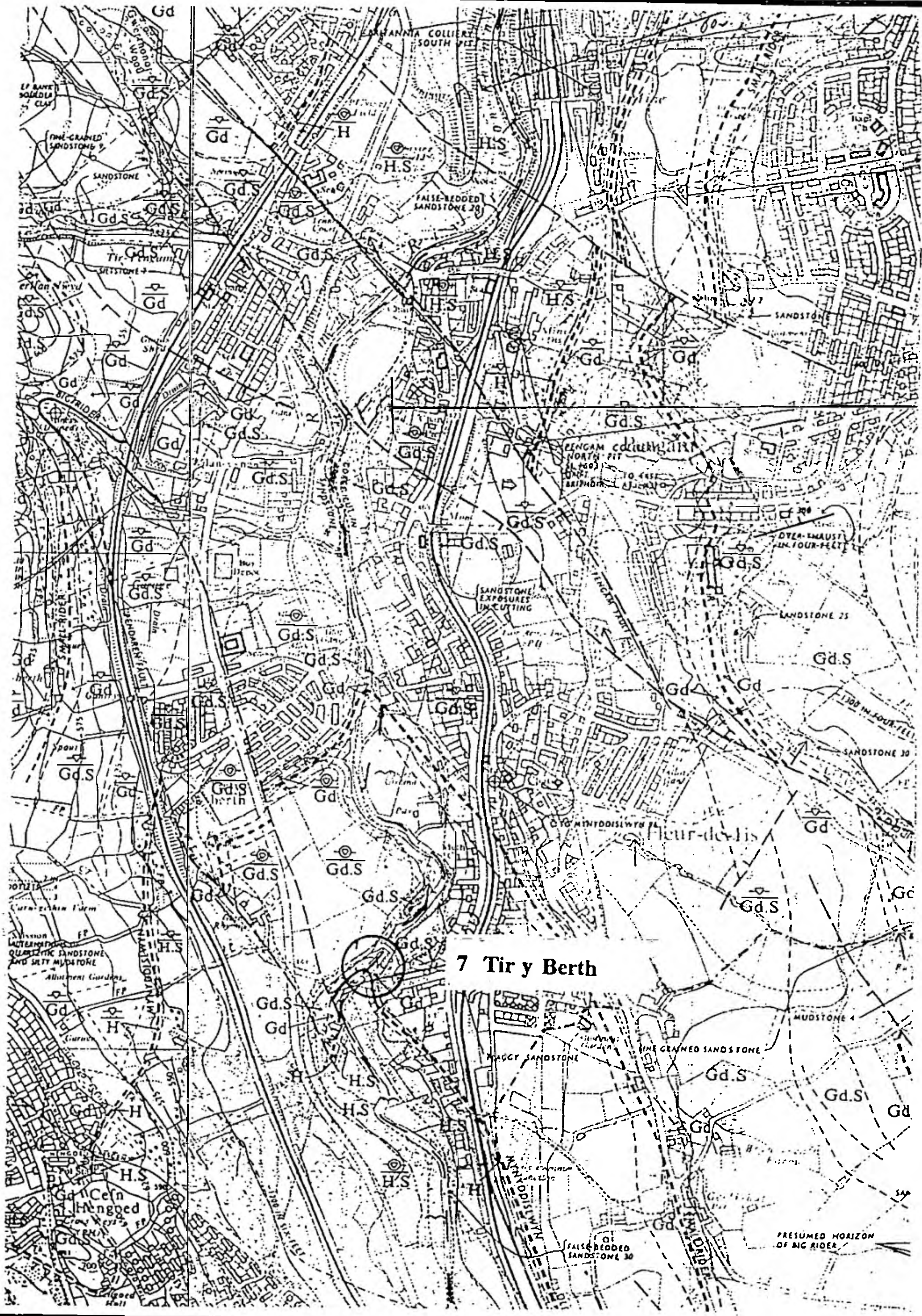
**Capital Costs**

| | |
|---|---|
| Sealing adits at Tir-y-Berth | £ 50,000 |
| Civil works to collect discharges | £ 30,000 |
| Pipeline to wetland areas - possibly 2kms @ 500mm diameter | £400,000 |
| Wetland approx 1Ha (includes land purchase price) | £250,000 |
| | £730,000 |

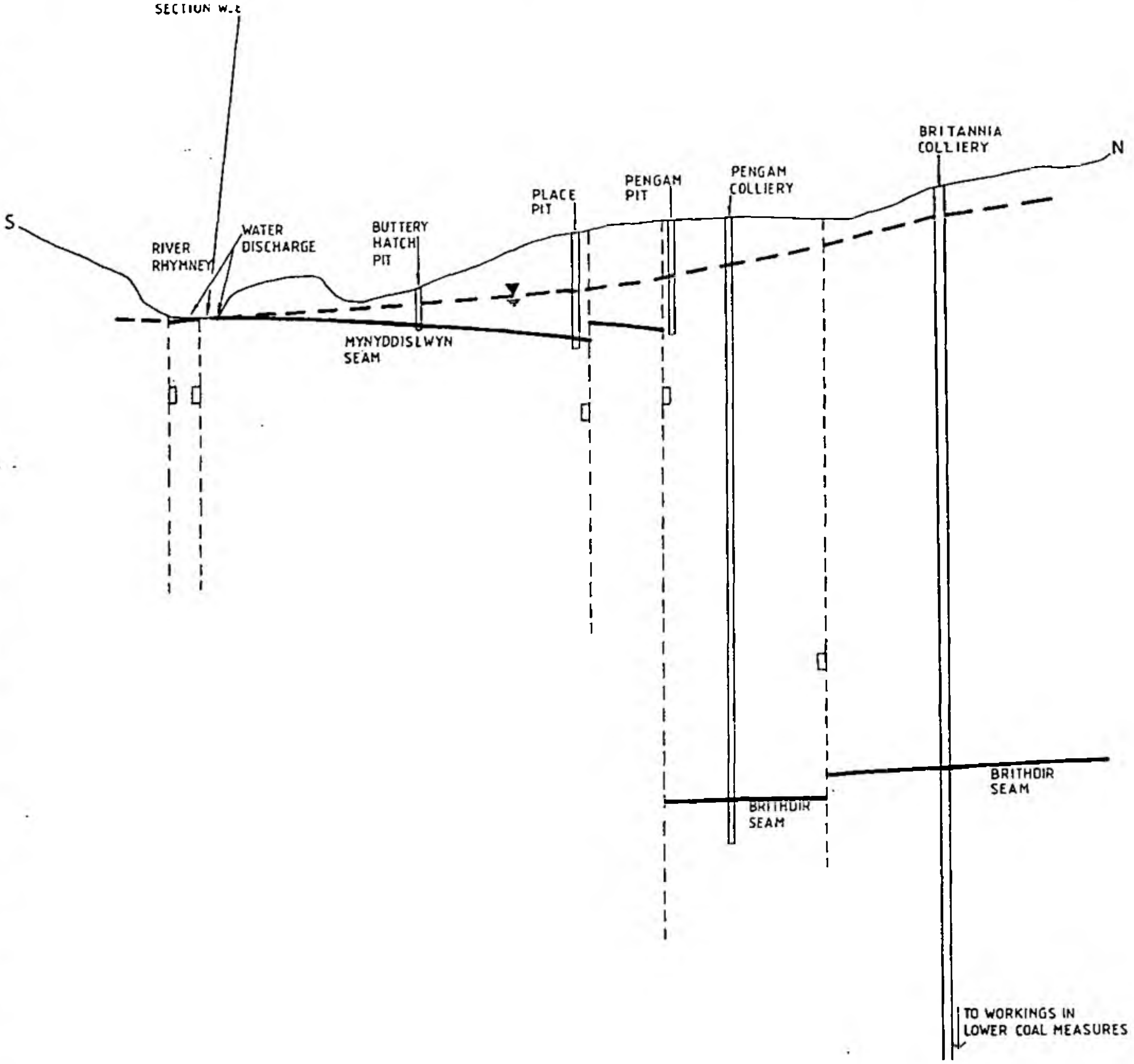
**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation/maintenance 10% of capital | £ 73,000 |
| 6 man days/year @ £250 | £1,500 |
| | £74,500 |

Sulphate reduction would have the highest risk and least impact due to the uncertainty of placing, loading and water flow paths. The highest chance of success would be a wetland but hydraulic balancing would also be significant and should be assessed as a priority.



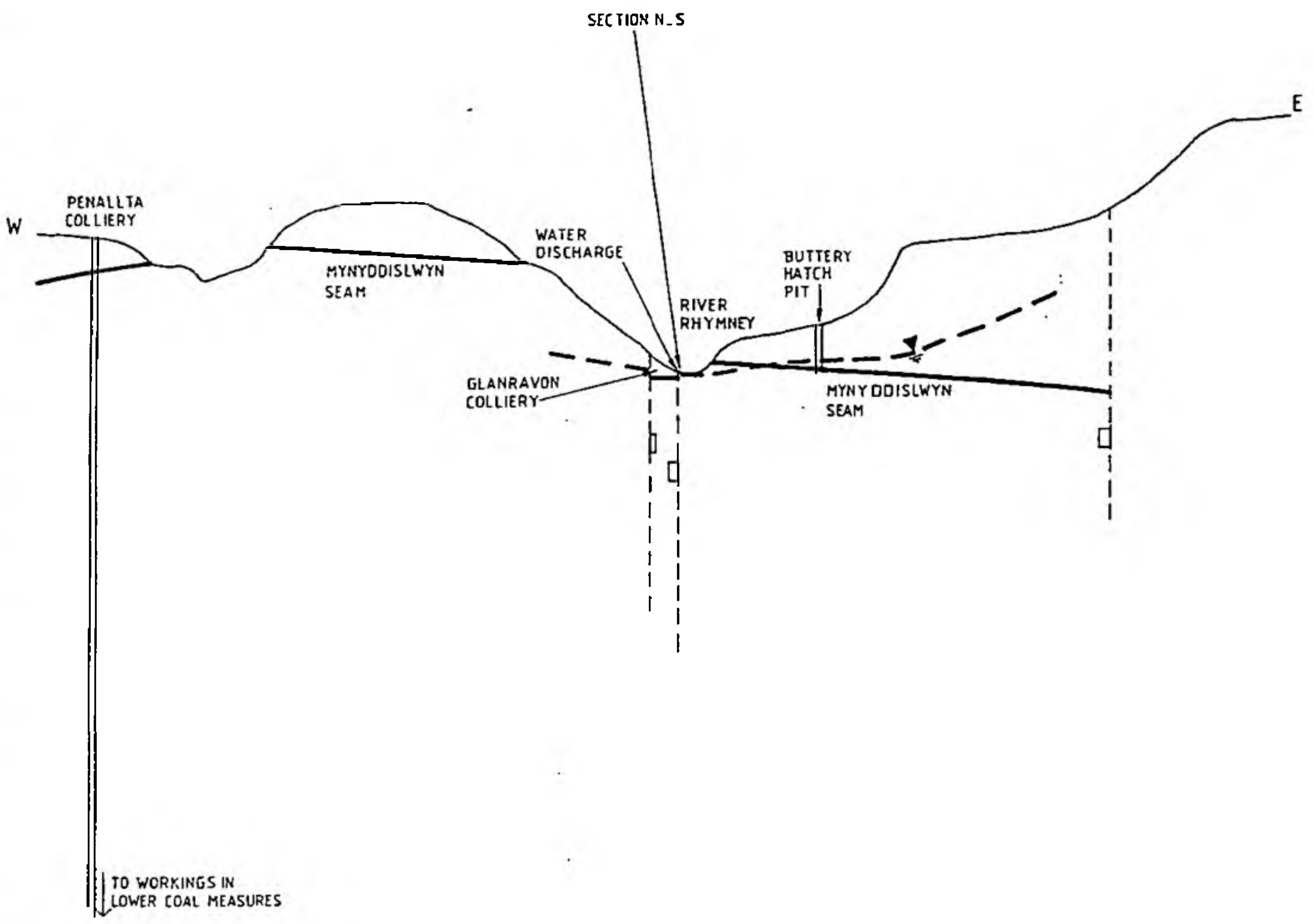

| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure |
|---|---|---|---|
| SRK | | SITE 7: TIR Y BERTH | 7.1 |




SCHEMATIC SECTION SOUTH_NORTH

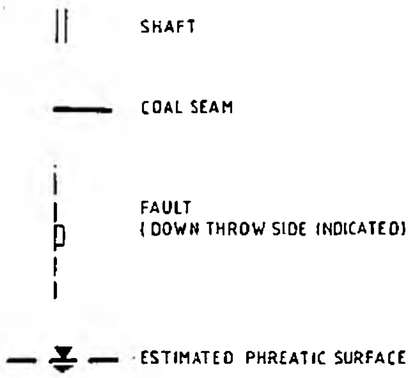
KEY


| DATE: 13/04/94 | PROJ. No: U489 | NRA/SRK ACID ROCK DRAINAGE | Figure 7.1b |
|---|---|---|---|
| SRK | | SITE 7: TIR Y BERTH | |




SCHEMATIC SECTION WEST_EAST

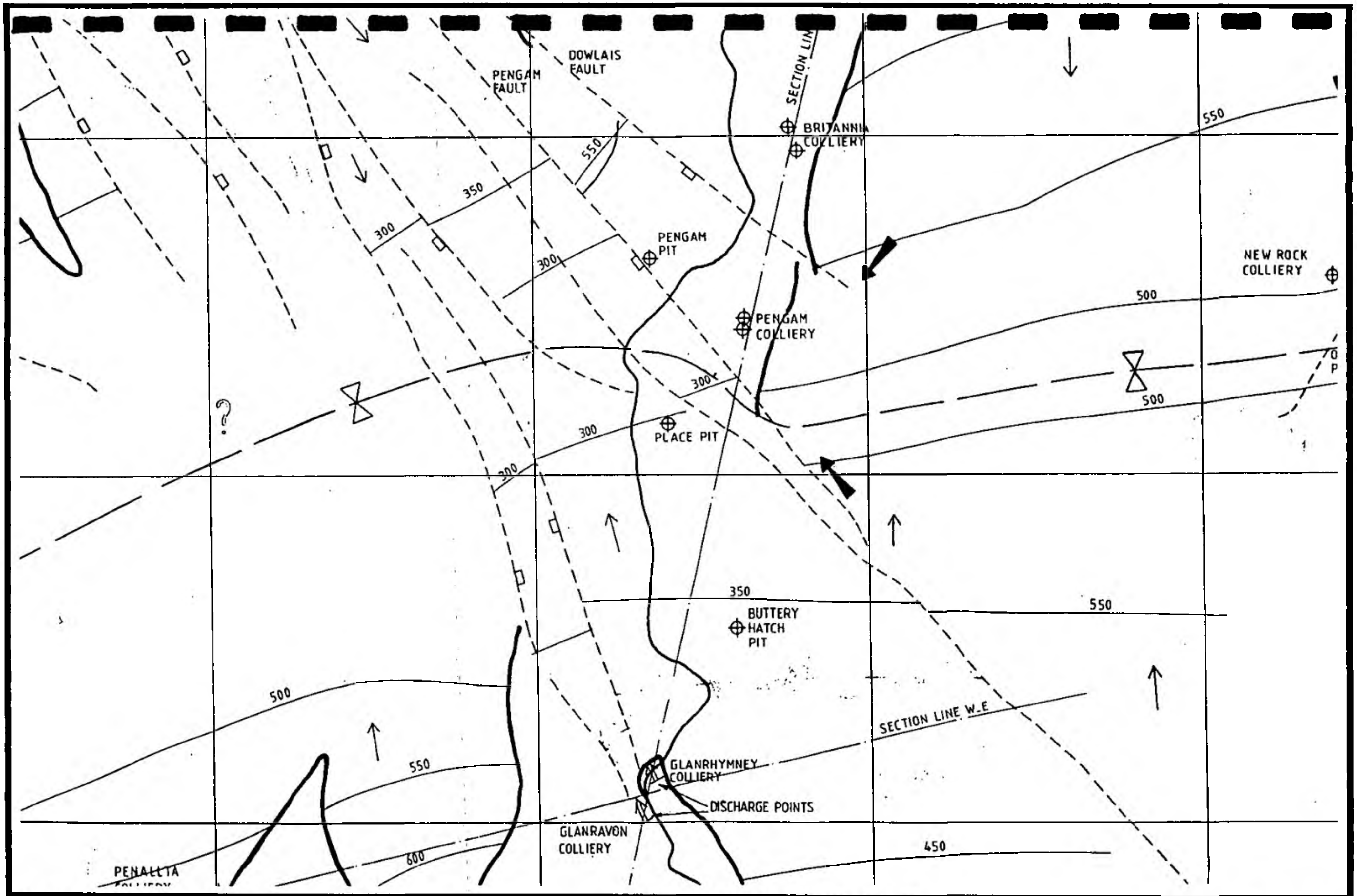
KEY




| DATE: 13/04/94 | PROJ. No: U489 | NRA/SRK ACID ROCK DRAINAGE | Figure 7.1c |
|---|---|---|---|
| SRK | | SITE 7: TIR Y BERTH | |

DISCHARGE FROM COLLAPSED ADIT ENTRANCE

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure |
|---|---|---|---|
| SRK | | SITE 7: RHYMNEY/ TIR-YR-BERTH | 7.1 D |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 7.1e |
|---|---|---|---|
| SRK | | SITE 7: TIR Y BERTH | |

# Site 7, Section 4. Discharge Water Quality and Load Assessment.

Flows Measured at Cefn Hengoed

Site #. 7
Site : Rhymney at Fleur-de-lis

Receiving water

Site #. 7
Site : Rhymney at Fleur-de-lis
Discharge

| Estimated Distr. (%) | | Discharge (m3/s) | U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l) | SO4 (mg/l) U/S | SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Calculated Receiving | Fe(T) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | Jul | 0.214 | 0.359 | 562 | 942 | 0.373 | | | | | | | 6.1 | 2.28 | | 3.424 | 65.5 | 0.065 | 11.3 | 0.1 | 0.033 | 665 | 373 |
| Aug | Aug | 0.209 | 0.762 | 548 | 2001 | 0.215 | | | | | | | 6.1 | 1.31 | | 3.344 | 64.0 | 0.064 | 11.5 | 0.1 | 0.032 | 665 | 365 |
| Sep | Sep | 0.205 | 0.895 | 538 | 2351 | 0.186 | 7.5 | 120 | 98 | 294 | 7.1 | 220 | 6.6 | 1.23 | 3.900 | 3.550 | 67.9 | 0.068 | 11.8 | 0.004 | 0.002 | 450 | 242 |
| Oct | Oct | 0.227 | 1.295 | 597 | 3402 | 0.149 | | | | | | | 6.1 | 0.91 | | 3.640 | 69.6 | 0.070 | 10.6 | 0.1 | 0.035 | 665 | 397 |
| Nov | Nov | 0.256 | 3.920 | 673 | 10296 | 0.061 | | | | | | | 6.1 | 0.37 | | 4.106 | 78.6 | 0.079 | 9.4 | 0.1 | 0.039 | 665 | 448 |
| Dec | Dec | 0.242 | 2.474 | 636 | 6498 | 0.089 | | | | | | | 6.1 | 0.54 | | 3.880 | 74.2 | 0.074 | 9.9 | 0.1 | 0.037 | 665 | 423 |
| Jan | Jan | 0.369 | 1.928 | 969 | 5065 | 0.161 | | | | | | | 6.1 | 0.98 | | 5.906 | .113.0 | 0.113 | 6.5 | 0.1 | 0.057 | 665 | 644 |
| Feb | Feb | 0.283 | 1.383 | 744 | 3631 | 0.170 | | | | | | | 6.1 | 1.04 | | 4.538 | 86.8 | 0.087 | 8.5 | 0.1 | 0.043 | 665 | 495 |
| Mar | Mar | 0.225 | 0.440 | 591 | 1157 | 0.338 | 7.9 | 115 | 141.5 | 284 | 7.1 | 218 | 8.3 | 2.81 | 2.600 | 4.907 | 93.9 | 0.094 | 10.7 | 0.111 | 0.066 | 808 | 478 |
| Apr | Apr | 0.219 | 2.416 | 576 | 6345 | 0.083 | | | | | | | 6.1 | 0.51 | | 3.513 | 67.2 | 0.067 | 11.0 | 0.1 | 0.034 | 665 | 383 |
| May | May | 0.150 | 0.706 | 393 | 1854 | 0.175 | | | | | | | 6.1 | 1.07 | | 2.394 | 45.8 | 0.046 | 16.1 | 0.1 | 0.023 | 665 | 261 |
| Jun | Jun | 0.234 | 0.702 | 615 | 1844 | 0.250 | 7.0 | 112 | 117 | 256 | 7.0 | 222 | 3.4 | 0.85 | 1.270 | 2.084 | 39.9 | 0.040 | 10.3 | 0.06 | 0.037 | 736 | 453 |
| | mean | 0.236 | 1.440 | 7443 | 45387 | 0.188 | | 116 | | | | 220 | 6.1 | 1.157 | | 45.3 | 866.4 | 0.866 | 10.6 | 0.1 | 0.437 | 665 | 4960.2 |
| | min. | 0.150 | 0.359 | | | 0.061 | | | | | | | | 0.374 | | | | | 6.5 | | | | |
| | max. | 0.369 | 3.920 | | | 0.373 | | | | | | | | 2.807 | | | | | 16.1 | | | | |

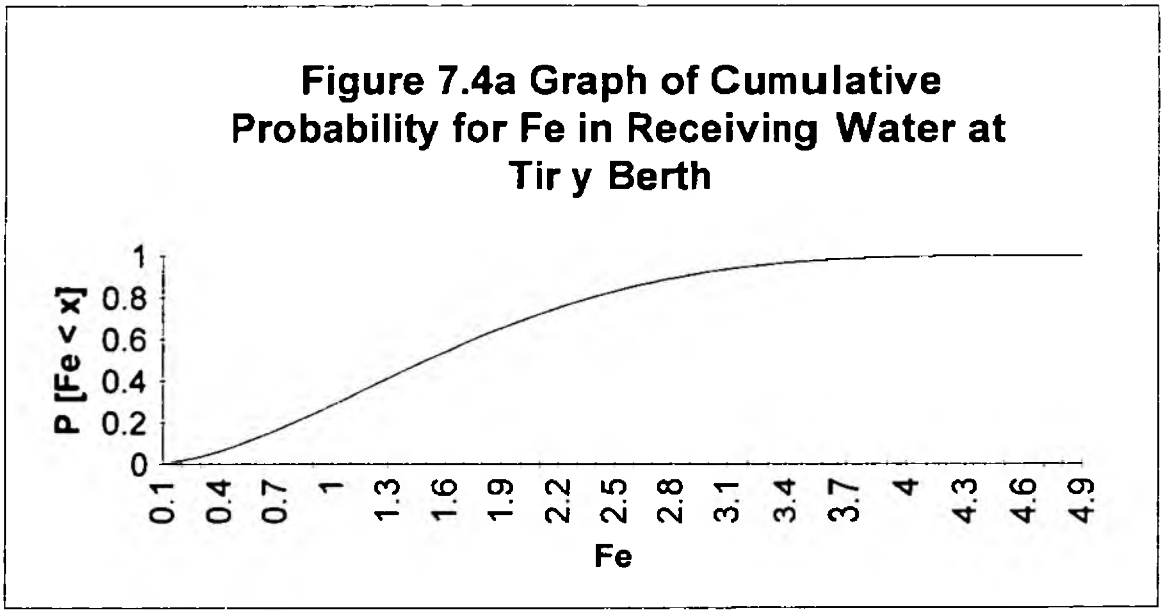


Figure 7.4a Graph of Cumulative Probability for Fe in Receiving Water at Tir y Berth
P [Fe < x]
1
0.8
0.6
0.4
0.2
0
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9
Fe

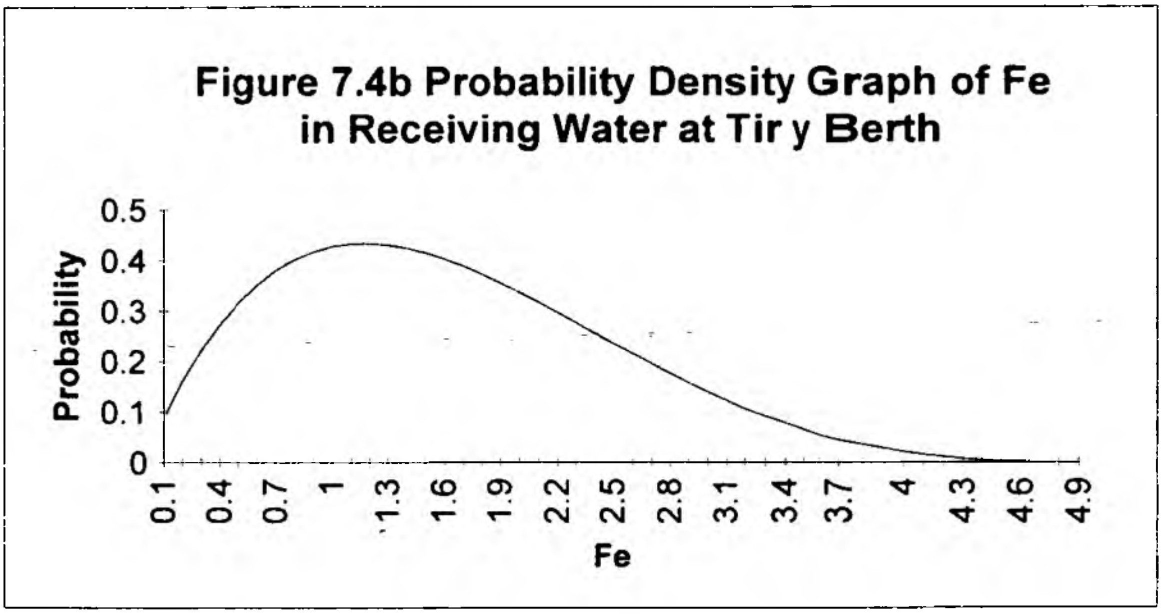



Figure 7.4b Probability Density Graph of Fe in Receiving Water at Tir y Berth
Probability
0.5
0.4
0.3
0.2
0.1
0
0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4 4.3 4.6 4.9
Fe

4

4

## Site 10 - BLAENAVON

### 10.1 GEOLOGY AND MINING

Mine water is discharged from mine workings near to Blaenavon, Gwent via an adit named River Arch, which also serves as an emergency escape route from the Big Pit Mining Museum. Flow from the discharge combines with a minor run-off flow approximately 30m downstream from where the adit daylights and with the culverted River Lwyd a further 400m downstream.

The coal seams of the Middle and Lower Coal Measures outcrop in the area around the discharge, seams above the Meadow vein being above the discharge, seams between the Meadow and the Garw being below. Above and below the Garw are several ironstone beds. The geology is shown on Fig 10.1.

The strata dips to the south east at between 5° and 8°, though there are local variations. The regional structure is dominated by two sub-parallel faults about 1.2km apart, striking just west of north. The Blaenavon fault is the more westerly and has a throw of between 45m and 60m whereas the Carreg Maen Taro fault has a throw of 12m. Between these is a down-thrown block known as the Blaenavon Trough.

Exploitation of both coals and ironstones in the area has been extensive. Many of the coal outcrop workings in the area date from the late 18th and early 19th Century. Virtually all mineable coal near outcrop has been extracted apart from that left for support. Unfortunately, no plans are known for many of these workings.

The latter half of the 19th Century and the 20th Century saw the introduction of larger scale and more systematic mining to the dip. Eventually, most of the accessible resources of coal were depleted and the mines closed. The last deep mine in the area to close was the Big Pit at Blaenavon, which was finally abandoned in 1980. This mine has now been converted into a tourist attraction, utilising some of the shallow workings and the shafts.

A few underground licensed mines survive in the area, the Blaentillery Drift, which works the Brithdir Seam above and to the west of Blaenavon and the Johnson and Winstone Mines working the Big Vein to the south of Big Pit.

Since 1940, many of the coal pillars in the outcropping areas have been worked by opencast methods, some areas more than once. The recent refusal of planning permission for the Pwll Du scheme would seem to bring to an end large scale opencast mining in the area, though small schemes such as the current Kays and Kears Site will presumably continue to be permitted as part of land reclamation schemes.

The planning applications for these schemes have included in-depth investigations into the hydrogeological aspects of the area, with particular regard to water flow paths. This information has been reviewed and interpreted for the present project.

## 10.2 CONTAMINATION SOURCES

Elsewhere in the coalfield, the seams of the Middle and Lower Coal Measures are known to be low in sulphur (generally <1%), however at Blaenavon the content is somewhat greater. The proposed Pwll Du opencast (situated to the north of the discharge) was stated to contain coal with an average sulphur content of 1.68% with some seams in excess of 2%.

There are three probable sources of contamination at the site:

- the area of opencast workings and shallow workings to the north which is free draining to the elevation of the River Arch and so the process of oxidation will be continuing in unflooded workings;
- oxidation will also be taking place in the Big Pit workings which remain unflooded. Drainage channels flowing within the mine can be seen to contain ferruginous material and the pyrite can be easily seen in the exposed coal faces.
- In addition, there will be substantial accumulations of ferruginous materials within the flooded workings which will be available for flushing out or dissolution.

## 10.3 HYDROGEOLOGICAL MODEL

In the 18th and 19th Century it was usual to develop long drainage tunnels to enable as much water as possible to be decanted by gravity from the mineworkings.

The Blaenavon area is served by two major systems, the Golynos Watercourse (which discharges at Big Arch, several miles to the south near Abersychan) and the Blaenavon Watercourse (which discharges at River Arch).

The lower (and larger) of the two is the Golynos Watercourse. Substantial quantities of water have been discharging at Big Arch since 1974, when the deeper workings at Blaenavon were abandoned and pumping ceased. The Golynos watercourse has been developed in both coal and ironstone seams, though much of the route is through old workings in the Old Coal and Garw Seams. The watercourse is thought to drain a large area of workings above an elevation of 262.1m. The exact route of the watercourse is not known and much of the route is inaccessible. Below this elevation, the workings are certain to be flooded.

Some associated workings are not linked at this lowest elevation and a substantial area is flooded to an elevation of 280.1m. Overflow from this area decants to the Golynos Watercourse.

The River Arch system discharges at an elevation of 323m. This discharge is the combination of two watercourses, Woods Level draining from the north of the Afon Lwyd and Forge Level draining from the south. Each of these two levels is stated to discharge between 2.5 and 3.5Ml/day. Prior to cessation of pumping at Big Pit, pumped discharge water also entered the Afon Lwyd via River Arch. Reclamation work in the area has resulted in the excavation of a bypass culvert further to the south for the Afon Lwyd, so the water discharging at River Arch is now believed to be only mine water.

Woods Level drains a large area to the north and west. It is linked via Cinder Pits and Kears Slope to the Blaenavon Watercourse on the Threequarters Seam which drains Milfraen, Garn Slope, Kays Slope and Garn Pits on the west side of the Blaenavon Fault. The recently started Kays and Kears Opencast Mine is in this area.

A collection trench has been constructed around the site and settlement ponds installed prior to discharge to the Afon Lwyd. It is anticipated that infiltration may increase through the base of the opencast area during working and additional pyrite oxidation may occur. The impact of this operation on the flow and quality of the discharge has not been investigated.

The source of the water flowing to Forge Level and thence to River Arch is from the Threequarters seam and from surface filtration directly through Forge Pit. This water is thought to mainly come from workings to the east and north on the Threequarters Seam up to outcrop.

In summary, the water discharged at River Arch has come from extensive workings in the Threequarters Seam and above, to the west, north and east of the discharge. These workings are continuous to outcrop with many entrances and have been extensively opencast mined. Proper plans of many of these workings do not exist.

Hydrologically, the River Arch and Big Arch are draining ground water which has attempted to recover to pre-mining levels. The numerous mine workings will intercept downward flowing recharge water as well as receive upward flowing ground water.

## 10.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge water is at a neutral pH but does not indicate an alkalinity that would suggest equilibrium with a carbonate based neutralizing agent. The iron concentration is low (less than 2.0mg/l) but historic data indicate intermittent events of high concentration. These events may be related to activities within the Big Pit Mine during which accumulated iron hydroxide sludges are disturbed, resulting in the flushing of suspended precipitates and contained pore waters.

Because the mine workings are partially flooded, it is considered that the source for contaminant release is continued oxidation within the aerated zones and dissolution of stored oxidation products. The oxidising conditions that exist within the unflooded section of the mine are likely to be contributing to the precipitation and accumulation of a large proportion of the iron within the mine workings. Other sources that are contributing to the total load include the opencast workings upstream of the discharge point.

Based on an average iron concentration of 1.6mg/l, it is estimated that a total iron loading of about 4 tonnes and a sulphate loading of 253 tonnes are associated with the discharge. The aluminium concentration is low and accounts for a loading of about 350kg per year.

## 10.5 ENVIRONMENTAL COSTS AND BENEFITS

The Afon Lwyd is a small stream at the top of the catchment Lower down, the river is fished by Cwmbran Anglers and Pontypool Anglers. It is a brown trout fishery with some potential for improving salmon and sea trout runs. The ferruginous impact is small in area ($500m^2$) and it has been small impact on trout spawning.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 1 | No or very small impact on angling or spawning |
| Accessibility - footpaths | 3 | Path within 100m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 2 | Small stream, litter present |
| Proximity to built up area | 2 | Houses and factories within 100m |
| Proximity to recreation area | 1 | Recreation area > 500m |

Site specific details: Not likely to be seen by casual visitors to area, although Big Pit Mining Museum close by brings in many visitors. The new opencast operation at Kays and Kears visually dominates the area. The relics of industrial development are generally unreclaimed and there remains much derelict land.

The low scores indicate a small benefit to fisheries and aesthetics should remediation go ahead.

## 10.6 OPTIONS FOR REMEDIATION AND COSTS

The primary constraint on the abatement of this discharge is the Big Pit Mining Museum. Oxygen exclusion options can be implemented only at the cost of the museum. Abatement options are therefore limited to diversion and treatment.

It is considered likely that there is significant direct recharge to the underground through the shallow and outcrop workings and the many access points. Due to the large area of these workings and the absence of records of many of the openings, it is considered impractical to locate and block all of the entry points.

As discussed previously, it is considered that iron is released through active oxidation and the dissolution of stored oxidation products from the flooded portion of the underground workings. Whilst some underground access is possible, any re-routing of the flows may require extensive rehabilitation and excavation works. The effectiveness of re-routing water flows would depend on the availability of alternative, uncontaminated routes through the mine workings to the point of discharge. The source would then be limited to active oxidation only. Alternatively, the flows may be redirected to flow through the flooded section and a sulphate reduction system could be implemented. While this could provide a highly effective removal of iron, the associated hydrogen sulphide would pose a safety hazard to the Big Pit Museum.

The discharge is relatively low in iron, and installation of an ALD is not warranted. It is considered that there is sufficient space immediately downstream from the discharge to construct a retention pond for the removal of iron to a level acceptable for discharge. When necessary, sludge disposal within the underground mine could be considered.

Surface diversions are unlikely to be effective due to the large areas involved and creating underground mined diversions would be problematic due to the complex nature of the workings. Hydraulic balancing may be utilised to reduce or eliminate the discharge from River Arch by creating a connection between the 2 main levels draining the mines, thereby increasing the amount of water discharging at Big Arch (Golynos). This would involve drilling a borehole of ±150m to connect the two watercourse systems. Water from the Woods Level would be diverted to the Golynos Watercourse so the relative water qualities of the two streams and the effect of removing these on subsequent water qualities downstream from River Arch and at Golynos would need to be carefully investigated.

The large area of complex workings and the low iron concentration mean that the effectiveness of any non end-of-pipe solution may be limited. The best options are the borehole diversion and the wetland.

**Capital Costs**

| | |
|---|---|
| Boreholes between 2 levels, 150m for investigation and implementation | £ 28,000 |

**Operating/Maintenance Costs**

Nil

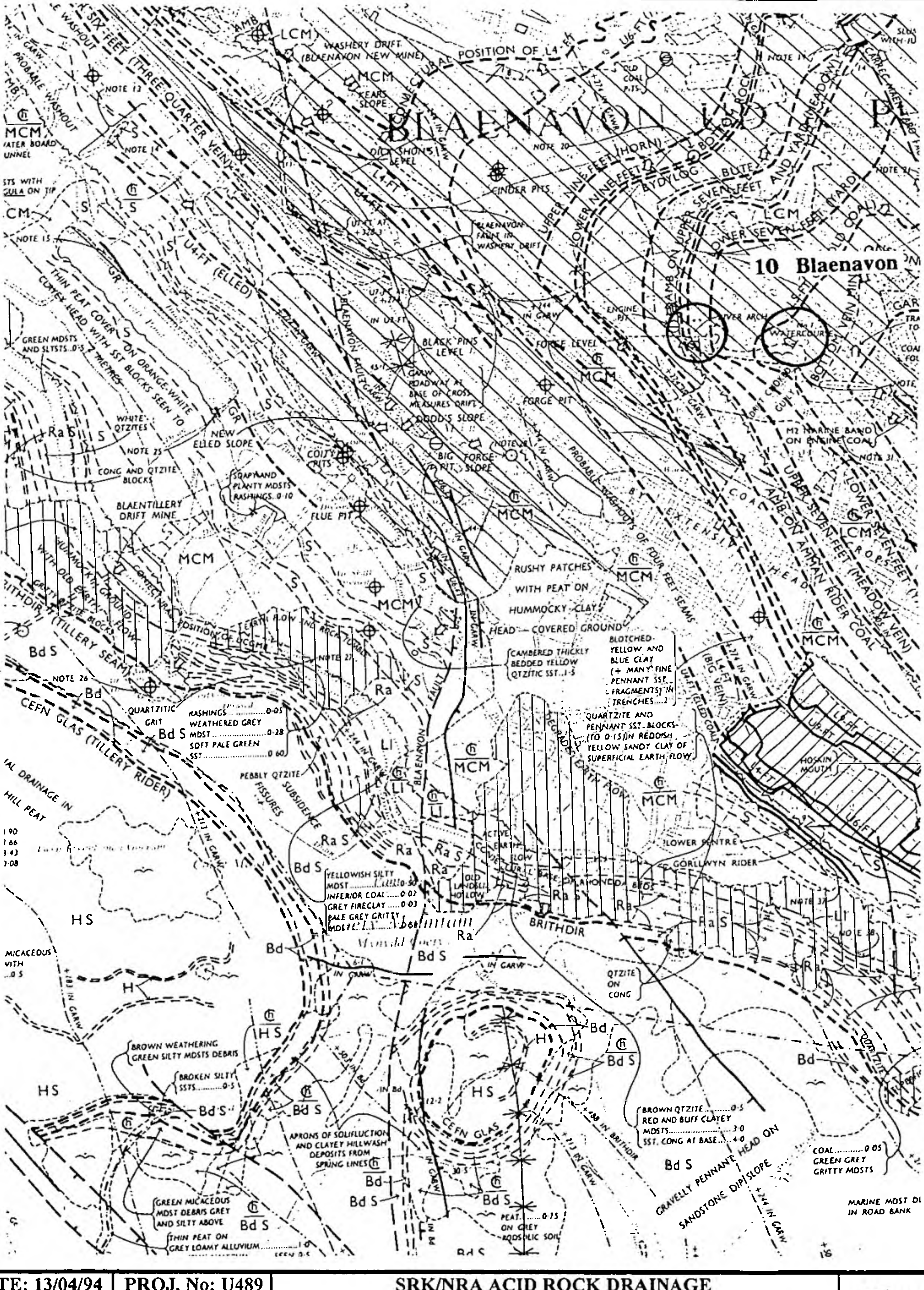
The most straightforward remedial measure remains a settlement lagoon/wetland with sludge removal at long intervals (say 10 years).

**Capital Cost**

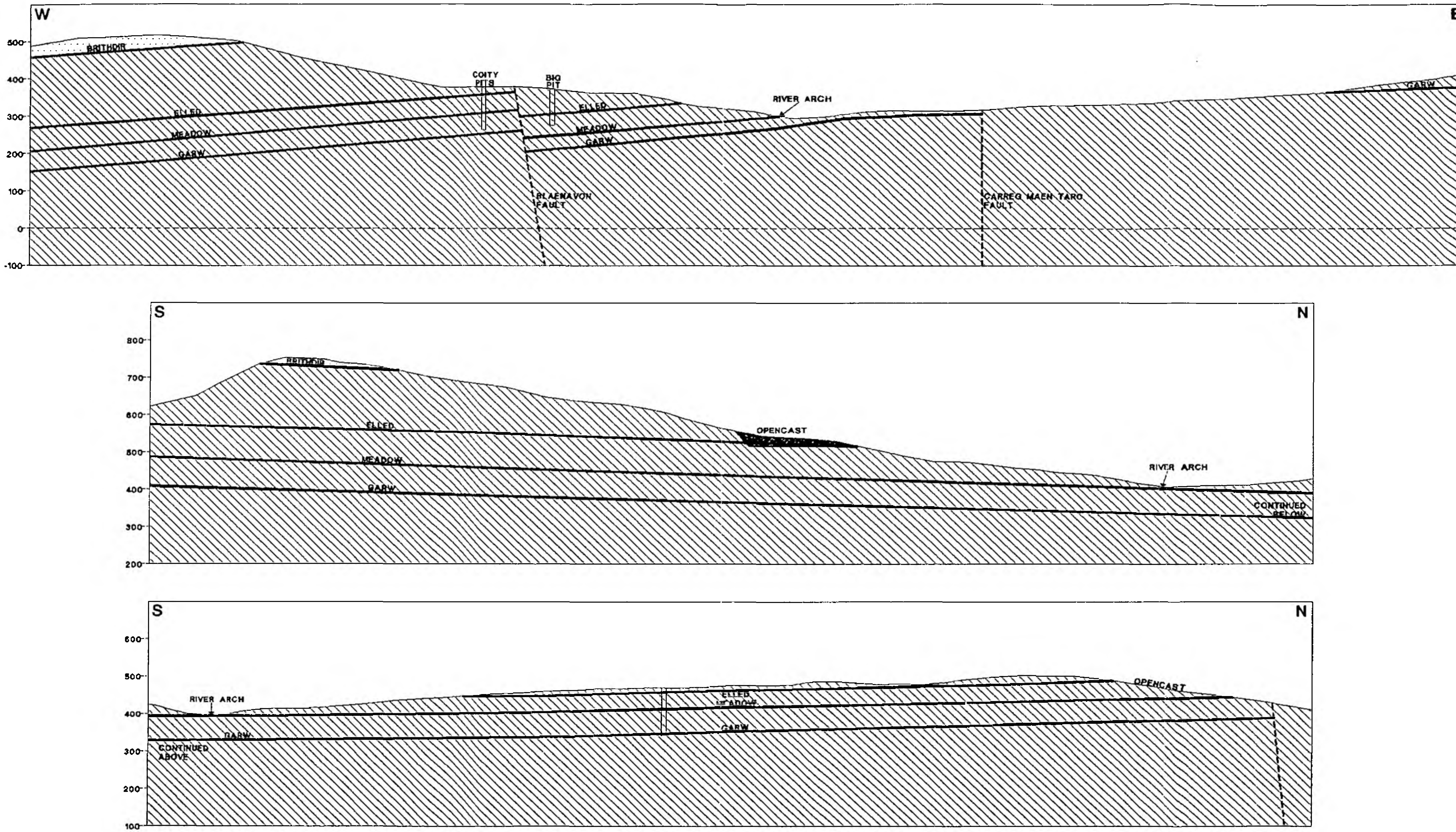
| | |
|---|---|
| Wetland of 0.2Ha | £150,000 |

**Operating/Maintenance**

| | |
|---|---|
| 6 Mandays/Year @ £250 | £1,500 |
| Depreciation/maintenance 10% of capital cost | £ 10,000 |
| | £11,500 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 10.1 |
|---|---|---|---|
| SRK | | SITE 10: BLAENAVON | |




BRITHDIR BEDS
RHONDDA/LLYNFI BEDS, MIDDLE & LOWER COAL MEASURES

| DATE: 15/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS<br>SRK (UK) Ltd., Summit House, 9/10 Windsor Place, Cardiff, CF1 3BX, U.K. | | SITE 10: BLAENAVON<br>W-E & N-S SECTIONS | Figure 10.1 |

DISCHARGE IMMEDIATELY DOWNSTREAM OF RIVER ARCH

DISCHARGE FROM RIVER ARCH

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | **SITE 10: BLAENAVON** | Figure 10.1 D |

DISCHARGE +-50m
DOWNSTREAM OF DISCHARGE

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 10: BLAENAVON | Figure 10.1 D |

# Site 10, Section 4. Discharge Water Quality and Load Assessment.

| | River Distr. (%) | Disch Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.8 |
| Oct | 8.9 | 7.7 |
| Nov | 15.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 5.8 | 7.7 |
| May | 4.7 | 6.5 |
| Jun | 5.0 | 7.9 |

Site #: 10
Site : Big Pit - unnamed tributary

| | Synthesized Discharge (m3/s) | U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water: pH | Receiving water: Alkalinity (mg CaCO3/l | Receiving water: SO4 (mg/l) U/S | Receiving water: SO4 (mg/l) D/S |
|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.070 | 0.069 | 184 | 182 | 0.503 | | | | |
| Aug | 0.084 | 0.067 | 169 | 175 | 0.491 | | | | |
| Sep | 0.070 | 0.059 | 185 | 154 | 0.545 | 7.1 | 38.5 | 37.1 | 90.2 |
| Oct | 0.072 | 0.129 | 190 | 339 | 0.359 | | | | |
| Nov | 0.084 | 0.217 | 222 | 569 | 0.280 | 7.1 | 24.18 | 47 | 44 |
| Dec | 0.090 | 0.238 | 237 | 626 | 0.275 | | | | |
| Jan | 0.104 | 0.193 | 273 | 507 | 0.350 | | | | |
| Feb | 0.100 | 0.150 | 263 | 393 | 0.400 | | | | |
| Mar | 0.074 | 0.099 | 194 | 259 | 0.428 | | | | |
| Apr | 0.072 | 0.083 | 189 | 218 | 0.464 | | | | |
| May | 0.061 | 0.067 | 159 | 177 | 0.473 | | | | |
| Jun | 0.074 | 0.072 | 193 | 189 | 0.506 | 7.1 | 37.1 | 26.6 | 107 |
| mean | 0.078 | 0.120 | 2457 | 3790 | 0.423 | | 33.3 | | |
| min. | 0.061 | 0.059 | | | 0.275 | | | | |
| max. | 0.104 | 0.238 | | | 0.545 | | | | |

Site #: 10
Site : Big Pit - unnamed tributary

| | Discharge: pH | Discharge: Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Calculated Receiving | Fe(T) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | | | 1.6 | 0.82 | | 0.301 | 5.8 | 0.006 | 3.0 | 0.1 | 0.026 | 103 | 18.946 |
| Aug | | | 1.6 | 0.80 | | 0.276 | 5.3 | 0.005 | 3.3 | 0.1 | 0.024 | 103 | 17.371 |
| Sep | 7.2 | 108 | 1.0 | 0.56 | 0.341 | 0.188 | 3.6 | 0.004 | 3.0 | 0.075 | 0.014 | 92 | 18.995 |
| Oct | | | 1.6 | 0.59 | | 0.311 | 5.9 | 0.006 | 2.9 | 0.1 | 0.027 | 103 | 19.539 |
| Nov | 7.3 | 67 | 0.9 | 0.26 | 0.441 | 0.209 | 4.0 | 0.004 | 2.5 | 0.149 | 0.033 | 110 | 24.382 |
| Dec | | | 1.6 | 0.45 | | 0.388 | 7.4 | 0.007 | 2.4 | 0.1 | 0.034 | 103 | 24.409 |
| Jan | | | 1.6 | 0.57 | | 0.447 | 8.5 | 0.009 | 2.1 | 0.1 | 0.039 | 103 | 28.106 |
| Feb | | | 1.6 | 0.68 | | 0.430 | 8.2 | 0.008 | 2.1 | 0.1 | 0.037 | 103 | 27.054 |
| Mar | | | 1.6 | 0.70 | | 0.318 | 6.1 | 0.006 | 2.9 | 0.1 | 0.028 | 103 | 20.032 |
| Apr | | | 1.6 | 0.76 | | 0.309 | 5.9 | 0.006 | 3.0 | 0.1 | 0.027 | 103 | 19.472 |
| May | | | 1.6 | 0.78 | | 0.280 | 5.0 | 0.005 | 3.5 | 0.1 | 0.023 | 103 | 16.390 |
| Jun | 7.3 | 111 | 3.0 | 1.49 | 0.980 | 0.571 | 10.9 | 0.011 | 2.9 | 0.203 | 0.039 | 107 | 20.695 |
| mean | | 95.3 | 1.6 | 0.703 | | 4.008 | 76.7 | 0.077 | 2.804 | 0.1 | 0.351 | 103.0 | 253.4 |
| min. | | | | 0.264 | | | | | 2.050 | | | | |
| max. | | | | 1.492 | | | | | 3.516 | | | | |

Figure 10.4a Graph of Cumulative Probability for Fe in Receiving Water at Blaenavon

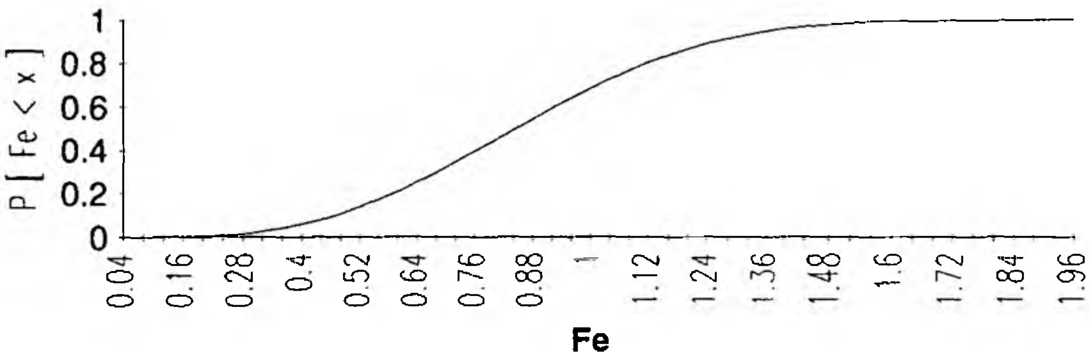
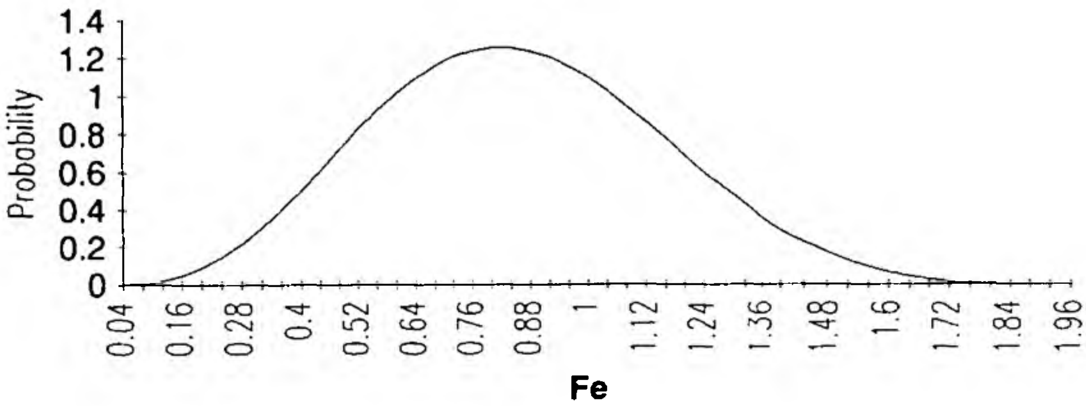



Figure 10.4b Probability Density Graph of Fe in Receiving Water at Blaenavon



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# SITE 12 - Y FFRWD (LLANWONNO)

## 12.1 GEOLOGY AND MINING

The site is located within a forested area on the banks of the Y Ffrwd, a tributary of the River Clydach within the catchment of the Taff. The discharge comprises a series of seeps or springs marked by ferruginous deposits. A small stretch (approximately 100m) of the upper reaches of the stream is relatively unaffected; the proportions and impact of the ferruginous seeps increase progressively downstream. Significant ferruginous deposits containing reddish coloured crystalline precipitates were observed along the flowpath. The reddish coloration is a sign of iron hydroxide weathering to a more stable iron oxide, suggesting ferruginous discharges have been occurring for some time.

The only coal seam recorded in the immediate area is the Brithdir Rider which has its conjectured outcrop to the east (and down slope) from the beginning of the discharge. There is no record of shallow mine workings in the area, however afforestation may have masked any traces of old mining which may have been present. A stone wall running through the wood very near to the discharges suggests some type of settlement or activity in antiquity during which time any easily available coal may have been exploited. Reference to old air photos (pre afforestation) and old maps may reveal more evidence of workings.

Geologically, there are no other sources for the discharge - the Llanwonno Fault which has a displacement eastward of 190m is situated 150m to the east of the site and workings from Mynachdy Colliery in the Darren Ddu Seam do not cross westward beyond the fault. To the west of the fault, there are no workings except at great depth some distance from the fault at National Colliery, which worked the Middle and Lower Coal Measures (shafts in Tylerstown in the Rhondda Fach).

## 12.2 CONTAMINATION SOURCES

It is conjectured that very old unrecorded outcrop workings are the source of the discharge, or alternatively oxidation of the outcrop. Old outcrop workings would be more likely to be the cause of the discharges, as tunnelling into the seam may have encouraged a 'spring' to develop a short distance above the river where the groundwater level is intersected. Continuing oxidation due to exposure of the pyrite to air and the flow of oxygenated water through the disturbed ground would be sufficient to maintain the discharge as it now is. It would appear that the discharge has been occurring for many years.

## 12.3 HYDROGEOLOGICAL MODEL

Active recharge and infiltration is thought to be the source of the water discharging into the Y Ffrwd.

The lack of known or obvious workings suggests there is no deep-seated movement of ground water. The various sites are at the head of the valley and in an area of springs forming the source of the river. It is assumed that the sources are spring seepages on a lithological change (presumably) coal, which may have been worked at outcrop at some time. They are part of the natural water balance and can be expected to flow indefinitely.

## 12.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge is at a slightly acidic pH; this however may be due in part to the release of organic acids from the surrounding forested area. As a consequence, the discharge has a relatively low alkalinity. The total iron concentration in the Y Ffrwd before its confluence with the Clydach is approximately 2mg/l. Considering the apparent impact on the stream, the sulphate concentration is relatively low at about 35mg/l. This would support the contention that natural, ongoing oxidation is the prevailing mechanism for contaminant release. It is likely that, if extensive mine workings were present, a significantly higher sulphate concentration would be observed.

The estimated total annual iron loading is estimated to be in the order of 1.6 tonnes, with a sulphate loading of about 26 tonnes. Based on this initial assessment, it is anticipated that the total iron concentration in the Clydach, downstream from the mixing zone, could meet the criterion of 1.0mg/l.

## 12.5 ENVIRONMENTAL COSTS AND BENEFITS

The discharge is at the top of a tributary in forestry and it is of no angling value. The lowest part of the Nant Clydach is probably fished by members of the Pontypridd and District Angling Club. The Y Ffrwd tributary is a trout spawning stream but as electrofishing showed a high population downstream of the discharge, there is no fishery impact.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 1 | No impact on spawning |
| Accessibility - footpaths | 3 | Path within 100 m |
| Accessibility - roads | 1 | Road within 1 km |
| Visual impact downstream | 4 | Discoloration affects stream badly |
| Proximity to built up area | 1 | Houses > 300 m |
| Proximity to recreation area | 1 | Recreation area > 500 m |

Site specific details: Not likely to be seen by casual visitors to area. The site is in an area of afforestation with tracks used by walkers and horse and bike riders, which is generally a 'country' area so the discharge is more unexpected and could create a greater impact.

The low scores indicate a small benefit from remediation.

## 12.6 OPTIONS FOR REMEDIATION AND COSTS

Since no evidence of mining activities at this site was found, source control options do not apply. Covers to reduce oxygen entry are not practical since the area is forested. The iron concentration in the discharge prior to its confluence with the River Clydach is about 2mg/l. It is estimated that the available dilution in the Clydach would halve this concentration.

Controlled discharge may therefore present a feasible alternative to collect and treat. To achieve a controlled, diffuse discharge, it may be necessary to pond the discharge to provide the necessary hydraulic head prior to release.

Since the stream has a relatively rapid flow, construction of such a pond could provide an adequate settling basin to negate the need for a diffuse discharge mechanism.

The wetland approach would be difficult to implement as the site is located in an area of steeply sloping ground.

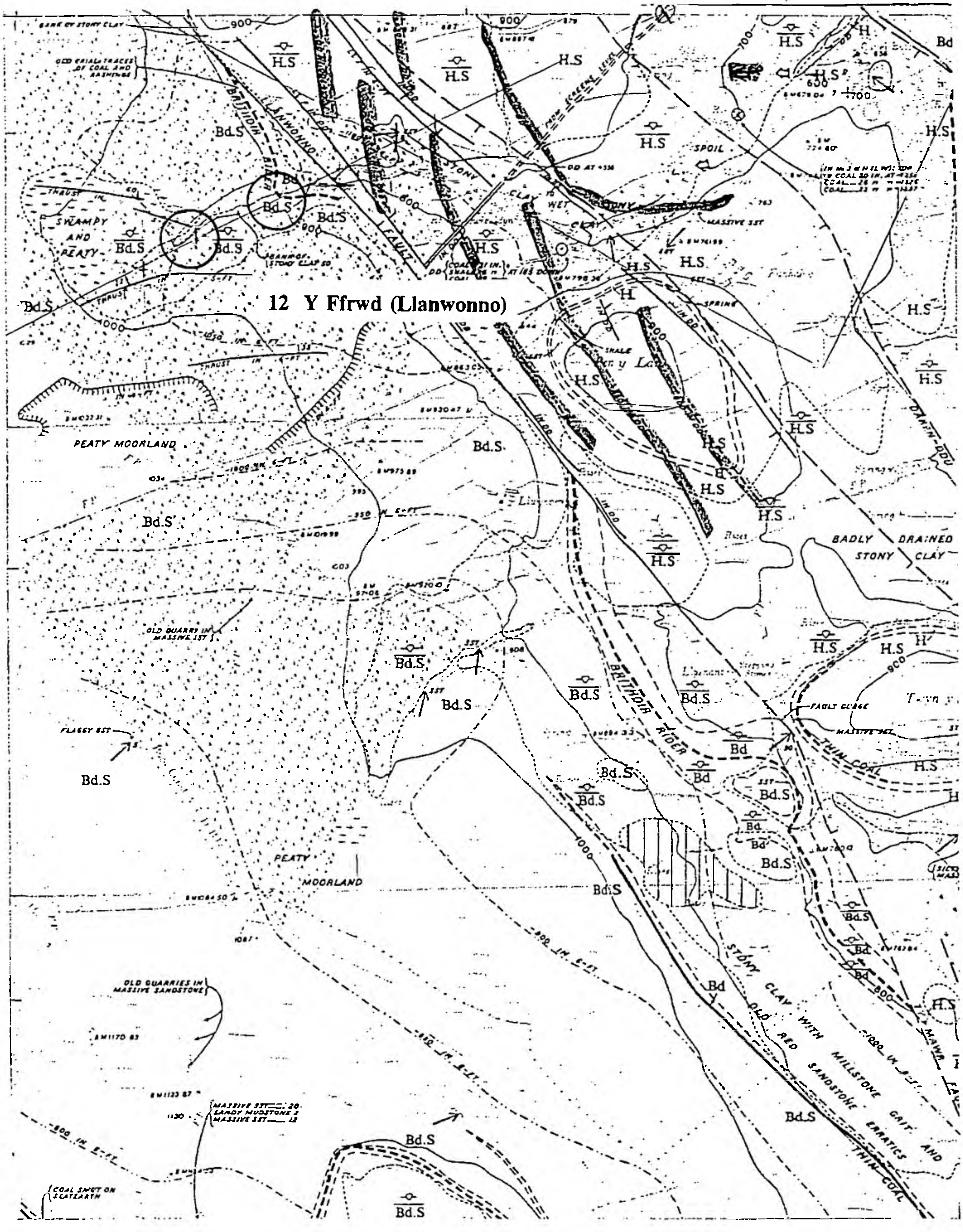
Construction of a dam and controlled discharge would entail the following costs:

**Capital Costs**

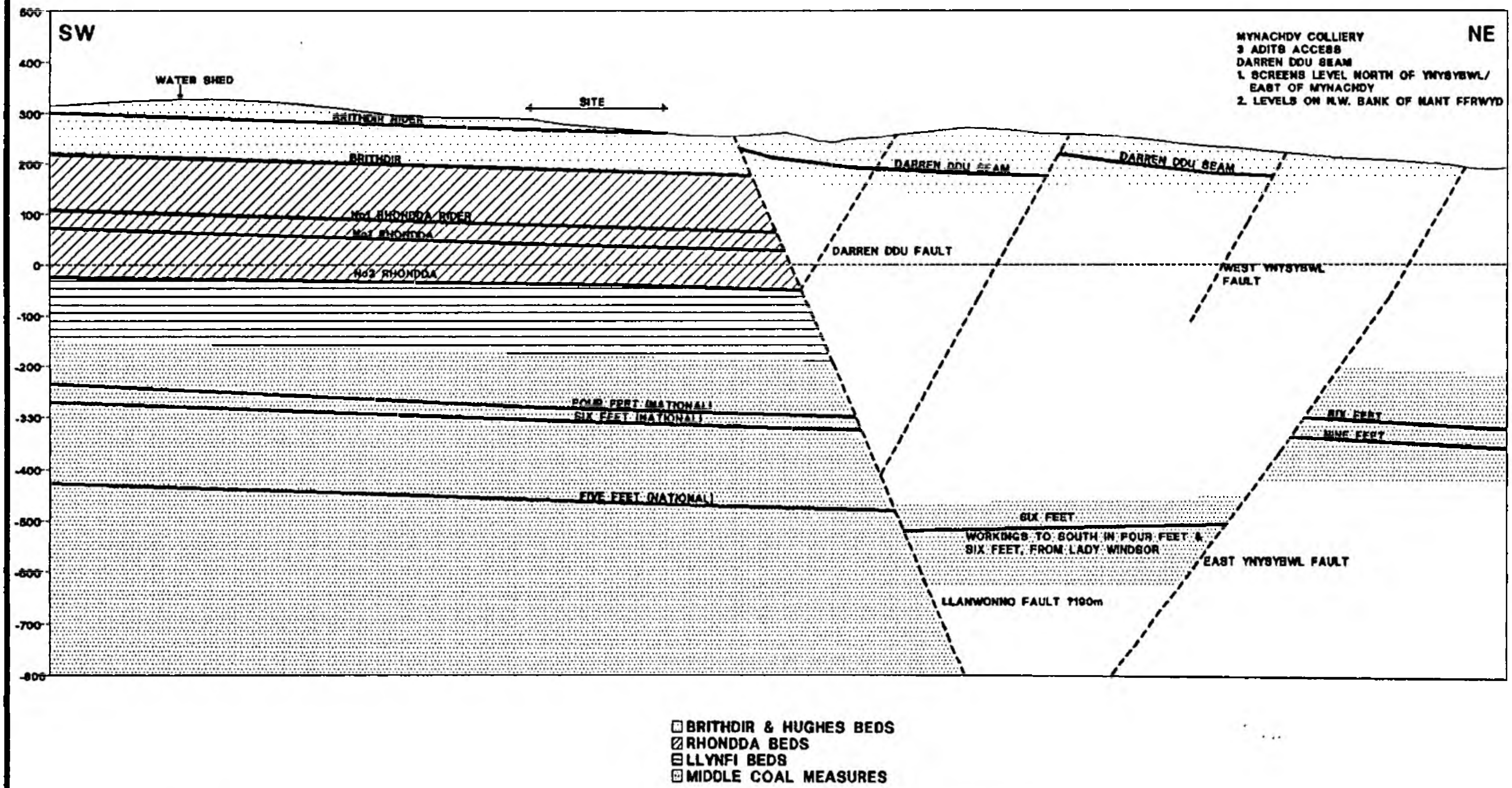
| | |
|---|---|
| Dam and spill way construction and associated works<br>(Does not include land purchase) | £ 25,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| 6 Mandays/Year @ £250 | £1,500 |
| Maintenance @ 10% of capital cost | £2,500 |
| | £4,000 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 12.1 |
|---|---|---|---|
| SRK | | SITE 12: Y FFRWD (LLANWONNO) | |




| DATE: 5/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN CONSULTING ENGINEERS | | SITE 12: LLANWONNO SW-NE SECTION | Figure 12.1b |

DISCHARGES IN AFFORESTED AREA

STAINING FROM UPSTREAM SOURCES.
DISCHARGE JOINING STREAM FROM LEFT

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure |
|---|---|---|---|
| SRK | | SITE 12: LLANWONNO | 12.1 D |

# Site 12, Section 4. Discharge Water Quality and Load Assessment.

Flows Measured at Cefn Hengoed

| | River Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.5 |
| Oct | 8.9 | 7.7 |
| Nov | 15.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 5.8 | 7.7 |
| May | 4.7 | 6.5 |
| Jun | 5.0 | 7.9 |

Site #: 12
Site : Clydach Taff / Llan Wonno

| | Synthesized Discharge (m3/s) | Clydach U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l) | SO4 (mg/l) U/S | SO4 (mg/l) D/S |
|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.022 | 0.031 | 57 | 83 | 0.408 | | | | |
| Aug | 0.020 | 0.030 | 52 | 79 | 0.397 | | | | |
| Sep | 0.022 | 0.027 | 57 | 70 | 0.450 | 7.1 | 9.38 | 16 | 23.7 |
| Oct | 0.022 | 0.059 | 59 | 154 | 0.278 | | | | |
| Nov | 0.026 | 0.098 | 69 | 258 | 0.210 | | | | |
| Dec | 0.028 | 0.108 | 73 | 284 | 0.205 | | | | |
| Jan | 0.032 | 0.088 | 85 | 230 | 0.269 | | | | |
| Feb | 0.031 | 0.068 | 81 | 179 | 0.313 | 7.8 | 3.92 | 14.8 | 23.8 |
| Mar | 0.023 | 0.045 | 60 | 118 | 0.339 | | | | |
| Apr | 0.022 | 0.038 | 59 | 99 | 0.372 | | | | |
| May | 0.019 | 0.031 | 49 | 80 | 0.380 | | | | |
| Jun | 0.023 | 0.033 | 60 | 86 | 0.411 | 7.7 | 7.7 | 14.5 | 23.7 |
| mean | 0.024 | 0.055 | 762 | 1720 | 0.336 | | 7.0 | | |
| min. | 0.019 | 0.027 | | | 0.205 | | | | |
| max. | 0.032 | 0.108 | | | 0.450 | | | | |

Site #: 12
Site : Clydach Taff / Llan Wonno

| | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Calculated Receiving | Fe(T) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | | | 2.1 | 0.87 | | 0.121 | 2.3 | 0.002 | 4.0 | 0.04 | 0.002 | 34.3 | 1.96 |
| Aug | | | 2.1 | 0.84 | | 0.111 | 2.1 | 0.002 | 4.3 | 0.08 | 0.002 | 34.3 | 1.79 |
| Sep | 6.2 | 38.8 | 2.3 | 1.03 | 0.840 | 0.132 | 2.5 | 0.003 | 3.9 | 0.051 | 0.003 | 38.8 | 2.22 |
| Oct | | | 2.1 | 0.59 | | 0.125 | 2.4 | 0.002 | 3.8 | 0.04 | 0.002 | 34.3 | 2.02 |
| Nov | | | 2.1 | 0.45 | | 0.146 | 2.8 | 0.003 | 3.3 | 0.04 | 0.003 | 34.3 | 2.36 |
| Dec | | | 2.1 | 0.44 | | 0.156 | 3.0 | 0.003 | 3.1 | 0.04 | 0.003 | 34.3 | 2.52 |
| Jan | | | 2.1 | 0.57 | | 0.180 | 3.4 | 0.003 | 2.7 | 0.04 | 0.003 | 34.3 | 2.90 |
| Feb | 6.2 | 32.69 | 2.0 | 0.64 | 1.080 | 0.166 | 3.2 | 0.003 | 2.8 | 0.056 | 0.005 | 26.6 | 2.17 |
| Mar | | | 2.1 | 0.72 | | 0.128 | 2.4 | 0.002 | 3.7 | 0.04 | 0.002 | 34.3 | 2.07 |
| Apr | | | 2.1 | 0.79 | | 0.124 | 2.4 | 0.002 | 3.8 | 0.04 | 0.002 | 34.3 | 2.01 |
| May | | | 2.1 | 0.81 | | 0.105 | 2.0 | 0.002 | 4.6 | 0.04 | 0.002 | 34.3 | 1.69 |
| Jun | 6.2 | 37 | 2.0 | 0.83 | 0.981 | 0.122 | 2.3 | 0.002 | 3.8 | 0.009 | 0.001 | 37.5 | 2.25 |
| mean | | 36.2 | 2.1 | 0.714 | | 1.6 | 30.9 | 0.031 | 3.645 | 0.04 | 0.030 | 34.3 | 25.95 |
| min. | | | | 0.436 | | | | | 2.665 | | | | |
| max. | | | | 1.035 | | | | | 4.570 | | | | |

**Figure 12.4a Graph of Cumulative Probability for Fe in Receiving Water at Y Ffrwd (Llanwonno)**

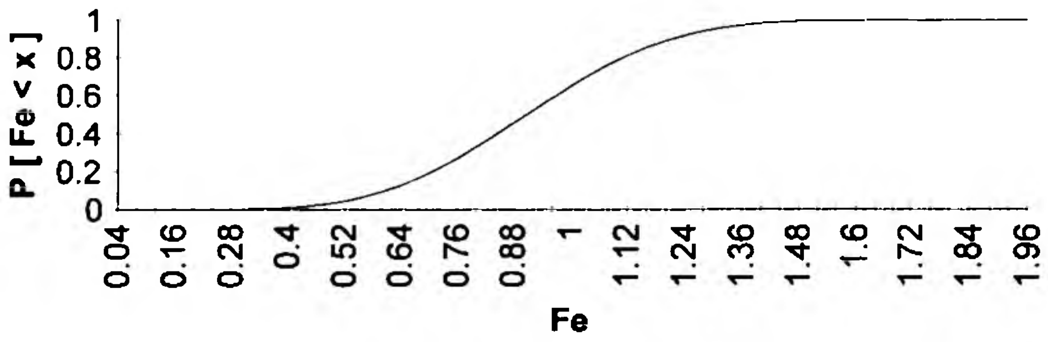
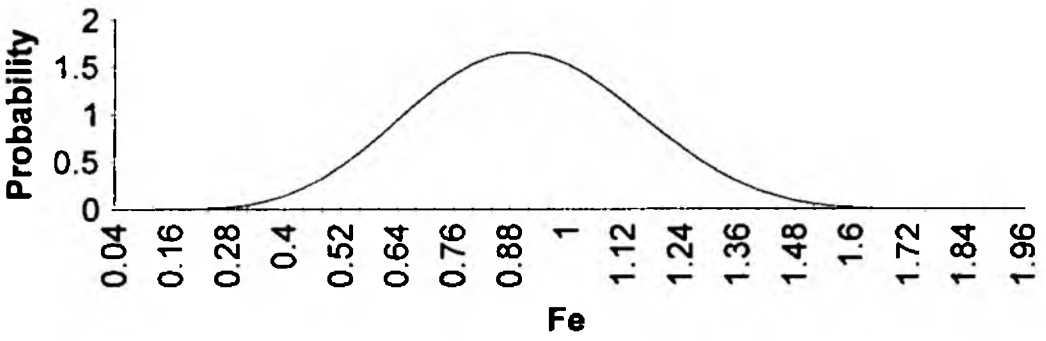



**Figure12.4b Probability Density Graph of Fe in Receiving Water at Y Ffrwd (Llanwonno)**



6

6

## SITE 15 - LLYNFI

### 15.1 GEOLOGY AND MINING

Mine water discharge is observed to be coming from two disused mine adits. The arch of the upstream adit is still apparent, but the second adit has collapsed. A third discharge is observed from a hole in the ground, apparently a result of mining, which is reported to have a depth of about 5m. There is also said to be an open shaft in an adjacent field. Mining records also report the presence of an old opencast operation up-slope from the adits. Downstream from the site, at the roadside, an additional ferruginous discharge was observed. The iron appears to be removed from this last flow by natural processes before it enters the main flow of the river.

The geology of the area mainly consists of sandstones of the Upper Pennant Measures. The area contains one shallow workable coal, the Bettws Four Feet Seam, which outcrops in the immediate area. The strata dips gently to the south and is on the north side of the axis of the Bettws - Tonyrefail syncline. To the north of the site, but separated by a major fault, lies the outcrop and workings on the Bettws Nine Feet Seam.

The Bettws Navigation Colliery worked the Bettws Four Feet Seam adjoining the site. The discharges appear to be coming from the accesses to this mine. The workings were accessed from two adits at 80m and 82m AOD. The workings of this mine do not appear to have been extensive, but "old workings" are shown adjoining and to the north (up-dip) to outcrop. A separate set of workings are shown some 200m to the south, with an adit at 84m AOD and another entrance by air shaft (86m AOD and 6m deep). There are other abandoned shallow mine workings on this seam in the immediate area, not all of which have been recorded.

Opencast workings in the Betws Four Feet Seam took place between 1944-1947. Four small sites were worked and areas of old underground workings were intersected. In particular, the Bettws North Site may drain through to the discharge points.

## 15.2 CONTAMINATION SOURCES

Contamination sources are likely to be from old underground workings to the east and north of the discharge. The opencast site will have influenced the drainage in that any old workings to the east of that site will have to drain through the opencast to reach the workings of the Bettws Navigation Colliery and hence the discharge. The contamination is mainly from unflooded underground workings with active oxidation, but there is also likely to be some contribution from saturated workings and from backfilled material in the opencast.

## 15.3 HYDROGEOLOGICAL MODEL

The discharges are probably a result of active recharge to a near surface groundwater system, flowing down dip to the discharges. Water probably passes through the opencast site from the east side to the down-dip workings and the discharge. The geological sections in Fig 15.1b/c show the Bettws Four Feet Seam to be flat lying and the area draining to the discharges is small. The site shows a number of bell pits and collapses to shallow, unsaturated workings. Other seeps could be expected in the subcrop and outcrop areas to the south.

## 15.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The pH of the discharge is near neutral, however it has a relatively low alkalinity. The average iron concentration is estimated at about 8.8mg/l. The sulphate concentration is relatively low at about 70 to 100mg/l, considering the presence of old mine workings. Based on these characteristics, it is considered that the primary mechanism for the generation of soluble iron is active, ongoing oxidation and not the dissolution of stored oxidation products. As shown in the photographs, an opening exists between the water level and the top of the archway which allows the ingress of oxygen into the mine workings. There are also likely to be other openings in the area. It is conjectured that sufficient alkaline host rock is exposed along the recharge or discharge flow path to maintain near neutral pH conditions.

It is estimated that the total iron loading generated by the site is in the order of 1.4 tonnes per year and the sulphate loading approximately 12 tonnes per year. Based on the calculated downstream iron concentration, a reduction in the iron loading would be required to meet the in stream criterion of 1.0mg/l.

It is estimated that less than 50kg of aluminium is generated annually and is not considered to be of concern.

## 15.5 ENVIRONMENTAL COSTS AND BENEFITS

The stream is too small for any angling interest. The tributary would be of moderate value for brown trout spawning. The River Llynfi has considerable scope for improvement for salmon and sea trout and a re-stocking programme is in progress by the NRA.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 2 | Possible impact on spawning |
| Accessibility - footpaths | 4 | Path within 50m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 3 | Discoloration on bed |
| Proximity to built up area | 1 | Houses >300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: There is no public access apart from a footpath through the farm yard adjacent to the discharges. The land is obviously disturbed by ancient mining including bell pits. Old woodland exists around several of the discharges and the area is obviously tended and grazed rather than 'natural'. The opencast area has been well restored.

The relatively low scores indicates a small benefit from remediation.

## 15.6 OPTIONS FOR REMEDIATION AND COSTS

Because of the number of discharges associated with the site and the relatively low iron loading, it is considered unlikely that installation of bulkheads for the purpose of flooding the underground workings would be practical or cost effective. The opencast area has been re-vegetated effectively and placement of a cover would not provide much additional benefit. Source control therefore could comprise limiting the entry of oxygen to the underground workings by installing plugs at the locations of the disused adits.

This however, could only achieve a small reduction in load at best.

Controlled or diffused discharge to the receiving waters is not considered to be a feasible option since insufficient dilution is available to achieve the 1.0 mg/l objective.

While the discharge characteristically has a low alkalinity, at the prevailing iron concentration an ALD is not considered necessary for a wetland system to be effective. It may be necessary to install a collection ditch or wall to intercept the flows and route them to an appropriate treatment facility. Given the relatively low loading, partial treatment or treatment of part of the flow could be considered.

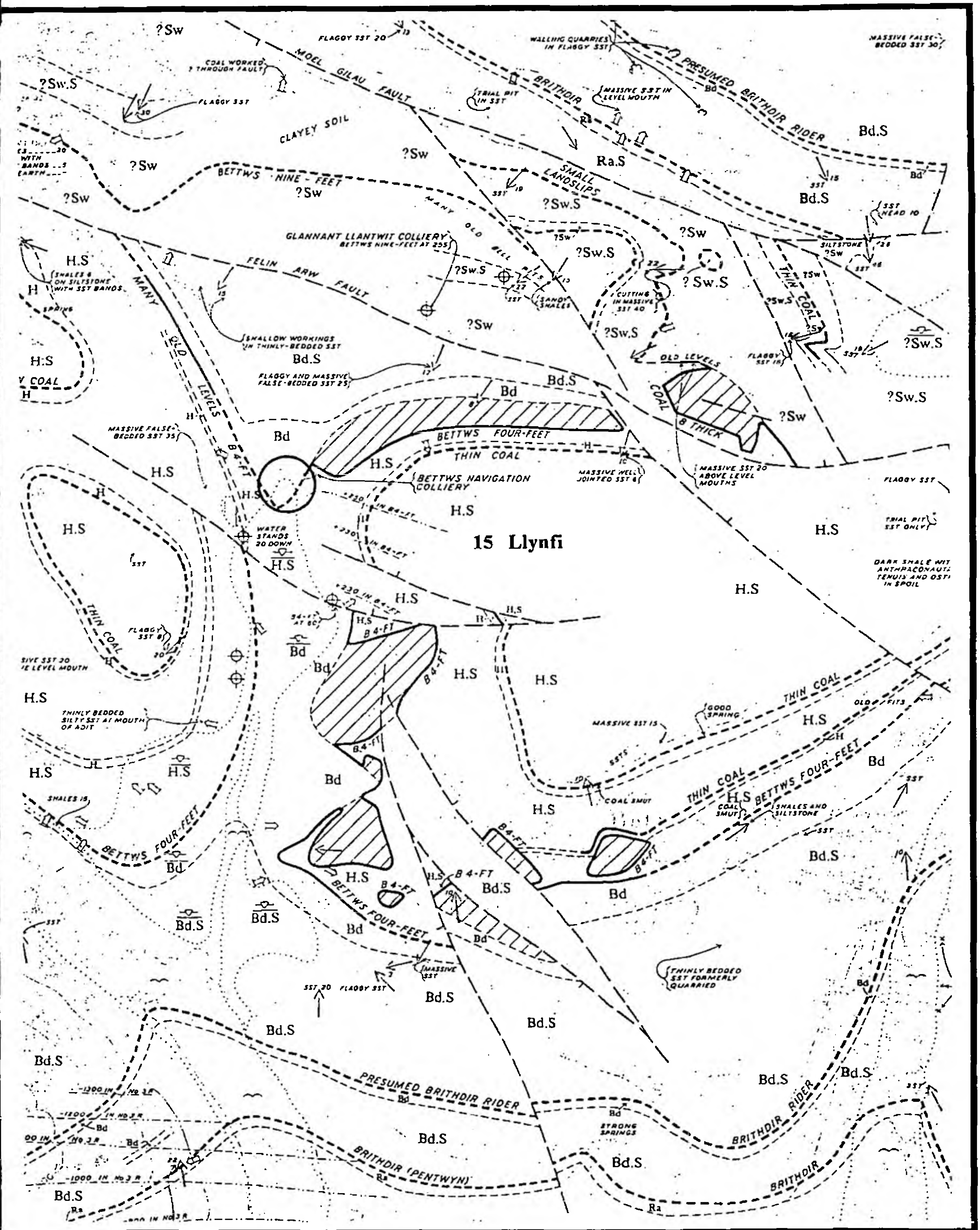
A combination of relatively low cost remediation measures may be implemented to reduce the impact of the discharge as follows:

**Capital Costs**

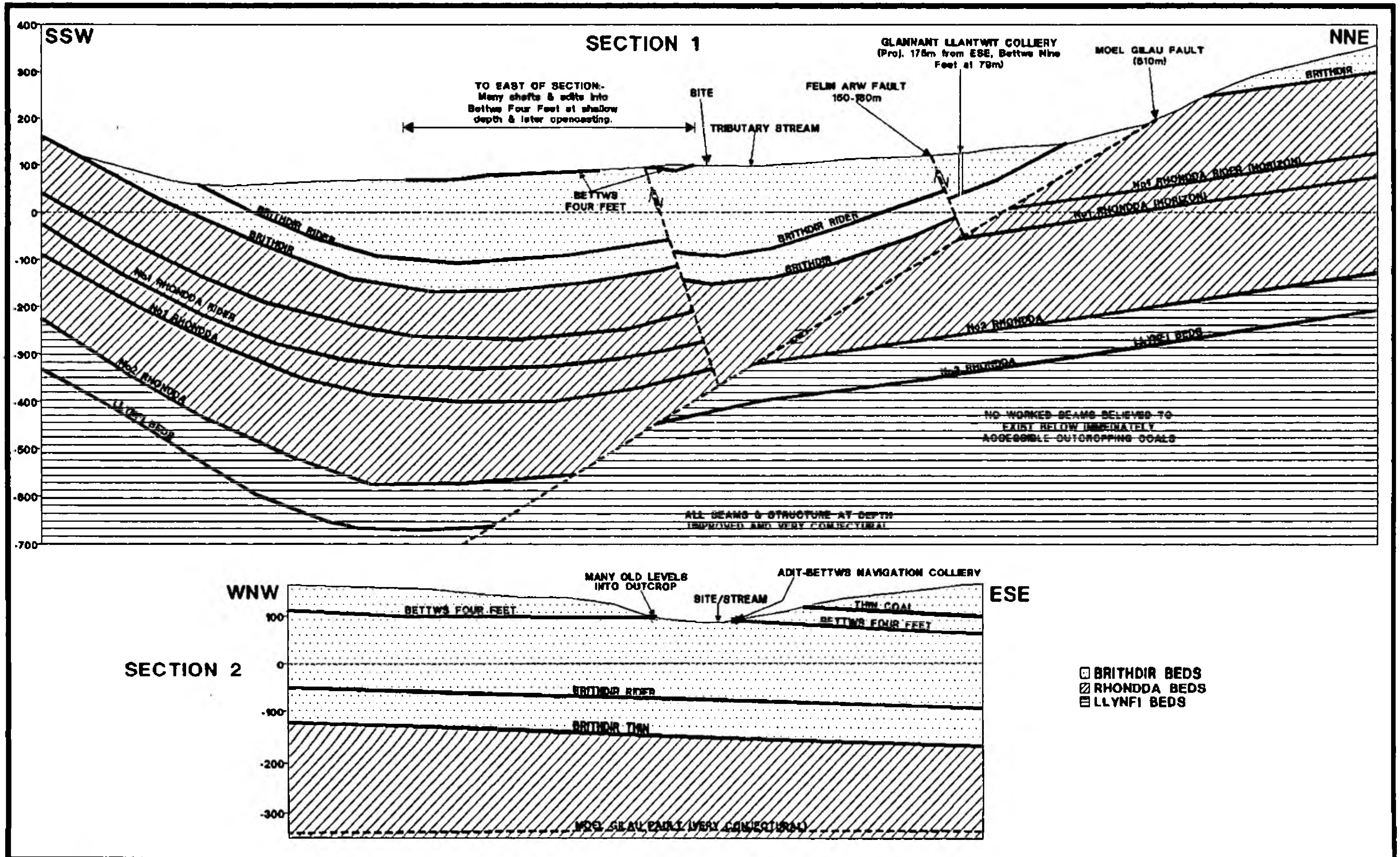
| | |
|---|---|
| 4 x plugs for adits and shaft (not essential) | £ 20,000 |
| Civil works to collect discharge and primary settlement | £ 10,000 |
| Polishing wetland/settlement area 0.05Ha | £ 25,000 |
| | £ 55,000 |

**Operating and Maintenance**

| | |
|---|---|
| Depreciation 10% of capital | £3,500 |
| Maintenance 6 man days/year @ £250 | £1,500 |
| | £5,000 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 15.1 |
| --- | --- | --- | --- |
| SRK | | SITE 15: LLYNFI | |




| DATE: 6/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|

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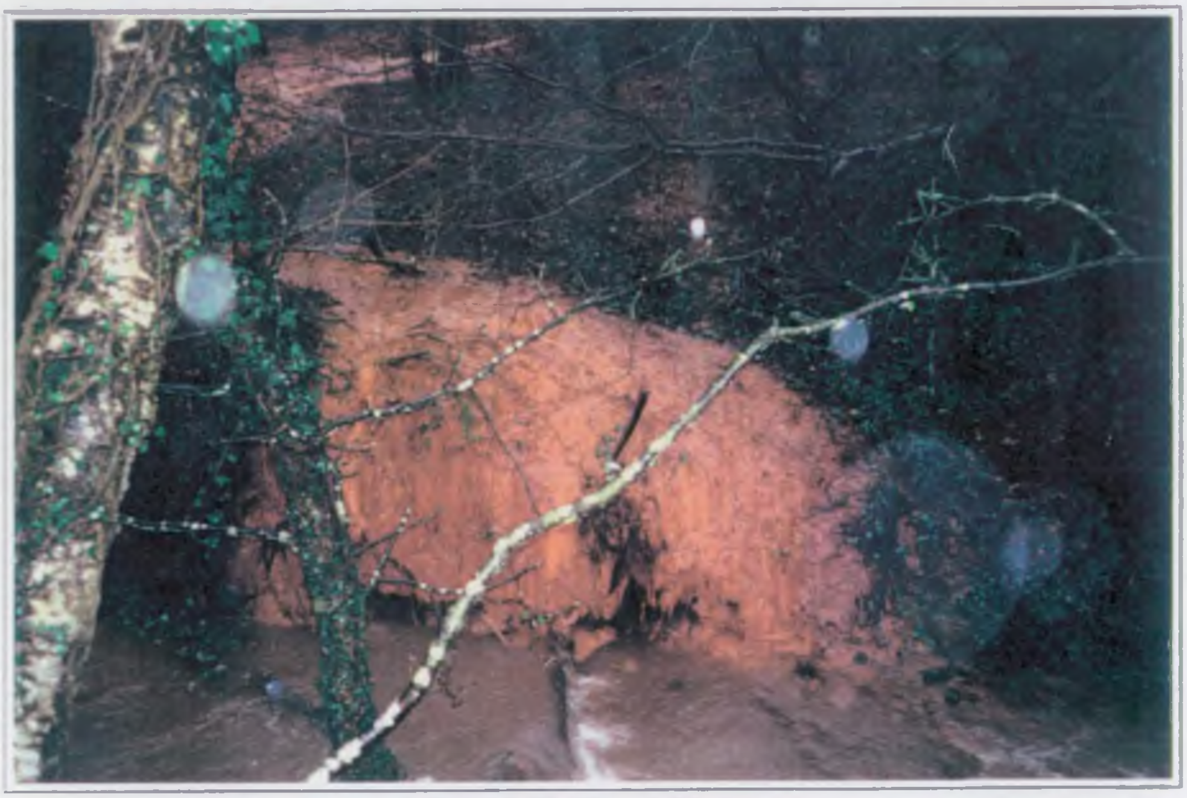
# SITE 15: LLYNFI
# SSW-NNE & WNW-ESE SECTIONS

Figure 15.1b/c

DISCHARGE FROM ADIT



DIFFUSE STAINING

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 15.1 D |
|---|---|---|---|
| SRK | | SITE 15: LLYNFI | |

SEEP FROM AREA OF BELL PITS

OVERFLOW FROM COVERED SHAFT

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | **SITE 15: LLYNFI** | Figure 15.1 D |

Site 15, Section 4. Discharge Water Quality and Load Assessment.

Site #: 15
Site : Llynfi

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.005 | 0.026 | 12 | 69 | 0.148 | | | | | | | 8.8 | 1.30 | | 0.105 | 2.0 | 0.002 | 16.4 | 0.21 | 0.002 | 71.9 | 0.86 |
| Aug | 4.6 | 6.9 | Aug | 0.006 | 0.025 | 11 | 66 | 0.143 | 6.5 | 9.18 | 13.1 | 15.6 | 6.9 | 46 | 8.9 | 1.26 | 0.912 | 0.097 | 1.9 | 0.002 | 17.9 | 0.556 | 0.006 | 63.2 | 0.69 |
| Sep | 4.1 | 7.5 | Sep | 0.005 | 0.022 | 12 | 58 | 0.171 | | | | | | | 8.8 | 1.50 | | 0.105 | 2.0 | 0.002 | 16.3 | 0.21 | 0.002 | 71.9 | 0.86 |
| Oct | 8.9 | 7.7 | Oct | 0.005 | 0.049 | 12 | 128 | 0.088 | | | | | | | 8.8 | 0.77 | | 0.108 | 2.1 | 0.002 | 15.9 | 0.21 | 0.003 | 71.9 | 0.89 |
| Nov | 15.0 | 9.0 | Nov | 0.005 | 0.082 | 14 | 214 | 0.063 | | | | | | | 8.8 | 0.55 | | 0.126 | 2.4 | 0.002 | 13.6 | 0.21 | 0.003 | 71.9 | 1.04 |
| Dec | 16.5 | 9.6 | Dec | 0.006 | 0.090 | 15 | 236 | 0.061 | | | | | | | 8.8 | 0.54 | | 0.135 | 2.6 | 0.003 | 12.7 | 0.21 | 0.003 | 71.9 | 1.11 |
| Jan | 13.4 | 11.1 | Jan | 0.007 | 0.073 | 18 | 191 | 0.085 | | | | | | | 8.8 | 0.74 | | 0.155 | 3.0 | 0.003 | 11.0 | 0.21 | 0.004 | 71.9 | 1.27 |
| Feb | 10.4 | 10.7 | Feb | 0.007 | 0.056 | 17 | 148 | 0.103 | 6.8 | 8.79 | 13.6 | 29.4 | 6.3 | 27.63 | 9.9 | 1.02 | 0.600 | 0.169 | 3.2 | 0.003 | 11.5 | 0.01 | 0.003 | 103.0 | 1.76 |
| Mar | 6.8 | 7.9 | Mar | 0.005 | 0.037 | 13 | 98 | 0.115 | | | | | | | 8.8 | 1.00 | | 0.111 | 2.1 | 0.002 | 15.5 | 0.21 | 0.003 | 71.9 | 0.91 |
| Apr | 5.8 | 7.7 | Apr | 0.005 | 0.031 | 12 | 82 | 0.130 | | | | | | | 8.8 | 1.14 | | 0.108 | 2.1 | 0.002 | 15.9 | 0.21 | 0.003 | 71.9 | 0.88 |
| May | 4.7 | 6.5 | May | 0.004 | 0.025 | 10 | 67 | 0.134 | | | | | | | 8.8 | 1.18 | | 0.091 | 1.7 | 0.002 | 18.9 | 0.21 | 0.002 | 71.9 | 0.74 |
| Jun | 5.0 | 7.9 | Jun | 0.005 | 0.027 | 13 | 71 | 0.150 | 7.2 | 14.5 | 13.7 | 17.5 | 6.9 | 33.5 | 7.5 | 1.13 | 2.070 | 0.094 | 1.8 | 0.002 | 15.6 | 0.055 | 0.001 | 49.4 | 0.62 |
| | | 100.0 | mean | 0.005 | 0.045 | 160 | 1427 | 0.116 | | 10.8 | | | | 35.7 | 8.8 | 1.011 | | 1.4 | 26.8 | 0.027 | 15.095 | 0.21 | 0.032 | 71.9 | 11.63 |
| | | | min. | 0.004 | 0.022 | | | 0.061 | | | | | | | | 0.537 | | | | | 11.038 | | | | |
| | | | max. | 0.007 | 0.090 | | | 0.171 | | | | | | | | 1.499 | | | | | 18.928 | | | | |

**Figure 15.4a Graph of Cumulative Probability for Fe in Receiving Water at Llynfi**

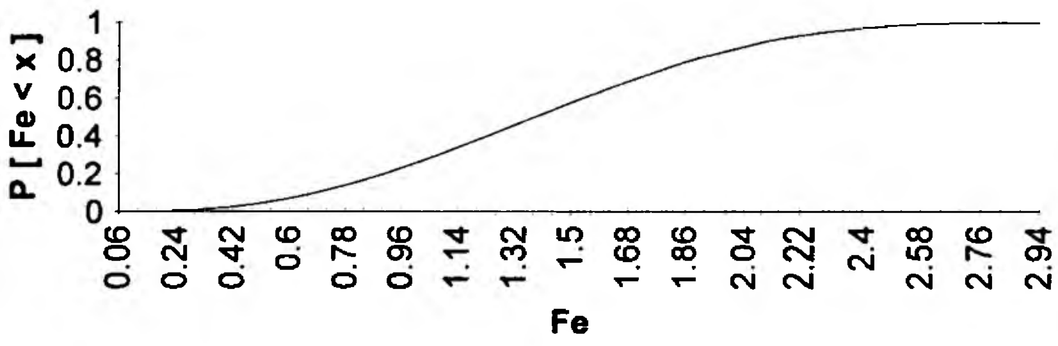
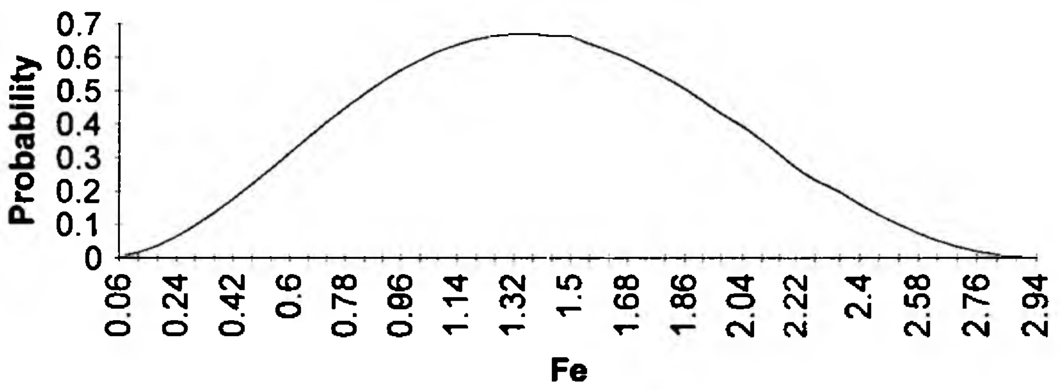



**Figure 15.4b Probability Density Graph of Fe in Receiving Water at Llynfi**



7

7

# SITE 16 CRAIG YR ABER (ABERBAIDEN)

## 16.1 GEOLOGY AND MINING

The Nant Craig yr Aber receives a number of diffuse iron bearing discharges along its length, however there are only two flows of significance. The primary flow enters from the right bank of the stream from an adit or culvert. The second flow enters the stream from its left bank, emanating from an old drift. The diffuse discharges along the length of the stream appear to originate from the spoil tips located along the left bank of the stream. Dense revegetation of the spoil tips has occurred.

The area of the discharges is on the southern edge of the South Wales Coalfield and the coal seams in this area dip 25° to 35° to the north from outcrop.

The discharges are associated with workings on the No. 2 Rhondda (Malthouse) and No. 3 Rhondda (Rock Fawr) Seams, which outcrop in the area.

The main drainage point (right bank) has been identified from old mine plans as being the end of a water course at Aberbaiden Colliery on the No.3 Rhondda Seam, draining the outcrop area as far as Pentre Colliery, 1.5km to the west. Aberbaiden Colliery was abandoned in 1959 and was the last deep mine to work in the area.

The discharge on the left bank is associated with old workings of Ty Talwyn Colliery. The area has since largely been reworked by the Ty Talwyn opencast site, operational between 1954 and 1956.

## 16.2 CONTAMINATION SOURCES

The discharges appear to be associated with drainage levels which are driven northwards to intersect the working seams and the discharges would be from largely flooded workings. The mine plans show that the drainage levels intersect the seam at a shallow depth.

The likely sources are primarily remobilised precipitates from the old workings with some contribution from active oxidation due to recharge through shallow, unsaturated workings and through the restored opencast areas.

## 16.3 HYDROGEOLOGICAL MODEL

Ground water will have recovered to conform generally to the topography. The steep dip of workings means that old workings will not behave as free drains as in the case of shallow dip workings. The site is in an area of frequent coal seams and lithological changes which prior to mining would have resulted in numerous small spring seepages. Many of these will have recovered and the flow from the discharge is likely to be from a small catchment area.

If the drainage adits were blocked, it would force the water to discharge from one of the other adits in the seam outcrop. This could result in reducing the drainage path length and reducing pollution load. This would require an evaluation of the outcrop adits and their relative levels. The steep dip of the seams is an advantage in that recharge to ground water could be taking a short drainage path through the upper workings and then through the drainage adit, unless there is a water bearing structural feature at depth in the workings.

If there are fresh springs occurring, these should be allowed to flow as much as possible to limit downward recharge to the workings.

The left bank workings will be less easy to manage due to the more dispersed flow in the former opencast workings.

## 16.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The water quality results obtained for the discharge during the March sampling program appears to be erroneous based on the iron and sulphate concentrations reported. The discharge contains an iron concentration of about 16mg/l and a sulphate concentration of about 550mg/l. It has a slightly acidic pH and a relatively low alkalinity.

An estimated 13 tonnes of iron and 450 tonnes of sulphate is being generated annually by the site. Based on the synthesized flow and concentration profiles, it is anticipated that the iron concentration in the downstream receiving water would consistently exceed the 1.0 mg/l criterion. Consequently, a reduction in the total loading will be required.

The aluminium loading at about 50kg per year is considered to be insignificant.

## 16.5 ENVIRONMENTAL COSTS AND BENEFITS

The stream, known downstream as Nant Iorweth Goch (Red Stream) is too small for any angling interest. The tributary is of high value for brown trout and to a lesser extent for sea trout spawning. Some obstructions inhibit access by salmon and sea trout.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 3 | Probable impact on spawning |
| Accessibility - footpaths | 5 | Path within 10m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 2 | Banks heavily wooded, not easily seen |
| Proximity to built up area | 1 | Houses >500m |
| Proximity to recreation area | 3 | Recreation area 100-200m |

Site specific details: The discharges are very likely to be seen by visitors to the country park area and walkers along the Ridgeway path. The area is well wooded and designed for public access and countryside recreation, although the industrial archaeology may well be of interest to some people (old mine buildings, tram roads etc).

The relatively high scores indicate a considerable degree of benefit from remediation of the discharge. This is mainly due to aesthetic benefits rather than fisheries.

## 16.6 OPTIONS FOR REMEDIATION AND COSTS

The loading observed for this site is significant. It is therefore considered important that source control options be considered to reduce the overall load. Our initial assessment, however, suggests that the installation of plugs to control oxygen entry will not be very effective as virtually all of the workings are flooded and there are many openings at outcrop.

Plugging to force the discharge out of one of the outcrop adits may reduce the drainage path and reduce loading. This would require a more detailed site survey to assess where the discharge may occur. The small contribution from spoil heaps means that the placement of covers to reduce infiltration and/or oxygen entry is not warranted.

Based on the prevailing water quality, it is considered that an ALD will be required to increase the alkalinity prior to oxidation and precipitation of the iron. For the high iron concentrations identified at this site, it will probably be necessary to increase the settling basin area to achieve adequate retention time to oxidize and precipitate a sufficient proportion of the contained iron. The surface area requirement will be in the order of 0.5 to 1.0Ha. An area this size may be difficult to locate in the vicinity of the discharge.

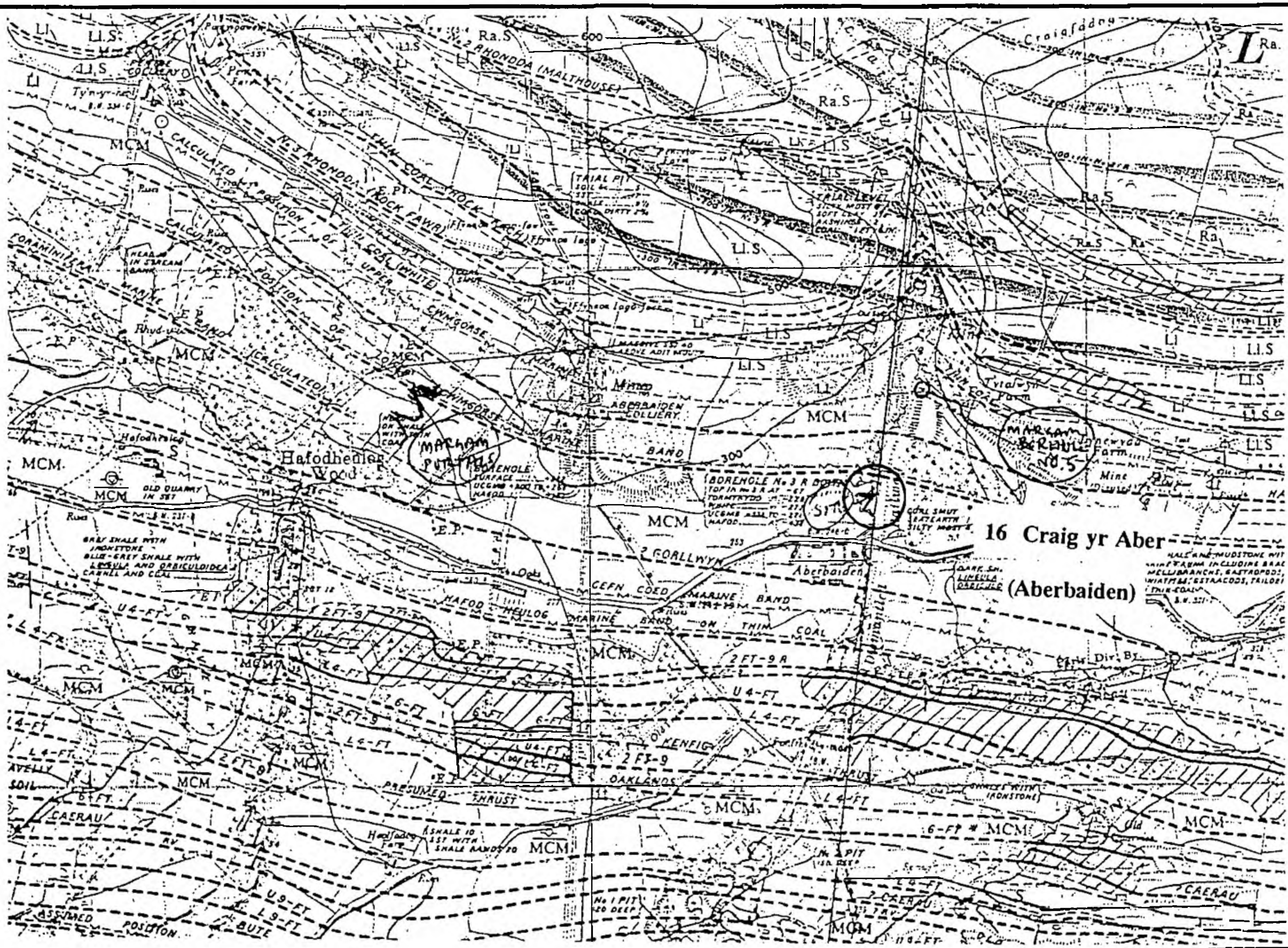
A combination of methods to reduce the impact of the discharge is likely to be effective as follows: bulkheads for hydraulic balancing, an ALD and a settlement lagoon/wetland to remove the hydroxides before discharge.

**Capital costs**

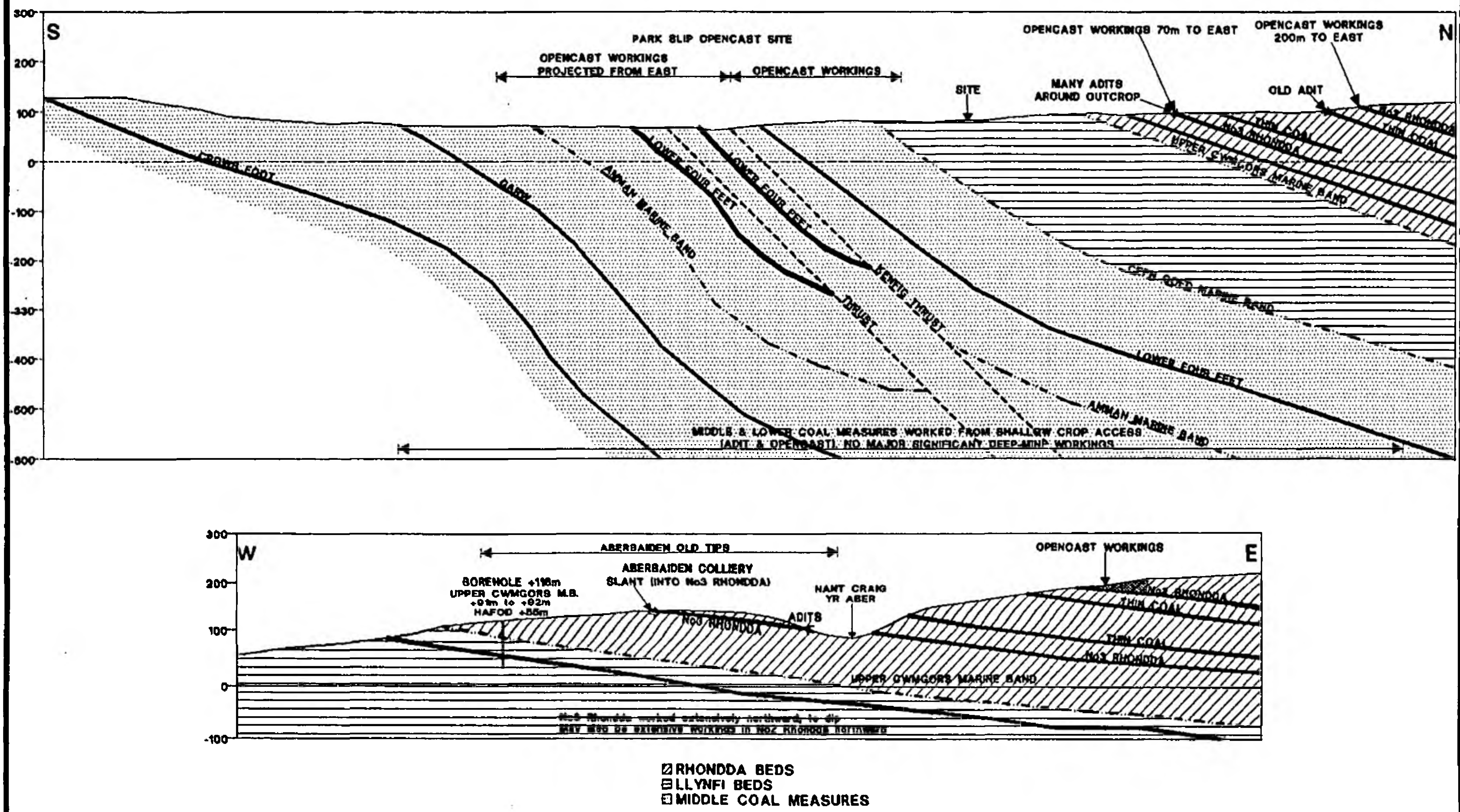
| | |
|---|---|
| Adit works (bulkheads) | £ 20,000 |
| Anoxic limestone drain 50m @ £40 | £ 2,000 |
| Aeration zone | £ 2,000 |
| Settlement/lagoon 0.5 - 1Ha | £250,000 |
| (This should be significantly reduced if the bulkhead system is effective) | £274,000 |

**Operating and Maintenance**

| | |
|---|---|
| Depreciation @ 10% of capital cost | £27,400 |
| Maintenance 6 man days/year @ £250 | £1,500 |
| | £28,900 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 16.1 |
|---|---|---|---|
| SRK | | SITE 16: CRAIG YR ABER (ABERBAIDEN) | |




DATE: 5/4/94 | PROJ. No: U489

SRK/NRA ACID ROCK DRAINAGE

SCALE 1:10560

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# SITE 16: CRAIG YR ABER
# SOUTH-NORTH & WEST-EAST SECTIONS

Figure 16.1b/c

# Site 16, Section 4. Discharge Water Quality and Load Assessment.

Flows Measured at Cefn Hengoed

Site #: 16
Site : Craig Yr Aber (Note: Results for MARCH may be wrong)
Receiving water

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | pH | Alkalinity (mg CaCO3/l | SO4 (mg/l) U/S | SO4 (mg/l) D/S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.025 | 0.060 | 65 | 159 | 0.292 | | | | |
| Aug | 4.6 | 6.9 | Aug | 0.023 | 0.058 | 60 | 153 | 0.282 | 6.83 | 11.69 | 18 | 101.9 |
| Sep | 4.1 | 7.5 | Sep | 0.025 | 0.051 | 66 | 134 | 0.328 | | | | |
| Oct | 8.9 | 7.7 | Oct | 0.026 | 0.112 | 67 | 295 | 0.186 | | | | |
| Nov | 15.0 | 9.0 | Nov | 0.030 | 0.189 | 79 | 496 | 0.137 | | | | |
| Dec | 16.5 | 9.6 | Dec | 0.032 | 0.208 | 84 | 545 | 0.134 | | | | |
| Jan | 13.4 | 11.1 | Jan | 0.037 | 0.168 | 97 | 441 | 0.180 | | | | |
| Feb | 10.4 | 10.7 | Feb | 0.036 | 0.131 | 93 | 343 | 0.214 | | | | |
| Mar | 8.6 | 7.9 | Mar | 0.026 | 0.086 | 69 | 226 | 0.234 | 6.9 | 11.22 | 14.7 | 25.3 |
| Apr | 5.8 | 7.7 | Apr | 0.026 | 0.072 | 67 | 190 | 0.261 | | | | |
| May | 4.7 | 6.5 | May | 0.022 | 0.059 | 58 | 154 | 0.268 | | | | |
| Jun | 5.0 | 7.9 | Jun | 0.026 | 0.063 | 69 | 165 | 0.294 | 7.0 | 43 | 19.2 | 174 |
| Total | 100.0 | 100.0 | mean | 0.028 | 0.105 | 872 | 3302 | 0.234 | | 27.3 | | |
| | | | min. | 0.022 | 0.051 | | | 0.134 | | | | |
| | | | max. | 0.037 | 0.208 | | | 0.328 | | | | |

Site #: 16
Site : Craig Yr Aber (Note: Results for MARCH may be wrong)
Discharge

| | pH | Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | | | 16.0 | 4.66 | | 1.044 | 20.0 | 0.020 | 27.8 | 0.06 | 0.004 | 555 | 36.2 |
| Aug | 5.92 | 39.8 | 15.3 | 4.32 | 4.060 | 0.918 | 17.6 | 0.018 | 30.3 | 0.077 | 0.005 | 537 | 32.1 |
| Sep | | | 16.0 | 5.24 | | 1.048 | 20.1 | 0.020 | 27.6 | 0.06 | 0.004 | 555 | 36.4 |
| Oct | | | 16.0 | 2.97 | | 1.076 | 20.6 | 0.021 | 26.9 | 0.06 | 0.004 | 555 | 37.4 |
| Nov | | | 16.0 | 2.19 | | 1.258 | 24.1 | 0.024 | 23.0 | 0.06 | 0.005 | 555 | 43.7 |
| Dec | | | 16.0 | 2.14 | | 1.345 | 25.7 | 0.026 | 21.5 | 0.06 | 0.005 | 555 | 46.7 |
| Jan | | | 16.0 | 2.88 | | 1.548 | 29.6 | 0.030 | 18.7 | 0.06 | 0.006 | 555 | 53.7 |
| Feb | | | 16.0 | 2.42 | | 1.490 | 28.5 | 0.029 | 19.4 | 0.06 | 0.006 | 555 | 51.7 |
| Mar | 6.6 | 17.75 | 2.0 | 0.47 | 0.639 | 0.137 | 2.6 | 0.003 | 26.2 | 0.013 | 0.001 | 20 | 1.4 |
| Apr | | | 16.0 | 4.17 | | 1.073 | 20.5 | 0.021 | 27.0 | 0.06 | 0.004 | 555 | 37.2 |
| May | | | 16.0 | 4.29 | | 0.903 | 17.3 | 0.017 | 32.1 | 0.06 | 0.004 | 555 | 31.3 |
| Jun | 6.3 | 117 | 16.6 | 4.89 | 4.760 | 1.143 | 21.9 | 0.022 | 26.4 | 0.05 | 0.003 | 573 | 39.3 |
| mean | | 78.4 | 16.0 | 3.469 | | 13.0 | 248.4 | 0.248 | 25.885 | 0.06 | 0.052 | 555 | 447.2 |
| min. | | | | 0.486 | | | | | 18.708 | | | | |
| max. | | | | 5.242 | | | | | 32.083 | | | | |

**Figure 16.4a Graph of Cumulative Probability For Fe in Receiving Water at Craig yr Aber (Aberbaiden)**

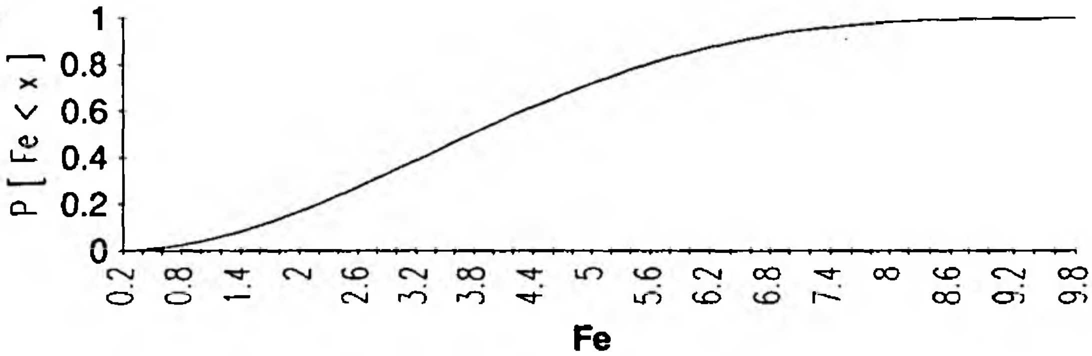
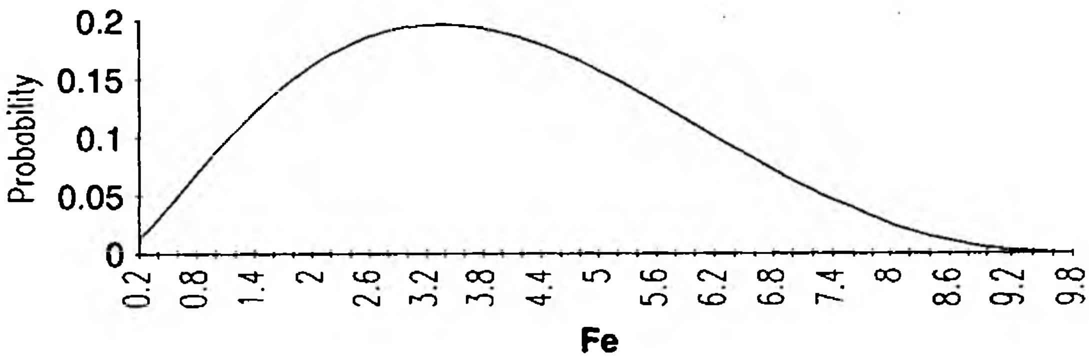



**Figure 16.4b Probability Density Graph of Fe in Receiving Water at Craig yr Aber (Aberbaiden)**



8

8

# SITE 17 & 17A - AFON CORRWG

## 17.1 GEOLOGY AND MINING

Two flows are observed at this location, one on each side of the Afon Corrwg. For the purpose of this study, the two flows have been labelled 17 which enters from the left bank and 17A which enters from the right further downstream. The volumetric flow rates were similar at the two sites, each being estimated to be approximately 1Ml/day.

The area is undermined at depth but these workings are unlikely to have any impact on the discharge. Two seams of the Upper Coal Measures have been mined in the immediate area, the No.2 Rhondda and the Fforest Fach (marked on the geological map as the No.1 Rhondda). The seam of most interest was the No 2 Rhondda, which has been extensively mined. Above the No 2 Rhondda is the Forest Fach Seam which outcrops on both sides of the Afon Corrwg Valley and has been mined where of sufficient thickness. The Glyncorrwg Fault to the west of the discharges downthrows to the west and limits mining in that direction. The strata dips to the south at about 7°.

Discharge 17 appears as an upwelling flow from the site of a collapsed adit. The NRA reports that this flow previously discharged from a slightly different location which has since dried up, as shown in the lower photograph. The mining plans for the area indicate that these discharges are or were from two adits which formerly accessed workings on the No.2 Rhondda Seam of the Glyncorrwg Colliery, abandoned in 1907. This mine extended to the north, up dip and so would have been free draining.

Discharge 17A flows from a collapsed adit above the right bank of the Afon Corrwg. The North Rhondda Colliery worked two seams here, the No.2 Rhondda was the lower and the Fforest Fach the upper. The workings in the Fforest Fach Seam extend 1.8km to the north west, the highest point of the workings being at 400m AOD and the adit levels at 341m and 353m. The workings in the No 2 Rhondda Seam extend 1.7km to the north east, the highest elevation worked in the seam being 401m and the adit level 295m AOD.

The west bank discharge is from one of these adits, though more investigation would be required to establish its exact identity. The mines would have been free draining.

## 17.2 CONTAMINATION SOURCES

The source is predominantly areas of active oxidation in unflooded workings, but it is not clear whether recent ground water recovery has occurred to mobilise previously deposited material. If the flows had been occurring for many years, free drainage would have established drainage paths which would limit the contribution of oxidation products.

The discharges are from the No2 Rhondda Seam which is fairly flat lying and underlies the Fforestfach Seam. It is assumed that the latter is oxidising as well as the No2 Rhondda which is also a source of remobilisation.

## 17.3 HYDROGEOLOGICAL MODEL

The above suggests that the unflooded mine workings are receiving vertical infiltration from rainfall which is washing down active oxidation products into the drainage channels. The flow is then direct to the discharge with little opportunity to pick up alkalinity.

The catchment areas are fairly large as indicated by the flow in the river. Recharge from rainfall is likely to be good and increased in the outcrop and shallow undermined areas to the north. The discharges are at the lowest points of the seams, therefore the water travels through the full length of the workings.

The discharges would have occurred following ground water recovery after closure of the deep mines. The present discharges represent a replacement of what would have been base flow to the river under natural conditions.

It is possible that sealing the lower adits on the No2 Rhondda could reduce the iron load by reducing the drainage through the No2 Rhondda and limiting it to the Fforestfach workings.

## 17.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

Similar water qualities are observed for the two discharges. The iron concentration observed at Site 17, at about 15mg/l, is slightly higher than that observed at Site 17A (10mg/l). Sulphate concentrations in the order of 200mg/l are observed at both sites, which is comparatively low. Both discharges are relatively low in alkalinity. It is anticipated that a high proportion of this load is being generated through active, ongoing, oxidation processes.

The total iron loadings generated at Sites 17 and 17A respectively are estimated to be in the order of 5 and 4 tonnes per year respectively. The corresponding sulphate loadings are in the order of 65 and 86 tonnes per year. The aluminium production at these sites is insignificant.

## 17.5 ENVIRONMENTAL COSTS AND BENEFITS

The stream is too small for any angling interest. The stream is of moderate value for brown trout spawning. A small fish pass is being considered to improve access for brown trout and sea trout at a point where a culvert takes the stream past the old mine workings. There is, therefore, scope for a modest improvement in migratory fish spawning.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 2 | Possible impact on spawning |
| Accessibility - footpaths | 4 | Path within 50m |
| Accessibility - roads | 1 | Road within 1km |
| Visual impact downstream | 4 | Open banks, very noticeable |
| Proximity to built up area | 1 | Houses >300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: The discharges are at a remote site unlikely to be seen by casual visitors. Walkers and riders may be impacted. Those interested in industrial heritage may see it, but are less likely to be concerned. There is a colliery site in the valley bottom and spoil heaps along valley sides, otherwise the Afon Corrwg is a good 'clean' mountain stream upstream of the discharge.

The low scores indicate a small benefit in terms of fisheries and aesthetics should remediation take place.

## 17.6 OPTIONS FOR REMEDIATION AND COSTS

The discharges are similar, in that both are collapsed mine adits draining extensive up-dip workings.

It is considered that the primary source for contamination is the unflooded workings in the No.2 Rhondda and Fforest Fach Seams.

By sealing the adits associated with these workings, oxygen entry could be restricted which could significantly reduce oxidation within the mine workings.

As a result of the combined loading from the two discharges, achieving the EQS of 1.0mg/l for iron in the downstream receiving water is unlikely to be achieved. At least partial treatment would be required to reduce the current impact.

It is anticipated that if a wetland approach is to be considered, an ALD would be required for the conditioning of the discharge water prior to treatment. Such a system may be constructed at Site 17 by excavating and reconditioning the adit and backfilling it with crushed limestone. However, this adit has been abandoned for nearly 90 years and so has probably collapsed extensively. A similar system could be installed at site 17A, where the adit was abandoned comparatively recently and is likely to be in better condition. Land availability for the construction of a settling basin however is limited due to the relatively narrow valley and steep topography. It may be necessary to construct settling basins similar to those observed further downstream from the site. These are likely to require significant maintenance.

The most likely method of remediation for the combined discharges is anoxic limestone drains followed by aeration and settling. Oxygen exclusion by plugging the adits may also be considered to reduce the ongoing oxidation.

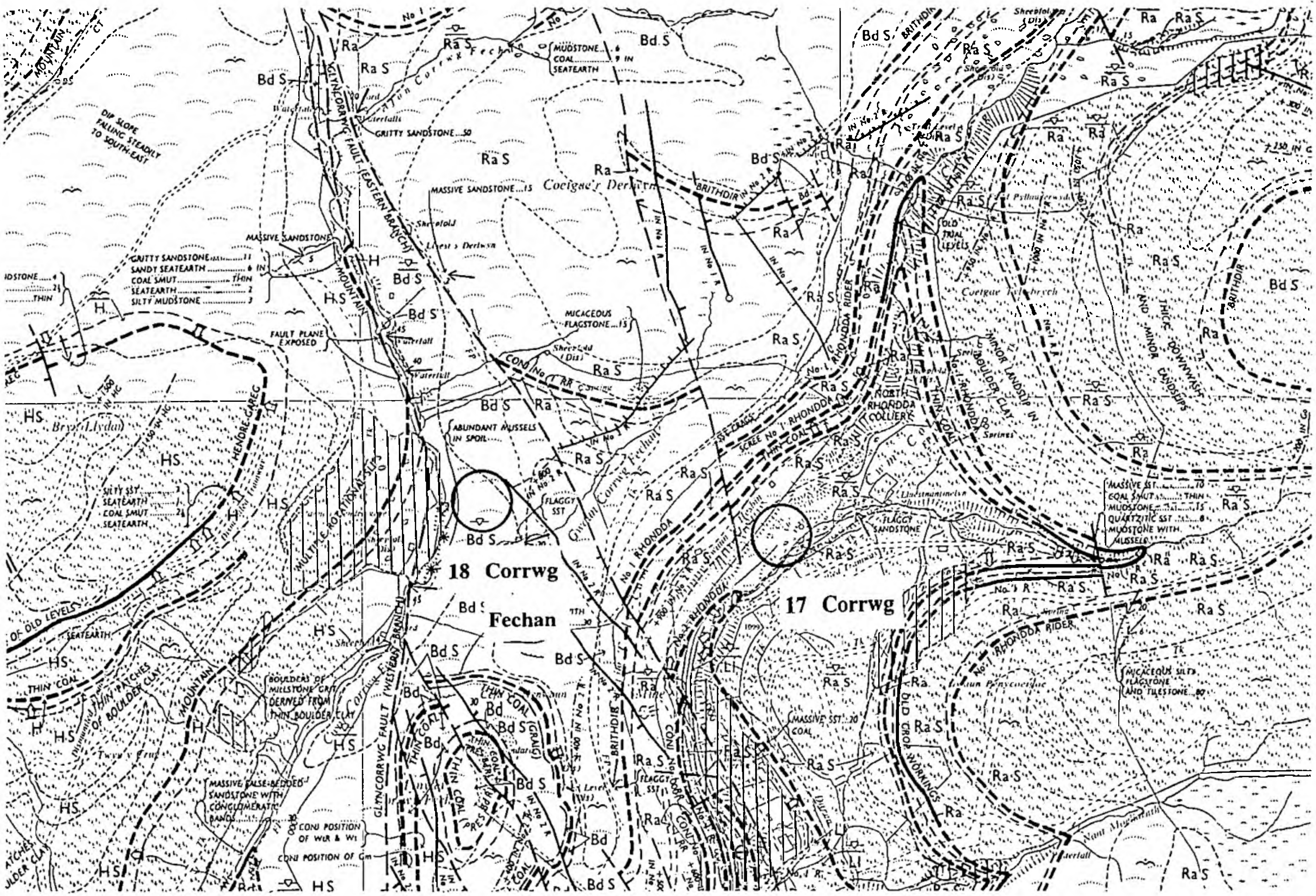
It is suggested that potential for oxygen entry control be assessed prior to the consideration of a passive/active treatment system.

**Capital Costs**

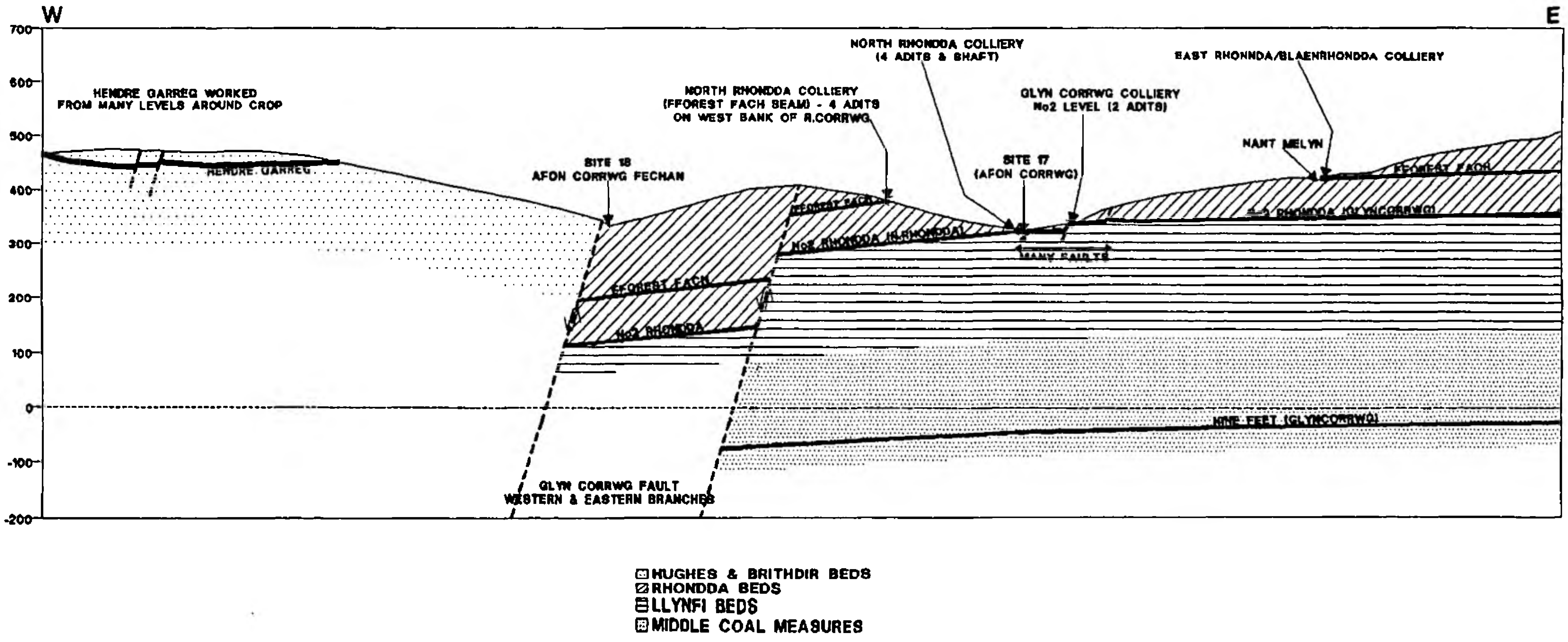
| | |
|---|---|
| 4 x oxygen plugs | £ 20,000 |
| 2 x ALD's 30m | £ 2,500 |
| 2 x aeration facilities | £ 2,500 |
| Pipelines, total 400m | £ 50,000 |
| Settlement lagoons/wetlands (probably a series due to lack of space) | |
| Total - 0.2Ha | £ 50,000 |
| | £125,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation @ 10% of capital costs | £12,500 |
| Maintenance 6 man days/year @ £250/day | £ 1,500 |
| | £14,000 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 17.1 |
|---|---|---|---|
| SRK | | SITE 17: CORRWG | |




| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN CONSULTING ENGINEERS | | SITE 17: CORRWG WEST-EAST SECTION | Figure 17.1b |

DISCHARGE CHANNEL TO RIVER

PREVIOUS DISCHARGE SITE

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 17A: GLYN CORRWG | Figure 17A.1 D |

Site 17a, Section 4. Discharge Water Quality and Load Assessment.

| | Rive Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.5 |
| Oct | 8.9 | 7.7 |
| Nov | 15.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 5.8 | 7.7 |
| May | 4.7 | 6.5 |
| Jun | 6.0 | 7.9 |

Site #: 17A
Site : Afon Corrwg

Receiving water

| | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | pH | Alkalinity (mg CaCO3/l) | SO4 (mg/l) U/S | D/S |
|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.010 | 0.128 | 27 | 330 | 0.076 | 7.1 | 39.3 | 12.6 | ? |
| Aug | 0.009 | 0.121 | 24 | 317 | 0.072 | | | | |
| Sep | 0.010 | 0.106 | 27 | 279 | 0.088 | | | | |
| Oct | 0.010 | 0.234 | 26 | 614 | 0.043 | | | | |
| Nov | 0.012 | 0.392 | 32 | 1031 | 0.030 | | | | |
| Dec | 0.013 | 0.432 | 34 | 1134 | 0.029 | | | | |
| Jan | 0.015 | 0.349 | 40 | 917 | 0.041 | | | | |
| Feb | 0.015 | 0.271 | 38 | 712 | 0.051 | 7.5 | 54.09 | 14.1 | ? |
| Mar | 0.011 | 0.179 | 26 | 470 | 0.057 | | | | |
| Apr | 0.010 | 0.150 | 27 | 395 | 0.065 | | | | |
| May | 0.009 | 0.122 | 23 | 320 | 0.067 | | | | |
| Jun | 0.011 | 0.130 | 28 | 342 | 0.076 | 7.6 | 25.8 | 11.6 | ? |
| mean | 0.011 | 0.218 | 356 | 6861 | 0.058 | | 39.7 | | |
| min. | 0.009 | 0.106 | | | 0.088 | | | | |
| max | 0.015 | 0.432 | | | 0.029 | | | | |

Site #: 17A
Site : Afon Corrwg
Discharge

| | pH | Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Calculated Receiving | Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 6.3 | 47 | 11.3 | 0.65 | 0.952 | 0.302 | 5.8 | 0.006 | 27.0 | 0.046 | 0.001 | 102 | 2.7 |
| Aug | | | 14.4 | 1.03 | | 0.353 | 6.8 | 0.007 | 29.4 | 0.04 | 0.001 | 182 | 4.5 |
| Sep | | | 14.4 | 1.26 | | 0.387 | 7.4 | 0.007 | 26.9 | 0.04 | 0.001 | 182 | 4.9 |
| Oct | | | 14.4 | 0.62 | | 0.397 | 7.6 | 0.008 | 26.2 | 0.04 | 0.001 | 182 | 5.0 |
| Nov | | | 14.4 | 0.44 | | 0.464 | 8.9 | 0.009 | 22.4 | 0.04 | 0.001 | 182 | 5.8 |
| Dec | | | 14.4 | 0.42 | | 0.496 | 9.5 | 0.009 | 20.9 | 0.04 | 0.001 | 182 | 6.3 |
| Jan | | | 14.4 | 0.60 | | 0.571 | 10.9 | 0.011 | 18.2 | 0.04 | 0.002 | 182 | 7.2 |
| Feb | 6.6 | 44.02 | 15.3 | 0.78 | 1.896 | 0.582 | 11.1 | 0.011 | 18.9 | 0.031 | 0.001 | 202 | 7.7 |
| Mar | | | 14.4 | 0.82 | | 0.407 | 7.8 | 0.008 | 25.5 | 0.04 | 0.001 | 182 | 5.1 |
| Apr | | | 14.4 | 0.94 | | 0.398 | 7.6 | 0.008 | 26.3 | 0.04 | 0.001 | 182 | 5.0 |
| May | | | 14.4 | 0.97 | | 0.333 | 6.4 | 0.006 | 31.2 | 0.04 | 0.001 | 182 | 4.2 |
| Jun | 6.1 | 39.6 | 16.7 | 1.26 | 0.690 | 0.468 | 9.0 | 0.009 | 25.7 | 0.05 | 0.001 | 242 | 6.8 |
| mean | | 43.5 | 14.4 | 0.832 | | 5.157 | 98.7 | 0.099 | 24.878 | 0.04 | 0.015 | 182 | 65.2 |
| min. | | | | 0.425 | | | | | 18.191 | | | | |
| max | | | | 1.264 | | | | | 31.196 | | | | |

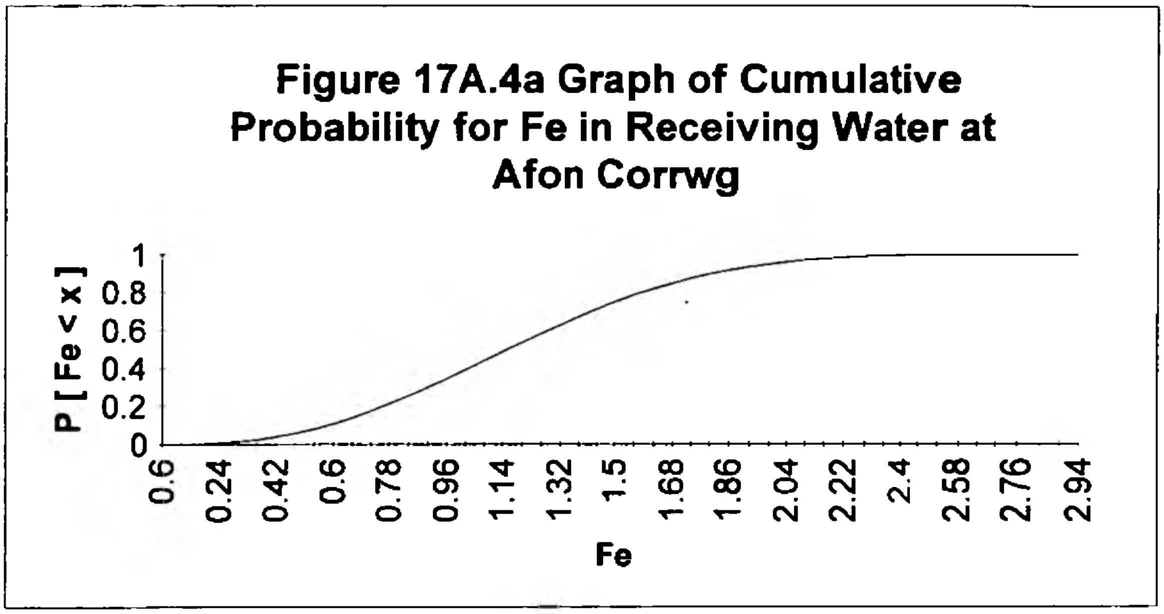


Figure 17A.4a Graph of Cumulative Probability for Fe in Receiving Water at Afon Corrwg
P [ Fe < x ]
1
0.8
0.6
0.4
0.2
0
0.6
0.24
0.42
0.6
0.78
0.96
1.14
1.32
1.5
1.68
1.86
2.04
2.22
2.4
2.58
2.76
2.94
Fe

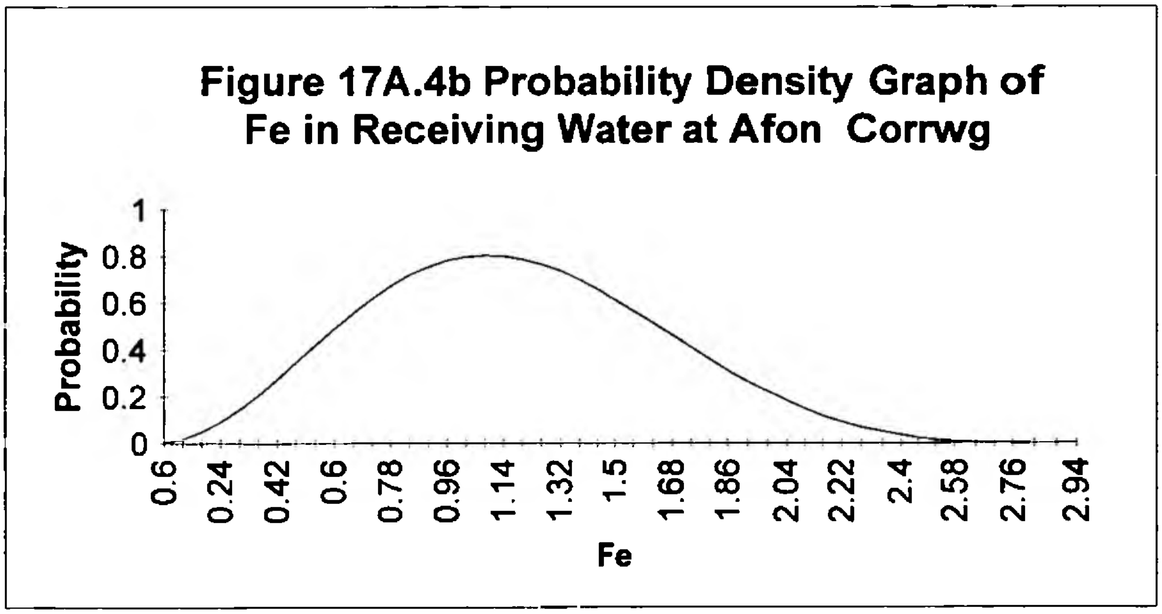


Figure 17A.4b Probability Density Graph of Fe in Receiving Water at Afon Corrwg
Probability
1
0.8
0.6
0.4
0.2
0
0.6
0.24
0.42
0.6
0.78
0.96
1.14
1.32
1.5
1.68
1.86
2.04
2.22
2.4
2.58
2.76
2.94
Fe

DISCHARGE POINT

DISCHARGE CHANNEL TO RIVER

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 17B: GLYNCORRWG | Figure 17B.1 D |

# Site 17b, Section 4. Discharge Water Quality and Load Assessment.

Site #: 17 B
Site : Afon Corrwg

| | River Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.5 |
| Oct | 8.9 | 7.7 |
| Nov | 15.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 5.8 | 7.7 |
| May | 4.7 | 6.5 |
| Jun | 5.0 | 7.9 |

Site #: 17 B
Site : Afon Corrwg
Discharge

| | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.011 | 0.132 | 29 | 347 | 0.076 | 7.1 | 39.3 | 12.6 | 33.6 | 6.7 | 82 |
| Aug | 0.010 | 0.127 | 26 | 334 | 0.073 | | | | | | |
| Sep | 0.011 | 0.112 | 29 | 294 | 0.089 | | | | | | |
| Oct | 0.011 | 0.246 | 30 | 647 | 0.044 | | | | | | |
| Nov | 0.013 | 0.413 | 35 | 1086 | 0.031 | | | | | | |
| Dec | 0.014 | 0.455 | 37 | 1194 | 0.030 | | | | | | |
| Jan | 0.016 | 0.368 | 43 | 967 | 0.042 | | | | | | |
| Feb | 0.016 | 0.286 | 41 | 750 | 0.052 | 7.5 | 54.09 | 14.1 | 36 | ? | ? |
| Mar | 0.012 | 0.188 | 30 | 495 | 0.058 | | | | | | |
| Apr | 0.011 | 0.155 | 29 | 416 | 0.066 | | | | | | |
| May | 0.009 | 0.129 | 25 | 338 | 0.069 | | | | | | |
| Jun | 0.011 | 0.137 | 30 | 361 | 0.077 | 7.6 | 25.6 | 11.6 | 24.95 | 6.6 | 90.4 |
| mean | 0.012 | 0.229 | 383 | 7226 | 0.059 | | | | | | 86.2 |
| min. | 0.009 | 0.112 | | | 0.089 | | | | | | |
| max. | 0.018 | 0.485 | | | 0.030 | | | | | | |

| | Fe(T) Concentration (mg/L) Discharge | Fe(T) Calculated Receiving | Fe(T) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 10.9 | 0.83 | 0.952 | 0.311 | 6.0 | 0.006 | 18.0 | (0.004 | 0.000 | 229 | 6.6 |
| Aug | 10.2 | 0.74 | | 0.268 | 5.1 | 0.006 | 20.7 | 0.02 | 0.001 | 225 | 5.9 |
| Sep | 10.2 | 0.91 | | 0.293 | 5.6 | 0.006 | 18.9 | 0.02 | 0.001 | 225 | 6.5 |
| Oct | 10.2 | 0.45 | | 0.301 | 5.8 | 0.006 | 18.4 | 0.02 | 0.001 | 225 | 6.7 |
| Nov | 10.2 | 0.31 | | 0.352 | 6.7 | 0.007 | 15.7 | 0.02 | 0.001 | 225 | 7.8 |
| Dec | 10.2 | 0.31 | | 0.378 | 7.2 | 0.007 | 14.7 | 0.02 | 0.001 | 225 | 8.3 |
| Jan | 10.2 | 0.43 | | 0.433 | 8.3 | 0.008 | 12.8 | 0.02 | 0.001 | 225 | 9.6 |
| Feb | 10.2 | 0.53 | 1.898 | 0.417 | 8.0 | 0.008 | 13.3 | 0.02 | 0.001 | 225 | 9.2 |
| Mar | 10.2 | 0.59 | | 0.309 | 5.9 | 0.006 | 17.9 | 0.02 | 0.001 | 225 | 6.8 |
| Apr | 10.2 | 0.67 | | 0.300 | 5.7 | 0.006 | 18.5 | 0.02 | 0.001 | 225 | 6.6 |
| May | 10.2 | 0.70 | | 0.253 | 4.8 | 0.005 | 21.9 | 0.02 | 0.001 | 225 | 5.6 |
| Jun | 9.5 | 0.73 | 0.690 | 0.287 | 5.5 | 0.005 | 18.0 | 0.044 | 0.001 | 221 | 6.7 |
| mean | 10.2 | 0.599 | | 3.899 | 74.6 | 0.075 | 17.486 | 0.02 | 0.009 | 225 | 86.2 |
| min. | | 0.306 | | | | | 12.766 | | | | |
| max. | | 0.906 | | | | | 21.927 | | | | |

**Figure 17B.4a Graph of Cumulative Probability for Fe in Receiving Water at Afon Corrwg**

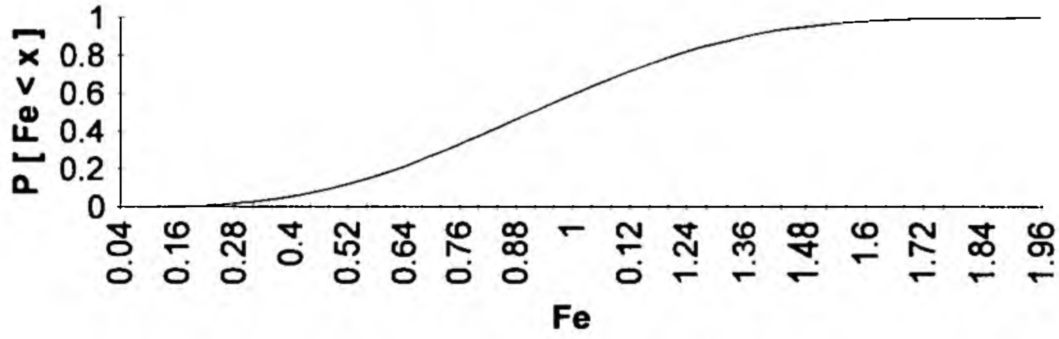
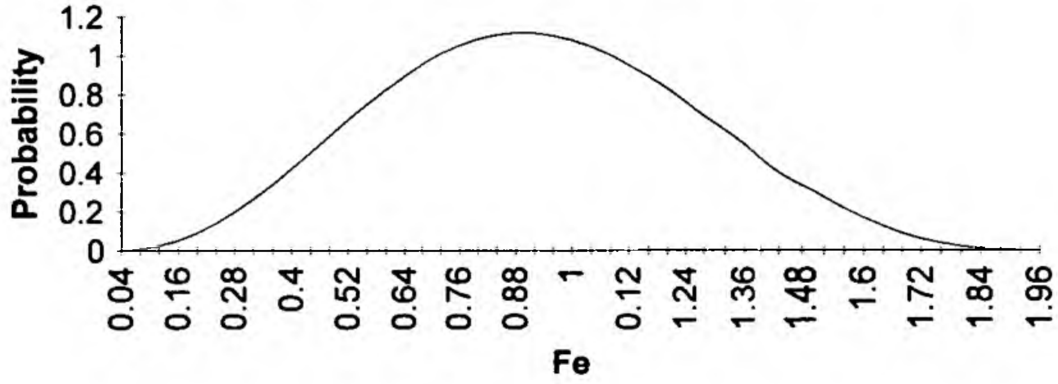



**Figure 17B.4b Probability Density Graph of Fe in Receiving Water at Afon Corrwg**



9

9

# SITE 18 AFON CORRWG FECHAN

## 18.1 GEOLOGY AND MINING

Site 18 drains a block of ground between the eastern and western branches of the major Glyncorrwg fault. This fault downthrows significantly to the west. The eastern branch of the fault downthrows this block in relation to the sites to the east in the Afon Corrwg (17 and 17A), so the Fforest Fach and No 2 Rhondda Seams are at greater depth. An adit is marked on the geological map on the eastern bank of the stream The mine plans show that it was driven for exploration and extends to the north east from an elevation at the entrance of 328m AOD to 330m at the end. Different plans show different details, but they suggest that the tunnels connect into the Fforest Fach Seam but not into the No 2 Rhondda, which was some way below. However, boreholes were drilled into both seams.

As shown in Section 18.1b/c, this discharge appears to be draining the mine workings located in the Fforest Fach Seam. The workings in this seam are not flooded as they extend up-dip.

## 18.2 CONTAMINATION SOURCES

The primary source is likely to be active oxidation within unsaturated workings.

## 18.3 HYDROGEOLOGICAL MODEL

The model is similar to Site 17 where ground water recovery was inhibited years ago due to the mine workings acting as a drainage adit. The infiltrating water will drain down to the adit and to discharge with some contribution from underlying rocks due to upward flow.

## 18.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge contains about 12mg/l total iron and about 125mg/l sulphate. The primary mechanism for contaminant release is ongoing sulphide oxidation since the mine workings are largely unflooded. The discharge has a relatively low alkalinity.

There is, however, sufficient exposed host rock containing alkaline minerals along the flow path to maintain a neutral pH at the discharge. Based on the rate at which sulphate is being generated, it is estimated that approximately 80% of the iron is being accumulated within the mine workings as hydroxides and/or other secondary mineral phases. Should the alkaline materials that are currently buffering the discharge to a neutral pH be exhausted or armoured by precipitates, it is possible that the iron concentration may increase approximately 6 to 7 fold.

It is estimated that, currently, the total iron loading generated at this site is in the order of 2.3 tonnes per year, while the sulphate is about 27 tonnes per year.

## 18.5 ENVIRONMENTAL COSTS AND BENEFITS

The stream is too small for angling interest. Limited suitability for brown trout spawning. There is a low potential for improved salmon and sea trout spawning.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 1 | No impact on angling or spawning |
| Accessibility - footpaths | 4 | Path within 15m |
| Accessibility - roads | 1 | Road within 1km |
| Visual impact downstream | 4 | Open valley, staining noticeable |
| Proximity to built up area | 1 | Houses > 300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: The site is remote and is unlikely to be seen by casual visitors. Those interested in industrial heritage may see it. The low scores indicate a small benefit from remediation.

## 18.6 OPTIONS FOR REMEDIATION AND COSTS

Mine records show a single adit at the location of the discharge. However, the workings may be linked to discharge 17A, depending on whether that is from the Fforest Fach or No.2 Rhondda workings. Oxygen exclusion by flooding could therefore possibly be achieved to provide an effective solution, but a combined approach with discharge 17A would need to be considered. Faulting in this area may limit the effective level of flooding that may be achieved by the installation of a bulkhead. If only partial flooding is achieved, a sulphate reduction system could be implemented immediately behind the bulkhead. To implement such a system, it would be necessary construct a bulkhead with two pipes through it. The first pipe would serve to inject the organic substrate some distance into the mine, while the second would be equipped with, for example, a pressure regulator to control the discharge rate. The intake would be immediately upstream from the bulkhead.

The records of the workings suggest that the development extends eastward. Openings on both sides of the high ground will act as a chimney and could result in large air flow rates through the mine workings. Sealing of any such openings may therefore result in a significant reduction of the rate of oxidation. This could provide a high efficiency at a relatively low cost, when compared with the installation of a bulkhead for flooding.

It is recommended that these options be further investigated.

No ALD would be required for the conditioning of the discharge prior to treatment in a wetland system. Implementation of a wetland system may however be restricted due to restricted space within the valley. As an alternative, a conventional treatment system, operated during the low flow season only, may be considered. However, since the primary source is active oxidation, such an option would have long term implications of high operating costs.

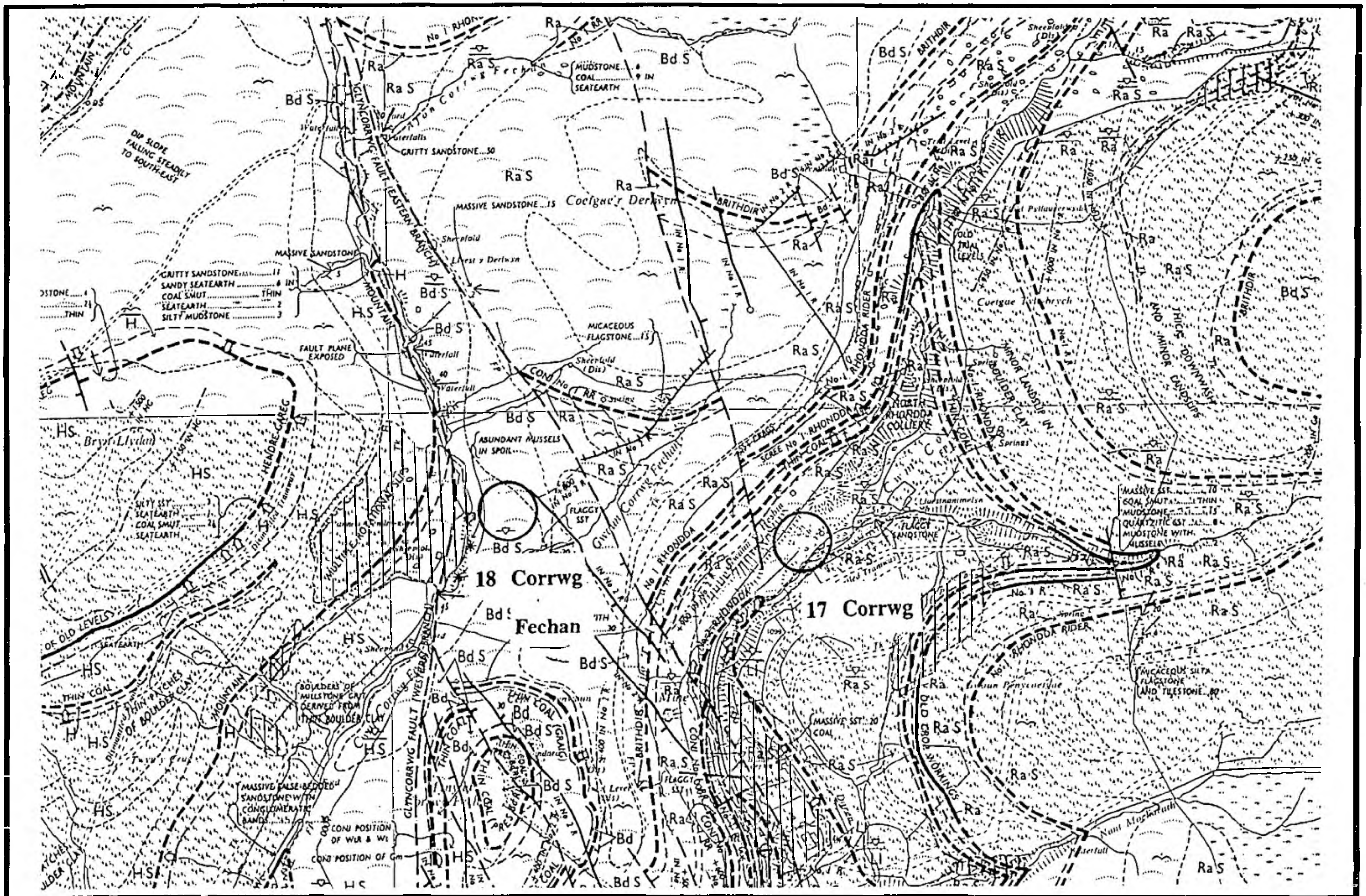
**Capital cost**

| | |
|---|---|
| Bulkhead for flooding/oxygen | £ 15,000 |
| Wetland/settlement .05Ha | £ 15,000 |
| Pipeline 100m | £ 6,000 |
| | £ 36,000 |

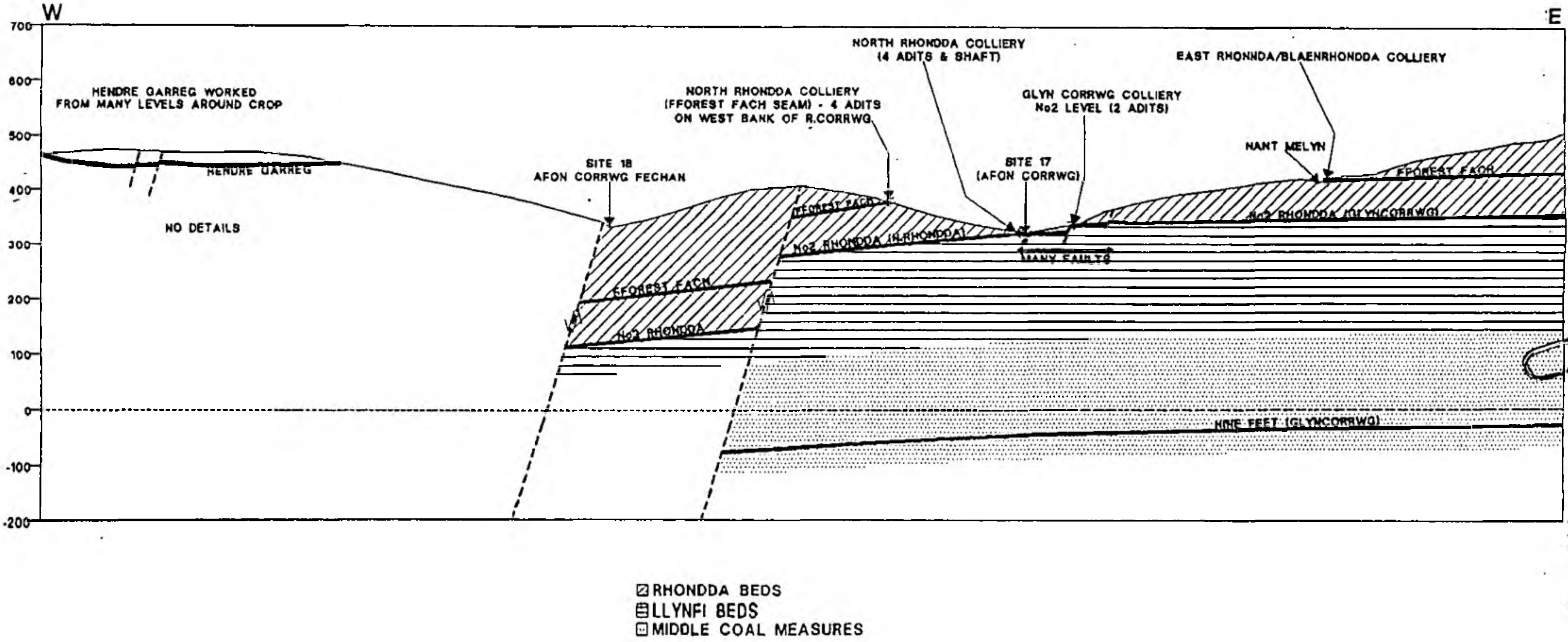
Note that a bulkhead would require similar bulkhead treatment as Site 17A.

**Operating/Maintenance Cost**

| | |
|---|---|
| Depreciation @ 10% of capital cost | £3,600 |
| Maintenance 6 man days/year @ £250/day | £1,500 |
| | £5,100 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 18.1 |
|---|---|---|---|
| SRK | | SITE 18: CORRWG FECHAN | |




| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN CONSULTING ENGINEERS | | SITE 18: CORRWG FECHAN WEST-EAST SECTION | Figure .8.1b |

Site 18, Section 4. Discharge Water Quality and Load Assessment.

Flows Measured at Cefn Hengoed

| | River Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.5 |
| Oct | 8.9 | 7.7 |
| Nov | 15.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 8.8 | 7.7 |
| May | 4.7 | 6.6 |
| Jun | 8.0 | 7.9 |

Site #: 18
Site : Corrwg Fechan

| | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.006 | 0.041 | 15 | 108 | 0.123 | | | | | | | 11.5 | 1.42 | | 0.174 | 3.3 | 0.003 | 21.4 | 0.02 | 0.000 | 136 | 2.1 |
| Aug | 0.005 | 0.039 | 14 | 103 | 0.118 | 6.5 | 11.06 | 9.3 | 25 | 6.7 | 131 | 11.2 | 1.31 | 1.540 | 0.154 | 3.0 | 0.003 | 23.4 | 0.019 | 0.000 | 121.4 | 1.7 |
| Sep | 0.006 | 0.035 | 15 | 91 | 0.143 | | | | | | | 11.5 | 1.64 | | 0.174 | 3.3 | 0.003 | 21.3 | 0.02 | 0.000 | 136 | 2.1 |
| Oct | 0.006 | 0.076 | 16 | 200 | 0.072 | | | | | | | 11.5 | 0.83 | | 0.179 | 3.4 | 0.003 | 20.8 | 0.02 | 0.000 | 136 | 2.1 |
| Nov | 0.007 | 0.128 | 18 | 336 | 0.051 | | | | | | | 11.5 | 0.59 | | 0.209 | 4.0 | 0.004 | 17.8 | 0.02 | 0.000 | 136 | 2.5 |
| Dec | 0.007 | 0.141 | 19 | 370 | 0.050 | | | | | | | 11.5 | 0.57 | | 0.224 | 4.3 | 0.004 | 16.6 | 0.02 | 0.000 | 136 | 2.6 |
| Jan | 0.009 | 0.114 | 22 | 299 | 0.070 | | | | | | | 11.5 | 0.80 | | 0.255 | 4.9 | 0.005 | 14.4 | 0.02 | 0.000 | 136 | 3.0 |
| Feb | 0.008 | 0.089 | 22 | 232 | 0.085 | 7.0 | 16.35 | 9.6 | 52.7 | 7.3 | 123.99 | 10.5 | 0.89 | 2.709 | 0.226 | 4.3 | 0.004 | 15.0 | 0.018 | 0.000 | 141.9 | 3.1 |
| Mar | 0.006 | 0.058 | 16 | 153 | 0.094 | | | | | | | 11.5 | 1.09 | | 0.184 | 3.5 | 0.004 | 20.3 | 0.02 | 0.000 | 136 | 2.2 |
| Apr | 0.006 | 0.049 | 16 | 129 | 0.107 | | | | | | | 11.5 | 1.24 | | 0.178 | 3.4 | 0.003 | 20.6 | 0.02 | 0.000 | 136 | 2.1 |
| May | 0.005 | 0.040 | 13 | 105 | 0.111 | | | | | | | 11.5 | 1.28 | | 0.150 | 2.9 | 0.003 | 24.8 | 0.02 | 0.000 | 136 | 1.8 |
| Jun | 0.006 | 0.043 | 16 | 112 | 0.124 | 6.1 | 2.8 | 9.9 | 145 | 6.8 | 127 | 12.9 | 1.60 | 0.610 | 0.205 | 3.9 | 0.004 | 20.4 | 0.019 | 0.000 | 145 | 2.3 |
| mean | 0.006 | 0.071 | 201 | 2239 | 0.096 | | | | | | 127.3 | 11.5 | 1.105 | | 2.315 | 44.3 | 0.044 | 19.7 | 0.02 | 0.004 | 136 | 27.5 |
| min. | 0.005 | 0.035 | | | 0.050 | | | | | | | | 0.575 | | | | | 14.4 | | | | |
| max. | 0.009 | 0.141 | | | 0.143 | | | | | | | | 1.641 | | | | | 24.8 | | | | |

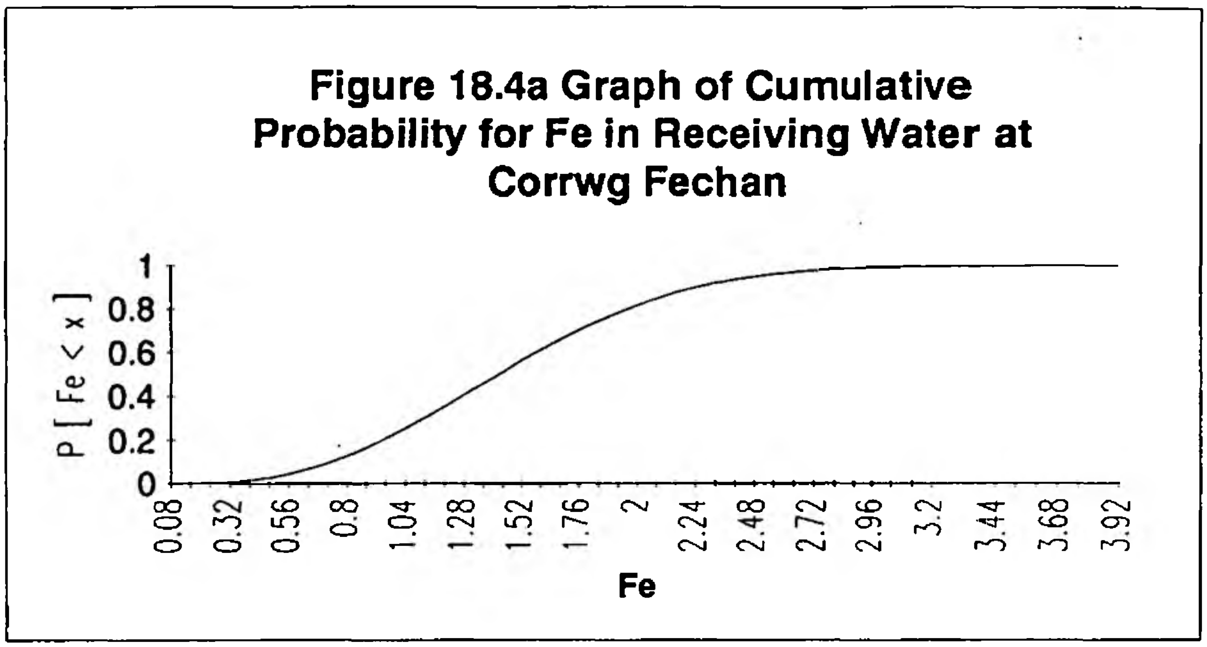


Figure 18.4a Graph of Cumulative Probability for Fe in Receiving Water at Corrwg Fechan
P [ Fe < x ]
1
0.8
0.6
0.4
0.2
0
0.08 0.32 0.56 0.8 1.04 1.28 1.52 1.76 2 2.24 2.48 2.72 2.96 3.2 3.44 3.68 3.92
Fe

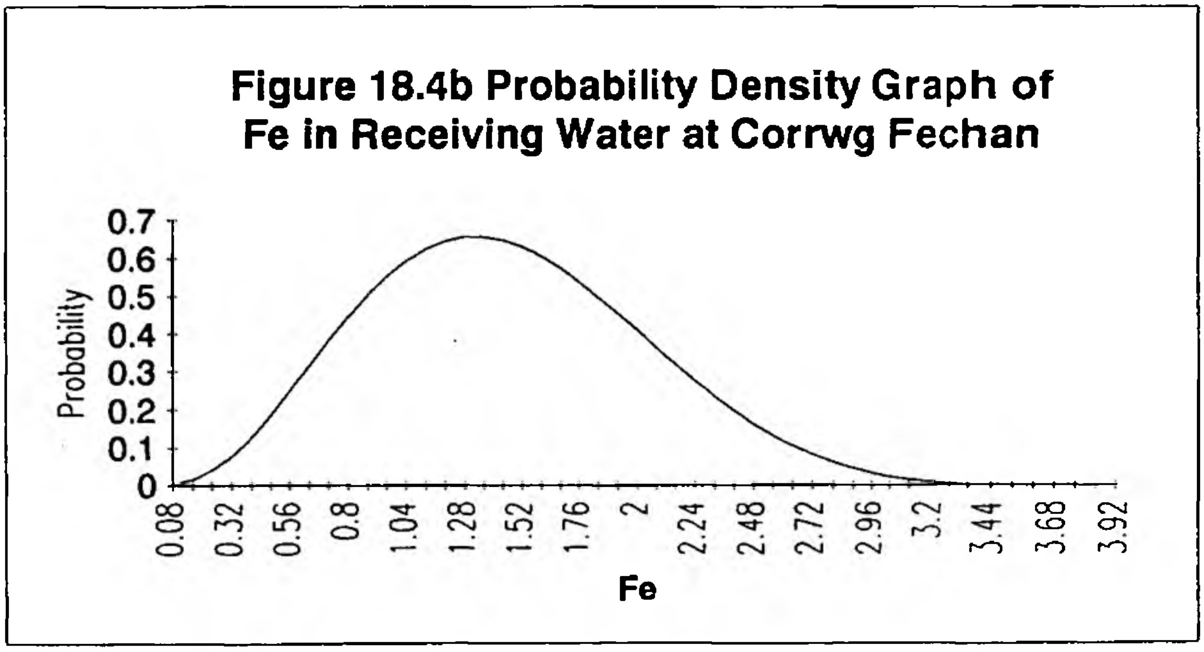


Figure 18.4b Probability Density Graph of Fe in Receiving Water at Corrwg Fechan
Probability
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.08 0.32 0.56 0.8 1.04 1.28 1.52 1.76 2 2.24 2.48 2.72 2.96 3.2 3.44 3.68 3.92
Fe

10

10

## SITE 19 - GWYNFI

### 19.1 GEOLOGY AND MINING

The discharge appears to be coming from a collapsed adit. The geological map shows adits on the outcrop of the No. 2 Rhondda seam, immediately to the east of the western branch of the Glyncorrwg Fault. The mine plans for the area show an adit of the Corrwg Rhondda Colliery at the discharge site, at an elevation of 286m AOD. This was not the lowest point of access to these workings as an adit existed to the south west at an elevation of 261m. The reason for there being no discharge at that point is not known.

The Cefn Mawr syncline (which runs roughly west-east) to the south of Sites 17 and 18 is to the north west of Site 19. At Site 19, the strata dip generally north north-west into the syncline. A shaft to the south of Glyncorrwg Village is on the lowest point of the syncline. There is a landslip area marked on the geological map, the eastern (down slip) edge of which coincides with the area of the discharge (Fig 19.1 and 19.1b/c). The collapse at the adit has been extensive and has involved circular failure of previous landslip material.

### 19.2 CONTAMINATION SOURCES

The contamination sources would appear to be generally unflooded workings on the No2 Rhondda Seam which are mobilising active oxygenation products due to recharge from rainfall.

### 19.3 HYDROGEOLOGICAL MODEL

The dip of the coal seams and the extent of the workings means that the majority of recharge to ground water is likely to eventually flow towards the present discharge point. The workings will have prevented ground water recovering to its pre-mining elevation, therefore there is likely to be some upward flow from the underlying Llynfi beds, but these rocks are of low permeability so yields will not be large. Hydrologically, it can be expected that the discharge flow will respond to rainfall patterns.

## 19.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge water quality appears to show some relationship to the flow rate. Increased concentrations are indicated for increased flow rates. However, for the purpose of this assessment an average iron concentration of 7.3mg/l was assumed. The corresponding sulphate concentration is estimated at about 126mg/l. Whilst the discharge is at a near neutral pH, the contained alkalinity is relatively low. Based on the observed water quality for the discharge, it is anticipated that ongoing, active oxidation is the primary mechanism for contaminant release. The flow rate at the time of the site visit was estimated to be about 4.3Ml/day.

The annual load of iron released to Nant Gwynfi is estimated to be about 3 tonnes and the sulphate loading is estimated to be in the order of 55 tonnes.

## 19.5 ENVIRONMENTAL COSTS AND BENEFITS

The site is a small stream in an afforested area with no angling interest. Because of steep flow and being sited at the top of the tributary, this is only of very limited brown trout spawning value.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 1 | No impact on angling or spawning |
| Accessibility - footpaths | 3 | Path within 100m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 3 | Open valley, staining noticeable |
| Proximity to built up area | 1 | Houses > 300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: Unlikely to be seen by casual visitors. There is a forested area nearby in the valley and the forestry tracks are probably used by local walkers and riders. It is a clean mountain stream upstream of the discharge, but the effects are not very noticeable by the time the stream passes through the village.

The low scores indicates a low level of aesthetic and fisheries benefit from remediation.

## 19.6 OPTIONS FOR REMEDIATION AND COSTS

It is considered unlikely that flooding of the mine workings which are generating the observed loading could be practically achieved due to the extensive outcrop workings. Oxygen exclusion by entry limitation may however be more readily achievable.

Based on the observed water quality, an ALD would not be required for the conditioning of the discharge water. The steep topography of the valley sides will however, limit the size of the settling basin. To achieve effective removal of the iron in a wetland system may require a surface area in the order of 0.1Ha. It may be feasible to consider a smaller treatment basin to allow partial removal of the iron during high flow conditions.

At low flow conditions, the effective iron removal would be greater (higher retention) and the in-stream EQS could be achieved. It may be necessary to recondition the adit and install a suitable plug to allow effective collection and control of the discharge. However, this adit is on the toe of a deteriorating landslip.

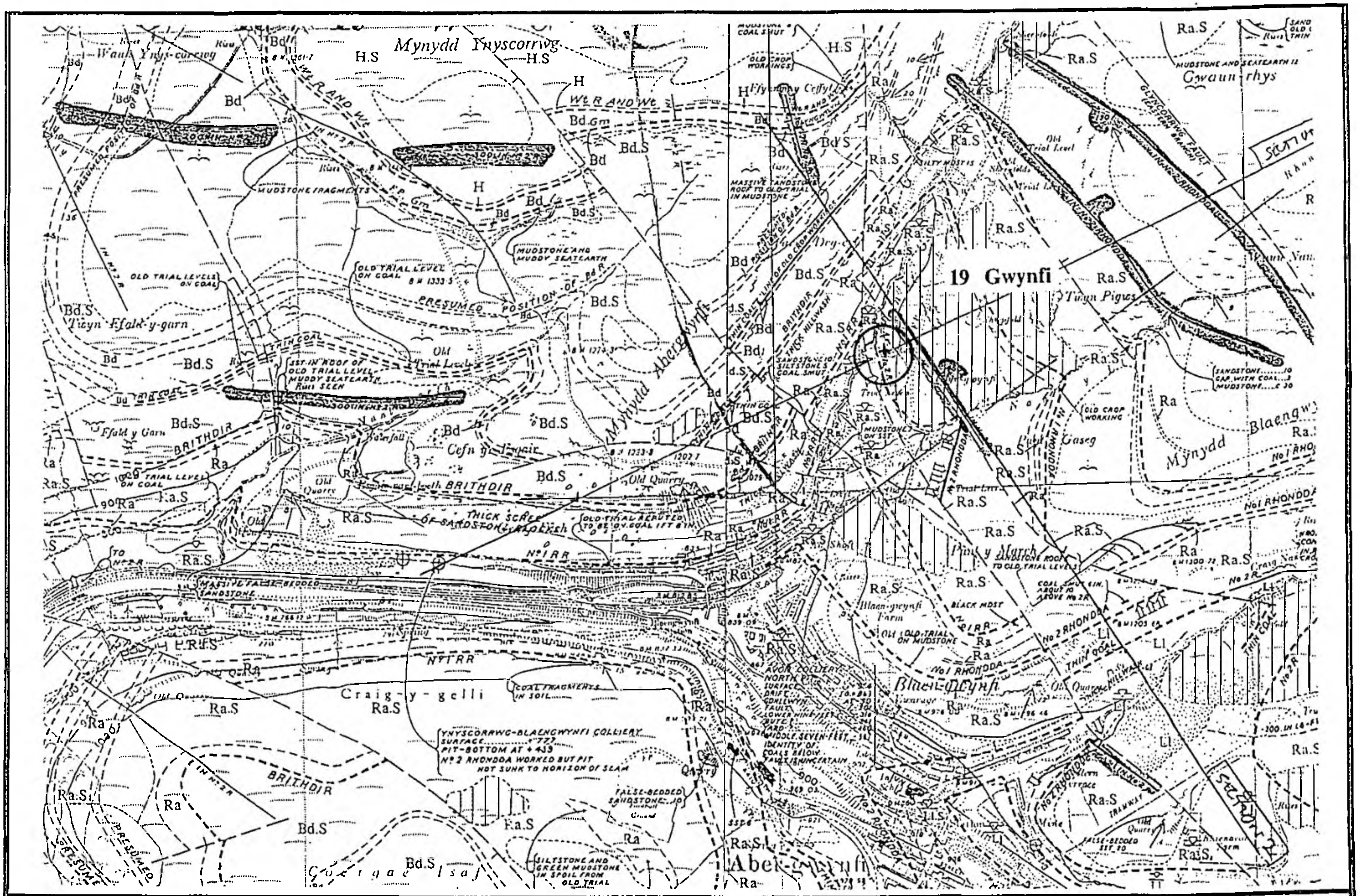
A combination of oxygen exclusion and settlement/wetland is the preferred approach.

**Capital Costs**

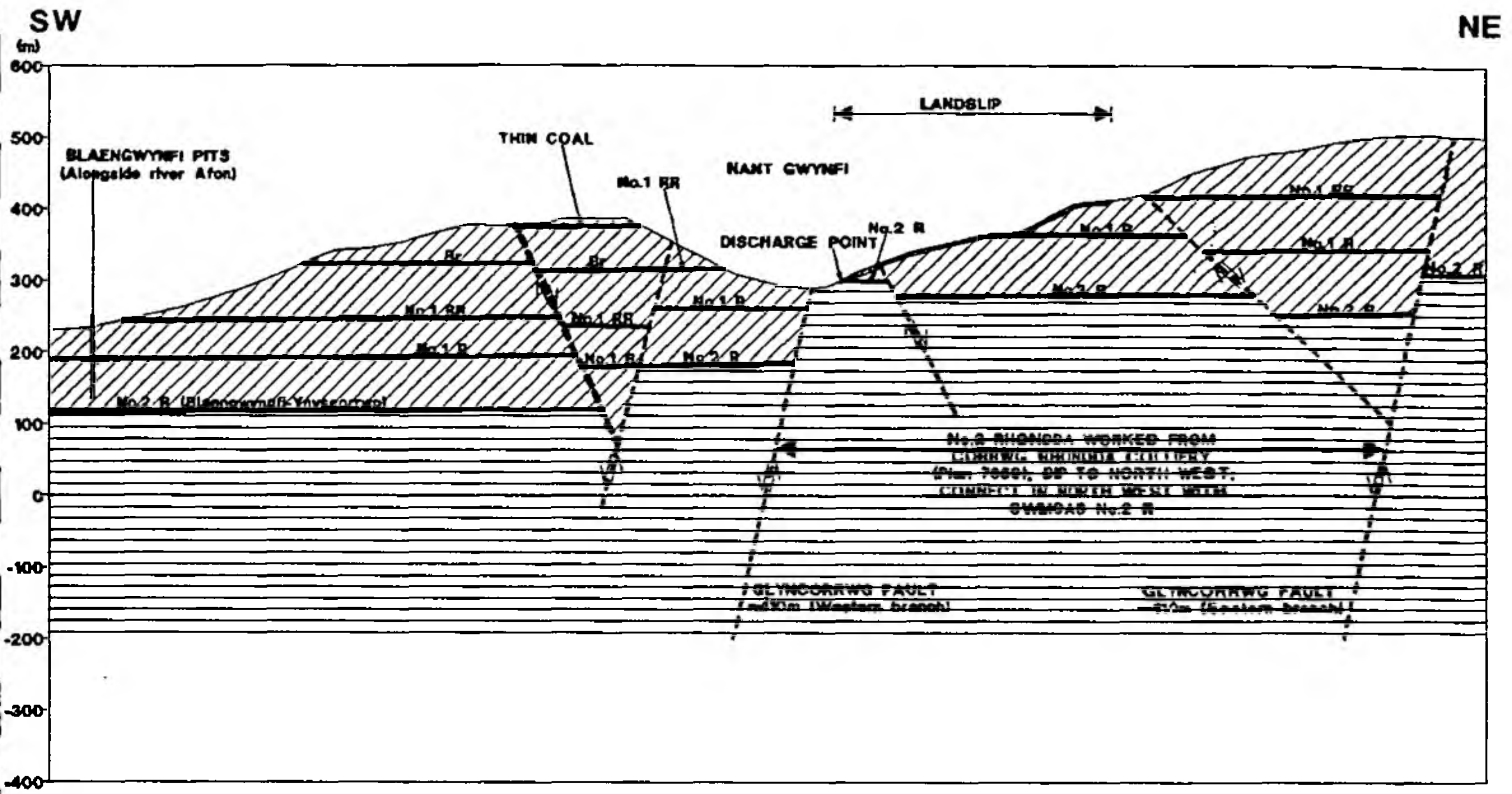
| | |
|---|---|
| Oxygen exclusion/control bulkhead | £ 10,000 |
| Pipeline 200m | £ 15,000 |
| Settlement/wetland 0.1Ha | £ 25,000 |
| | £50,000 |

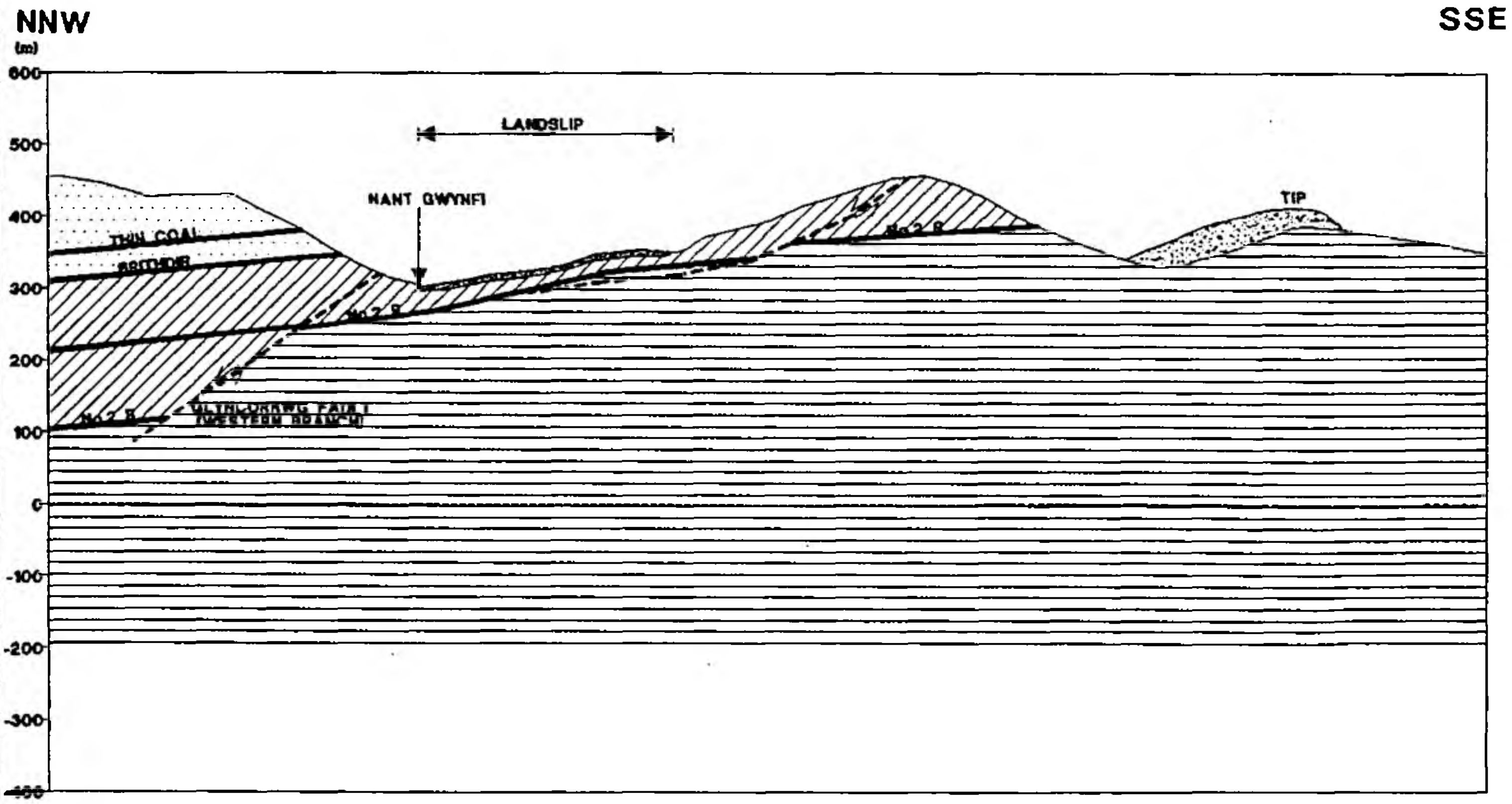
**Operating/Maintenance Cost**

| | |
|---|---|
| Depreciation 10% of capital cost | £5,000 |
| Maintenance 6 man days/year @ £250/day | £1,500 |
| | £6,500 |



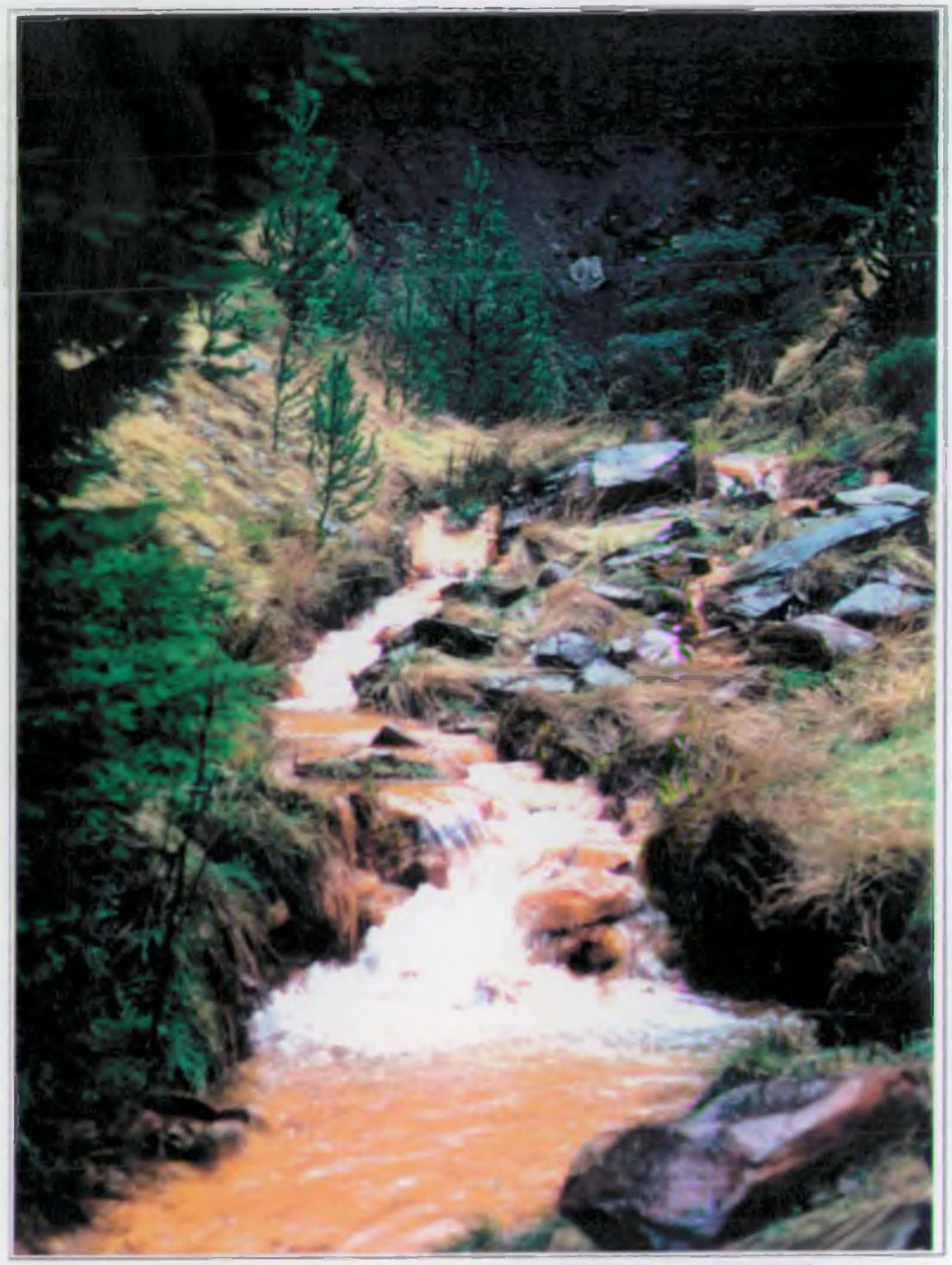

| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 19.1 |
|---|---|---|---|
| SRK | | **SITE 19: GWYNFI** | |




BRITHDIR BEDS
RHONDDA BEDS
LLYNFI BEDS

| DATE: 18/3/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Scale 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN CONSULTING ENGINEERS | | SITE 19: NANT GWYNFI SW-NE & NNW-SSE SECTIONS | Figure 19.1b/c |



DISCHARGE BEFORE ENTERING RIVER

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 19.1 D |
|---|---|---|---|
| SRK | | SITE 19: NANT GWYNFI | |

# Site 19, Section 4. Discharge Water Quality and Load Assessment.

Site #: 19
Site : Gwynfi

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.013 | 0.050 | 33 | 131 | 0.201 | | | | | | | 7.3 | 1.48 | | 0.243 | 4.7 | 0.006 | 13.7 | 0.04 | 0.001 | 126 | 4.2 |
| Aug | 4.6 | 6.9 | Aug | 0.012 | 0.048 | 30 | 126 | 0.194 | 6.8 | 8.3 | 9.2 | 20.4 | 6.6 | 31.0 | 5.2 | 1.01 | 0.589 | 0.159 | 3.0 | 0.003 | 15.0 | 0.048 | 0.001 | 112.2 | 3.4 |
| Sep | 4.1 | 7.5 | Sep | 0.013 | 0.042 | 33 | 111 | 0.230 | | | | | | | 7.3 | 1.69 | | 0.244 | 4.7 | 0.005 | 13.7 | 0.04 | 0.001 | 126 | 4.2 |
| Oct | 8.9 | 7.7 | Oct | 0.013 | 0.093 | 34 | 245 | 0.122 | | | | | | | 7.3 | 0.90 | | 0.251 | 4.8 | 0.005 | 13.3 | 0.04 | 0.001 | 126 | 4.3 |
| Nov | 15.0 | 9.0 | Nov | 0.015 | 0.156 | 40 | 411 | 0.089 | | | | | | | 7.3 | 0.65 | | 0.293 | 5.6 | 0.006 | 11.4 | 0.04 | 0.001 | 126 | 5.0 |
| Dec | 16.5 | 9.6 | Dec | 0.016 | 0.172 | 43 | 452 | 0.086 | | | | | | | 7.3 | 0.63 | | 0.313 | 6.0 | 0.006 | 10.7 | 0.04 | 0.002 | 126 | 5.4 |
| Jan | 13.4 | 11.1 | Jan | 0.019 | 0.139 | 49 | 366 | 0.118 | | | | | | | 7.3 | 0.87 | | 0.361 | 6.9 | 0.007 | 9.3 | 0.04 | 0.002 | 126 | 6.2 |
| Feb | 10.4 | 10.7 | Feb | 0.018 | 0.108 | 47 | 284 | 0.143 | | | | | | | 7.3 | 1.05 | | 0.347 | 6.6 | 0.007 | 9.6 | 0.04 | 0.002 | 126 | 5.9 |
| Mar | 6.8 | 7.9 | Mar | 0.013 | 0.071 | 35 | 187 | 0.158 | 7.5 | 27.9 | 11.3 | 53.5 | 0.6 | 52.0 | 8.5 | 1.50 | 2.100 | 0.334 | 6.4 | 0.006 | 13.0 | 0.027 | 0.001 | 183.4 | 5.7 |
| Apr | 5.8 | 7.7 | Apr | 0.013 | 0.060 | 34 | 157 | 0.178 | | | | | | | 7.3 | 1.31 | | 0.250 | 4.8 | 0.005 | 13.4 | 0.04 | 0.001 | 126 | 4.3 |
| May | 4.7 | 6.5 | May | 0.011 | 0.049 | 29 | 128 | 0.183 | | | | | | | 7.3 | 1.35 | | 0.210 | 4.0 | 0.004 | 15.9 | 0.04 | 0.001 | 126 | 3.6 |
| Jun | 5.0 | 7.9 | Jun | 0.013 | 0.052 | 35 | 136 | 0.200 | 7.4 | 15.9 | 10.1 | 27.5 | 6.5 | 38.0 | 7.3 | 1.48 | 1.032 | 0.253 | 4.8 | 0.005 | 13.1 | 0.035 | 0.001 | 101.1 | 3.5 |
| | | | mean | 0.014 | 0.087 | 442 | 2735 | 0.159 | | | | | | | 7.3 | 1.160 | | 3.260 | 62.4 | 0.062 | 12.7 | 0.04 | 0.016 | 126 | 55.6 |
| | | | min. | 0.011 | 0.042 | | | 0.086 | | | | | | | | 0.634 | | | | | 9.3 | | | | |
| | | | max. | 0.019 | 0.172 | | | 0.230 | | | | | | | | 1.690 | | | | | 15.9 | | | | |

**Figure 19.4a Graph of Cumulative Probability for Fe in Receiving Water at Gwynfi**

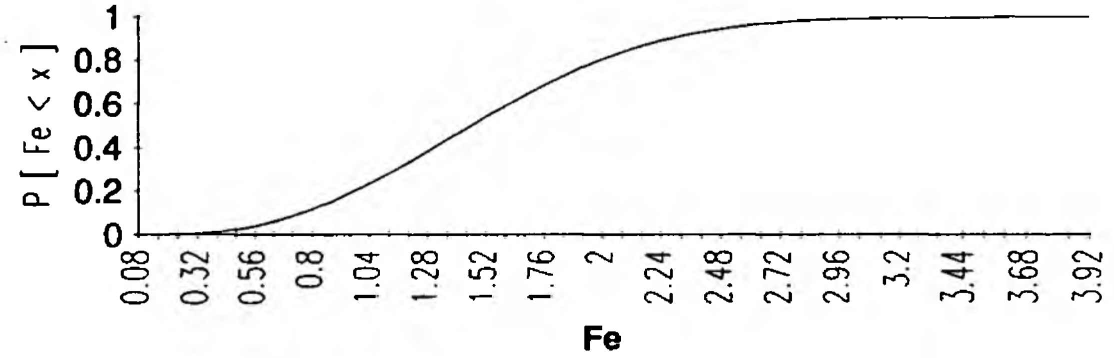
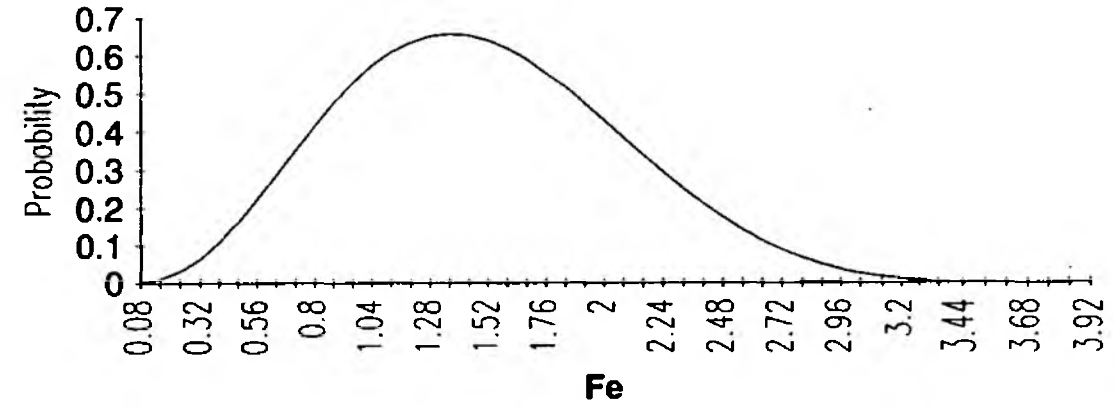



**Figure 19.4b Probability Density Graph of Fe in Receiving Water at Gwynfi**



11

11

# SITE 29 - CATHAN

## 29.1 GEOLOGY AND MINING

Mine water is discharged from a small pipe in the left bank of the River Cathan. There is evidence that an adit existed in the mountain side directly opposite the point of discharge. Along a narrow track ascending the mountainside, another two backfilled or collapsed adits were observed. The uppermost of these was only partially backfilled with broken rock and it is apparent that ingress of oxygen into mine workings could occur easily.

Two coal seams may have been mined in this area. The seams worked were the Duke seam with an average thickness of 0.8m and an un-named thin and discontinuous seam.

A number of abandonment plans of the area indicate that local mines worked the "Ynysarwed" seam. One of the plans refers to the same seam as the Duke seam. The local stratigraphy indicates the latter to be correct with possibly some minor workings in an overlying seam.

The local geology generally dips at 17° to the southeast and a northwest - southeast fault divides the area structurally.

Three collieries exploited the Duke Seam to the south and west of the discharge point, Garnswllt, Tanygarn and Garn No.2. The Cathan Colliery worked the area to the north and east. The Garnswllt and Tanygarn Collieries were accessed using 4 slants from the northern outcrop of the Duke Seam. No direct connection is recorded between these and the Garn No.2 colliery to the west. This colliery has been separated from the Garnswllt and Tanygarn Collieries by a barrier pillar surrounding the fault.

There is no discharge from the right bank of the river at present although a pipe is present which is partially filled with ochre deposits, suggesting a previous discharge. This would be from Cathan Colliery. No direct link between the western workings and those on the east bank is apparent from the mine plans.

These mines are mostly recent licensed mines, the most recent being the Tanygarn, which was closed in 1990.

## 29.2 CONTAMINATION SOURCES

The contamination sources are likely to be primarily active oxidation in the unflooded and near surface flooded workings in the area of the Tan-y-Garn and Garnswllt Collieries.

## 29.3 HYDROGEOLOGICAL MODEL

The ground water catchment area appears to be small. It is banked on the west by a major fault which is also a barrier pillar in the mine (Fig 29.1b/c). The catchment extends to the south where the Rhondda beds are overlain by Pennant sandstones.

It is likely that the main part of the flooded workings remain fairly static hydraulically and that recharge from rainfall will flow towards the north and through the upper part of the flooded and unflooded workings. The flow then decants from the lowest workings.

## 29.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge has a slightly acidic pH (about 5.7) with an elevated iron concentration, about 72mg/l. The sulphate concentration is also elevated at about 480mg/l. At the observed pH conditions, partial neutralization and accumulation of oxidation products is occurring within the mine workings. It is considered possible that these alkaline materials could be depleted or armoured at some stage in the future and that enhanced oxidation and acid generating conditions may develop.

The discharge flow rate was estimated to be in the order of 0.4Ml/day at the time of the site visit. It is estimated that the total iron loading from the site is in the order of 6.2 tonnes per year, and the corresponding sulphate loading is about 483 tonnes. Based on the observed water quality data, it is anticipated that a large component of the contaminant release is generated as a result of ongoing oxidation above the water table.

## 29.5 ENVIRONMENTAL COSTS AND BENEFITS

Although there are about two miles of stream above the discharge, the local water bailiffs have not noted this as a spawning area. It is too small for any angling interest and it is of limited spawning value.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 2 | Possible impact on spawning |
| Accessibility - footpaths | 5 | Path within 10m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 5 | Spectacular staining |
| Proximity to built up area | 1 | Houses > 300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: Not likely to be seen by casual visitors to area. Attractive setting of woods and open areas by river, but dramatic impact of discharge. Some litter along banks and in woods.

The general scores indicate same benefit from remediation in terms of aesthetics.

## 29.6 OPTIONS FOR REMEDIATION AND COSTS

Based on the appearance of the exposed rock face at the point of discharge, it is considered unlikely that the water table would significantly be increased by the installation of a bulkhead. It is considered that sealing of any openings to the atmosphere would be significantly more cost effective and should be given priority. If additional flooding can be achieved, this would be beneficial and the discharge should be taken from the highest water level.

It is considered that an ALD would be required for the conditioning of the mine water prior to treatment in a wetland system. This can be achieved by reconditioning the lowest of the adits and backfilling it with finely crushed limestone.

The adit can then be sealed off with a suitable bulkhead to allow discharge near the top of the adit. This would ensure full saturation of the limestone for effective contact. From this location, sufficient head would be available to cascade the flow for aeration purposes. The settling basin could be constructed on the left bank of the river, between the river and the road. This location would also ensure interception of ferruginous seeps that were observed at the toe of the road embankment. A settling basin in the order of 0.1 to 0.2Ha should be adequate to achieve the discharge objective.

It is possible that with the geometry of the workings and the decanting discharge, sulphate reduction in the mine workings could be done. This would achieve a partial reduction in iron loading but would have to be investigated further. This would be an expensive ongoing cost.

While the dilution in the receiving flow is estimated to be adequate to allow the implementation of a diffuse discharge system, it is considered that such a system would have a low rate of success because of the elevated iron concentration in the discharge. It is likely that the diffusing mechanism would be prone to plugging and staining of the river gravels would occur. This option should be investigated further.

**Capital Costs**

| | |
|---|---|
| 3 x oxygen exclusion | £ 15,000 |
| 1 x control bulkhead | £ 5,000 |
| ALD x 100m | £ 2,500 |
| Aeration system | £ 2,000 |
| Wetland 0.2Ha | £ 50,000 |
| | £ 74,500 |

**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation 10% of capital cost | £ 7,450 |
| Maintenance 6 man days/year @ £250/day | £ 1,500 |
| | £ 8,950 |

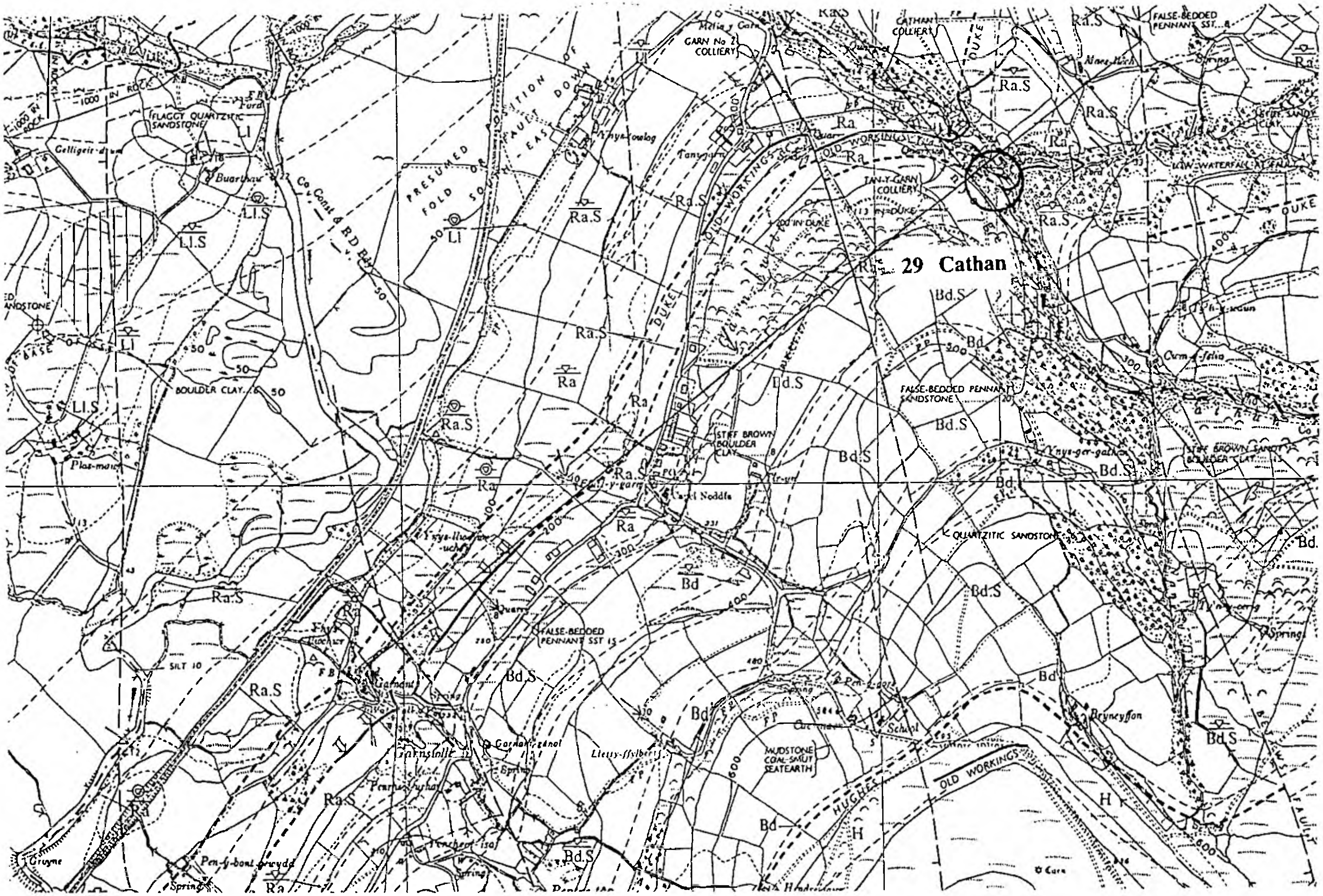
**Sulphate reduction (using sewage sludge)**

**Capital Cost**

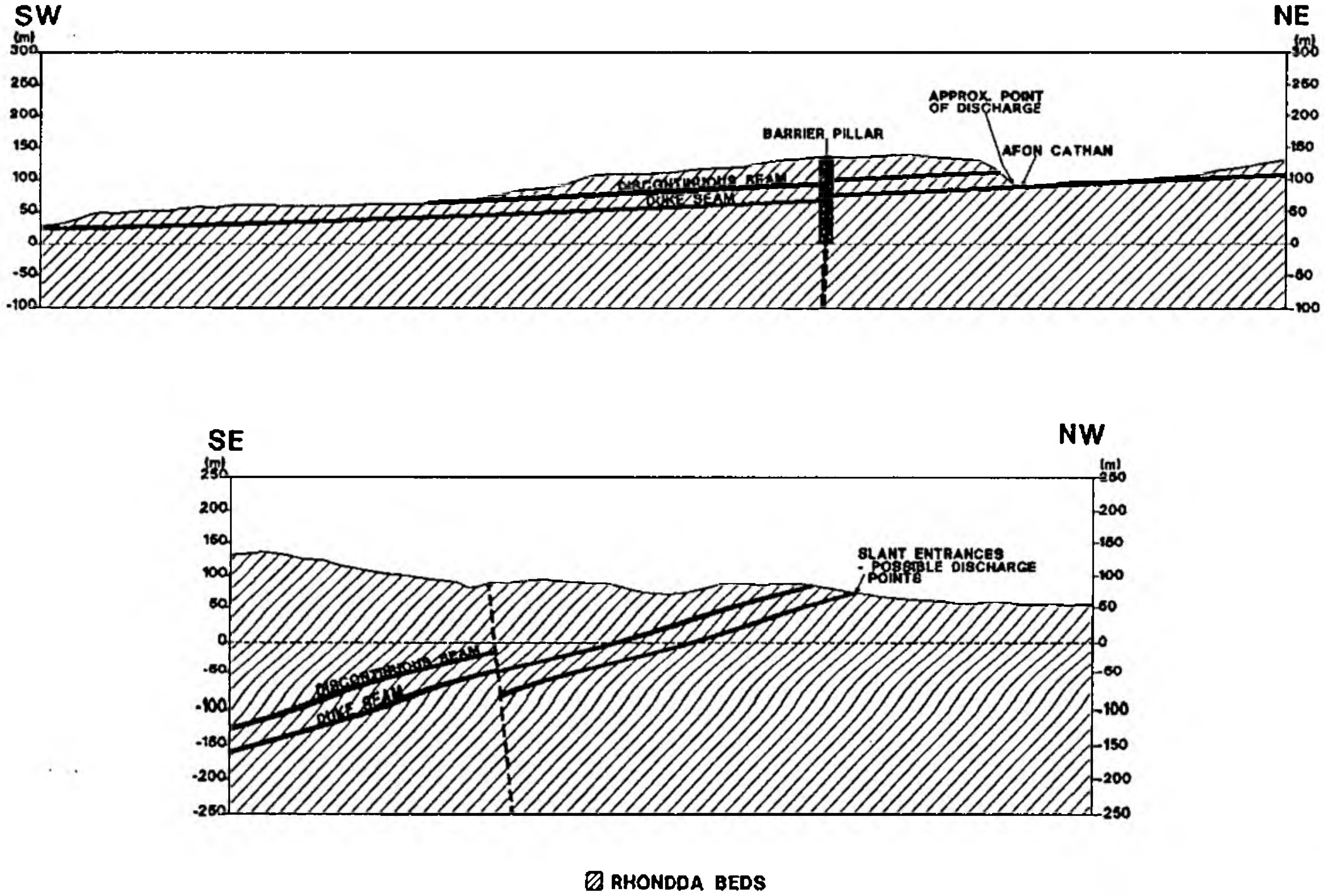
| | |
|---|---|
| 4 x boreholes x 400m | £150,000 |
| Substrate feed system | £ 40,000 |
| 4 x headworks | £20,000 |
| | £210,000 |

**Operating/Maintenance costs**

| | |
|---|---|
| £2,000/t for iron removed (ft) | £12,000 |
| Depreciation/maintenance 10% of capital | £21,000 |
| | £33,000 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 29.1 |
|---|---|---|---|
| SRK | | SITE 29: CATHAN | |




| DATE: 5/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN CONSULTING ENGINEERS | | SITE 29: CATHAN SW-NE & SE-NW | Figure 29.1b/c |

DISCHARGE PIPE TO RIVER

SECOND PIPE (Not discharging) ON
OPPOSITE BANK, STAINING IN RIVER

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 29:CATHAN | Figure 29.1 D |

# Site 29, Section 4. Discharge Water Quality and Load Assessment.

| | River Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | 4.8 | 7.5 |
| Aug | 4.6 | 6.9 |
| Sep | 4.1 | 7.5 |
| Oct | 5.9 | 7.7 |
| Nov | 16.0 | 9.0 |
| Dec | 16.5 | 9.6 |
| Jan | 13.4 | 11.1 |
| Feb | 10.4 | 10.7 |
| Mar | 6.8 | 7.9 |
| Apr | 5.8 | 7.7 |
| May | 4.7 | 6.5 |
| Jun | 6.0 | 7.9 |

Site #: 29
Site : Cathan

Site #: 29
Site : Cathan

| | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 0.002 | 0.194 | 6 | 510 | 0.012 | 6.2 | 49.0 | 32.0 | 42.0 | 5.7 | 24.6 | 73.0 | 0.91 | 1.200 | 0.470 | 9.0 | 0.009 | 134.2 | 1.000 | 0.006 | 444.0 | 2.9 |
| Aug | 0.002 | 0.187 | 6 | 490 | 0.012 | 7.1 | 48.4 | 38.4 | 47.2 | 5.5 | 15.7 | 61.0 | 0.73 | 1.750 | 0.360 | 6.9 | 0.007 | 146.4 | 0.657 | 0.004 | 515.0 | 3.0 |
| Sep | 0.008 | 0.164 | 6 | 432 | 0.015 | | | | | | | 71.9 | 1.06 | | 0.465 | 8.9 | 0.009 | 133.7 | 0.95 | 0.006 | 483 | 3.1 |
| Oct | 0.003 | 0.361 | 7 | 949 | 0.007 | | | | | | | 71.9 | 0.50 | | 0.477 | 9.1 | 0.009 | 130.2 | 0.95 | 0.006 | 483 | 3.2 |
| Nov | 0.003 | 0.608 | 8 | 1593 | 0.005 | | | | | | | 71.9 | 0.35 | | 0.558 | 10.7 | 0.011 | 111.4 | 0.95 | 0.007 | 483 | 3.7 |
| Dec | 0.003 | 0.667 | 8 | 1752 | 0.005 | | | | | | | 71.9 | 0.34 | | 0.596 | 11.4 | 0.011 | 104.2 | 0.95 | 0.008 | 483 | 4.0 |
| Jan | 0.004 | 0.540 | 10 | 1418 | 0.007 | | | | | | | 71.9 | 0.48 | | 0.686 | 13.1 | 0.013 | 90.5 | 0.95 | 0.009 | 483 | 4.6 |
| Feb | 0.004 | 0.419 | 9 | 1101 | 0.008 | | | | | | | 71.9 | 0.60 | | 0.661 | 12.6 | 0.013 | 94.0 | 0.95 | 0.009 | 483 | 4.4 |
| Mar | 0.003 | 0.276 | 7 | 726 | 0.009 | 7.7 | 50.0 | 42.5 | 54.9 | 5.8 | 18.2 | 61.6 | 0.76 | 1.951 | 0.556 | 10.6 | 0.011 | 127.0 | 1.203 | 0.008 | 488.7 | 3.3 |
| Apr | 0.003 | 0.232 | 7 | 611 | 0.011 | | | | | | | 71.9 | 0.77 | | 0.476 | 9.1 | 0.009 | 130.6 | 0.95 | 0.006 | 483 | 3.2 |
| May | 0.002 | 0.189 | 6 | 495 | 0.011 | | | | | | | 71.9 | 0.80 | | 0.400 | 7.7 | 0.008 | 155.2 | 0.95 | 0.005 | 483 | 2.7 |
| Jun | 0.003 | 0.201 | 7 | 529 | 0.013 | | | | | | | 71.9 | 0.91 | | 0.487 | 9.3 | 0.009 | 127.7 | 0.95 | 0.006 | 483 | 3.3 |
| mean | 0.003 | 0.336 | 86 | 10606 | 0.010 | | | | | | | 71.9 | 0.683 | | 6.2 | 118.4 | 0.118 | 123.7 | 0.95 | 0.082 | 483 | 41.5 |
| min. | 0.002 | 0.164 | | | 0.005 | | | | | | | | 0.339 | | | | | 90.5 | | | | |
| max. | 0.004 | 0.667 | | | 0.015 | | | | | | | | 1.061 | | | | | 155.2 | | | | |

**Figure 29.4a Graph of Cumulative Probability for Fe in Receiving Water at Cathan**

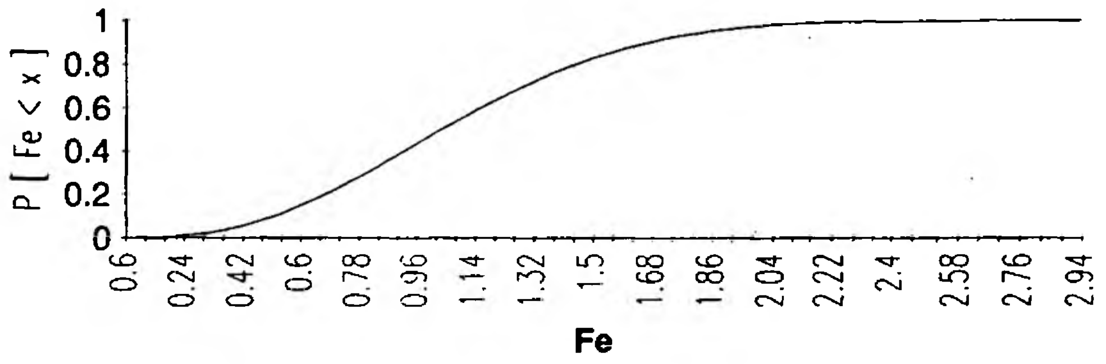
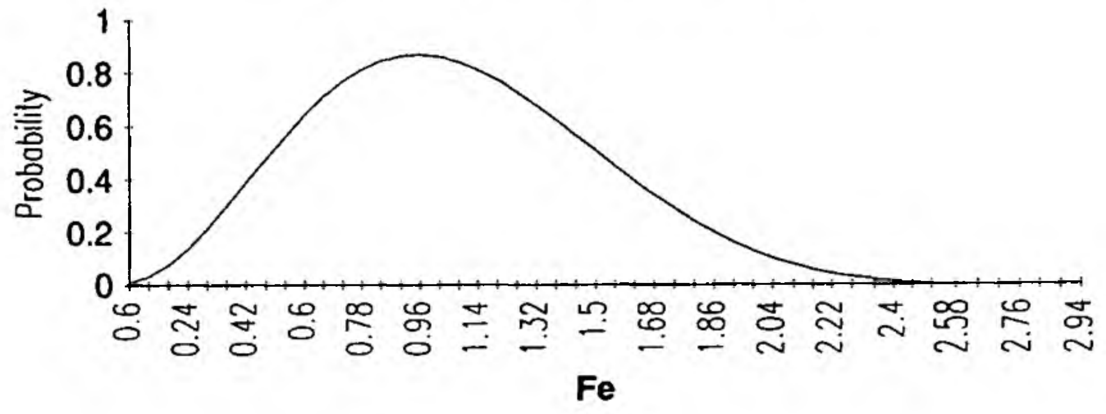
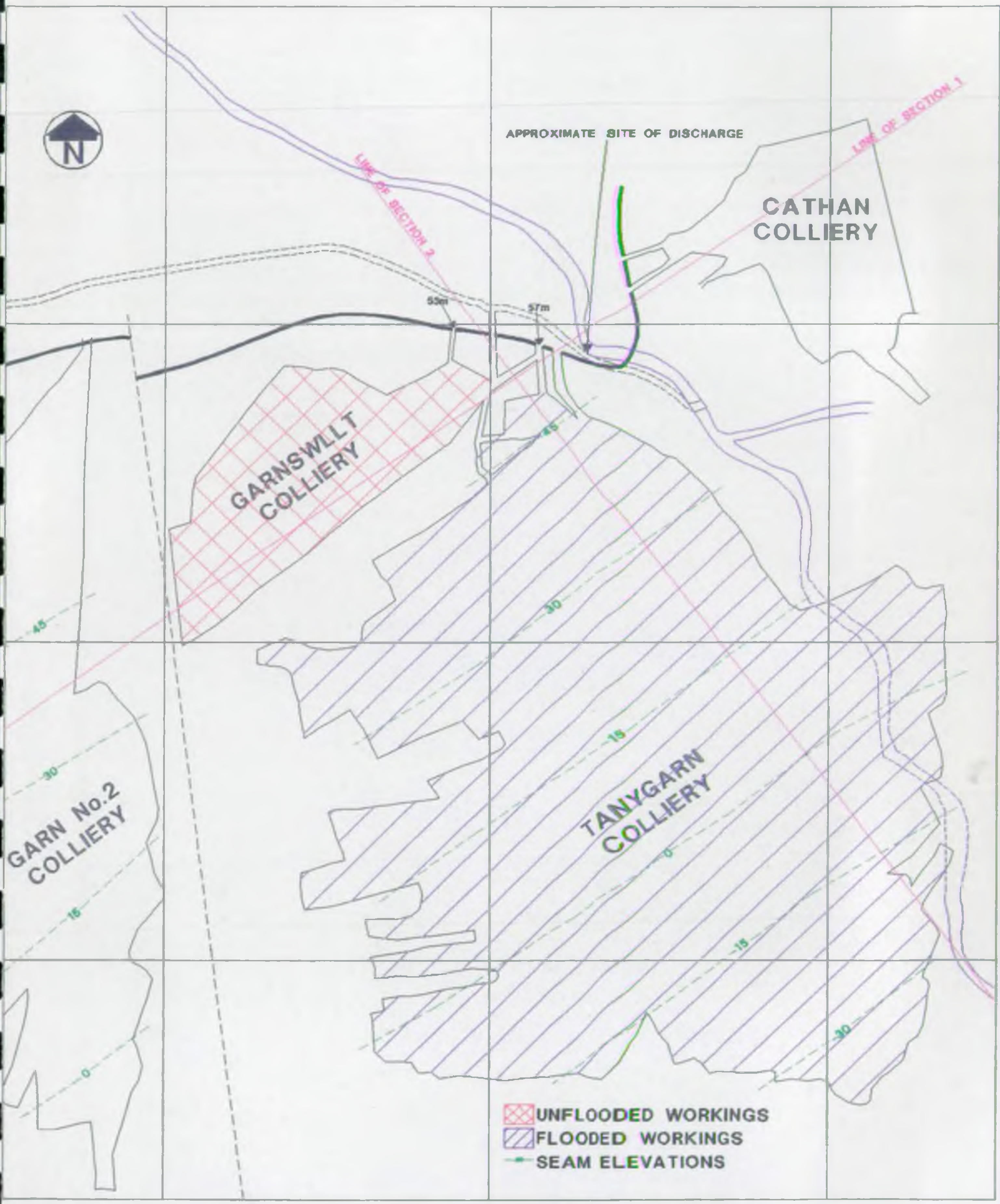



**Figure 29.4b Probability Density Graph of Fe in Receiving Water at Cathan**






| DATE: 29/3/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 29: CATHAN<br>EXTENT OF WORKINGS IN DUKE SEAM | Figure<br>29.1e |

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## SITE 30 - MORLAIS

### 30.1 GEOLOGY AND MINING

Mine water discharges directly from a disused mine shaft via a prepared overflow. The discharge flows along an open channel to the Morlais River immediately upstream from a railway bridge. At the point where the discharge enters the river, the river is subject to tidal flows.

The discharge is coming directly from the workings of the Morlais Colliery, located on the west side of the River Loughor in Dyfed. Morlais Colliery was latterly linked underground and worked with Brynlliw Colliery, situated on the east side of the River Loughor in W Glamorgan. The collieries were the last deep mines to work in the area and were abandoned in September 1983. Following closure, the shafts at Morlais were backfilled with limestone.

The mines worked the Swansea 3 Ft, Swansea 6 Ft and Swansea 2 Ft Seams, all of which are hosted by the Upper Coal Measures. Structurally, the workings lie within the Gowerton and Gorseinon synclines and the seams outcrop to the south and north within 10km. The area is affected by north-south striking faults which divide the basin into large blocks. The Morlais and Brynlliw workings are in the deepest part of the basin and the discharge at Morlais, being just above sea level, is the lowest point of access to the workings in the area.

During the period of mining, it was found that the entire area was linked hydrogeologically. As a consequence, a large pumping station was maintained at Clydach Merthyr Colliery (12km to the east) until Brynlliw/Morlais closed. This was done to intercept water at shallow depth and reduce load on the deep mines. Some mining continues at outcrop to the north, particularly at Graig Merthyr Colliery.

### 30.2 CONTAMINATION SOURCES

The mine system is extensive and water is draining from the synclinal basin to Morlais. It can be expected that the contamination sources are also very extensive and will include dissolution of stored product as well as active oxidation.

## 30.3 HYDROGEOLOGICAL MODEL

As mentioned above, drainage underground is from a very large area. The site is in the flood plain of the River Loughor and therefore receives vertical recharge from rainfall onto the whole mining area as well as lateral recharge due to regional ground water flow from the hills. Both sources provide the hydraulic head creating the extension flow at Morlais.

## 30.3 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The elevated alkalinity observed for the discharge and its neutral pH are consistent with the fact that the shaft had been backfilled with limestone. The iron concentration in the discharge is elevated and does appear to fluctuate, which would suggest that there are no solubility controls present. This is probably a result of the high flow rate, resulting in a relatively short retention time for the iron bearing mine waters within the limestone filled zone and consequently, insufficient time for the precipitation of a controlling substance such as siderite. For the purpose of this assessment, an average concentration of about 62mg/l for iron was assumed.

At the time of the site visit, the discharge flow rate was estimated at about 22 to 26Ml/day. The estimated annual iron loading discharged to the Morlais river is estimated to be in the order of 400 tonnes and the corresponding sulphate loading is 6,000 tonnes. Based on the observed water quality data and the sections through the mine workings, it is apparent that dissolution of stored oxidation products as well as ongoing oxidation are contributing to the release of iron to the discharging mine waters.

It is estimated that, on average, the iron concentration in the Morlais river downstream from the discharge point is an order of magnitude higher than the 1mg/l criterion and that a significant load reduction would be required to meet this objective.

The total annual aluminium loading for this site is estimated at about 2 tonnes. While this is significant, at the high flow rate the concentration remains low.

## 30.4 ENVIRONMENTAL COSTS AND BENEFITS

There may be some informal or casual angling on this small river but it is not sufficient for an angling club to take an interest. There is some concern that the ferruginous area may pose a barrier to the migration of salmon and sea trout. Some fish do get past, however, for small numbers of salmon par have been caught by electrofishing and there have been some cases of poaching for salmon and sea trout. Perhaps adult migration takes place during high flows in autumn and early winter. The river certainly has scope for improvement as a sea trout fishery.

One option for treatment is to divert the ferruginous discharge for treatment and settlement in reed beds and then discharge direct to the estuary. This would have the benefit of removing any barrier to migratory fish entering the River Morlais. In the estuary, any treated ferruginous discharge would possibly have an effect on the food of estuary birds and on the shellfish exploited to the estuary would be reduced, however, then the settlement of iron in the estuary mud should be less than that which occurs at present.

If the water quality improvement resulting from minewater treatment allowed access to migratory trout and occasional salmon, then about two miles of river would be worth renting to anglers.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 4 | Some reduction in fish/fishbarrier |
| Accessibility - footpaths | 1 | Path within 1km |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 5 | Very heavily stained channel |
| Proximity to built up area | 1 | Houses >300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: Discharge approached from derelict colliery site where fly tipping has taken place and is continuing. Close to motorway, no footpaths, discharge cannot be seen from Heart of Wales railway line (4 trains per day). No obvious access to marshes for birdwatchers, fishermen or cockle gatherers.

## 30.5 OPTIONS FOR REMEDIATION AND COSTS

The high flow rate observed at this location is indicative of the large extent of mine workings that drain to this point. These mine workings extend several hundred metres in elevation above the discharge location. It is therefore considered unlikely that installation of bulkheads for the flooding of the mine workings will be technically feasible. The consequence of that would be several uncontrollable discharges throughout the region. It may be possible to seal the Morlais shafts to raise the water level a few metres and allow the discharge to emanate from the north or north-east. This would reduce the iron loading by reducing iron concentration and flow. A detailed evaluation of all mine openings to assess possible discharges would be required.

Load reduction may be achieved by limiting oxygen entry to the workings above the water table that drain to this location. This may be costly, as it is anticipated that a large number of openings exist. *There are also active mine workings that discharge to the system which would preclude sealing.* Upon more detailed examination of the plans for the mine workings it may be possible to identify specific parts of the overall complex that may be either flooded or isolated from oxygen entry.

The configuration of the mine workings within the syncline indicates that the flow passes through the flooded, anoxic portion of the mining complex, prior to discharge. The potential for implementing a sulphate reduction system within this zone is high. To implement such a system, it would be necessary to define the flow path and the extent of the flooded, anoxic zone. Injection points for the introduction of an organic substrate to support the activity of the sulphate reducing bacteria can then be identified. Readily available organic substrates within the region should be identified. Depending on the rate of displacement through this flooded section, it may be possible to reduce the iron concentration to a few mg/l prior to discharge. Sewage sludge disposal would be a good option.

It is estimated that approximately 400 tonnes of iron, or about 7,700m$^3$ of ferruginous sludge could be generated at this site each year. This represents a significant logistical problem in terms of sludge handling and disposal. Preference should therefore be given to source control and load reduction. Implementation of a passive care oxidation/precipitation system would require a large settling basin. Sufficient flat surface area may be available for such an application.

The alternative to treatment that could be considered is direct discharge to the river estuary, within the tidal reach. However, the available dilution and the potential impact on the estuary should be assessed.

It has been established that the shaft from which the mine waters are being discharged has been backfilled with limestone. This means that if the mine waters contained any free acid, it would be neutralized prior to discharge. It is recommended that the quality of the mine water prior to discharge be investigated to determine:

- the rate of limestone depletion; and
- the potential water quality that may be discharge when the limestone has been depleted or armoured.

This may be done by drilling a hole into the mine workings and extracting representative water samples for testing and analysis. A knowledge of the actual mine water quality will be needed to determine the optimum approach for the abatement of this discharge.

**Capital Costs**

| | | |
|---|---|---|
| ALD | 100m | £ 5,000 |
| Pipeline | 200m | £ 20,000 |
| Wetland | (8 Ha: earthwalls) | £500,000 |
| | | £525,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation @ 10% of capital cost | £ 52,500 |
| Maintenance 6 man days/year @ £250/day | £1,500 |
| | £54,000 |

The alternative is a pipeline to the River Loughor, together with a diffuser system. The estimated cost would be £100,000.

The options for sealing the shaft and re-directing flow from higher up the catchment has not been costed because a wetland would still be required at the new site and although smaller, would be a significantly higher cost due to land availability.

**Sulphate reduction**

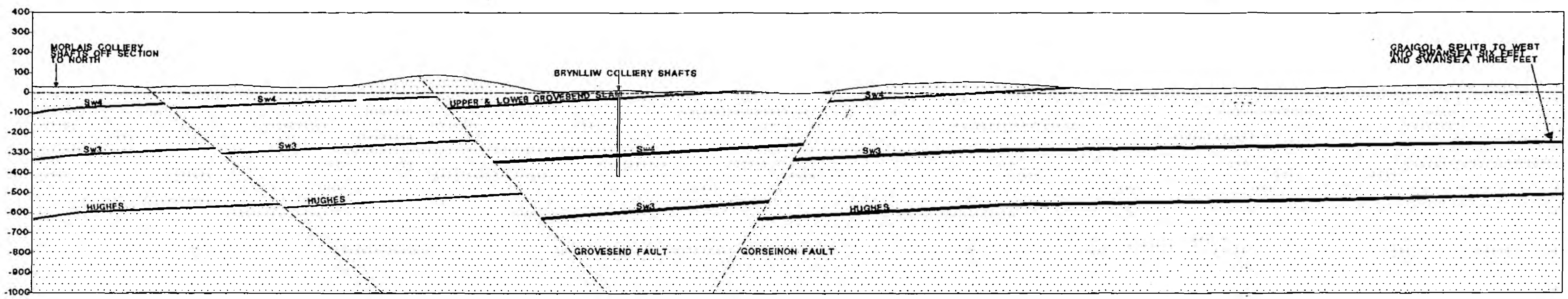
**Capital Costs**

| | |
|---|---|
| 4 x boreholes x 250m | £100,000 |
| 4 x headworks | £ 20,000 |
| Substrata feed system | £ 40,000 |
| | £160,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| £2,000/t iron removed (400t/yr) | £800,000 |
| Maintenance 10% of capital | £ 16,000 |
| | £816,000 |


| DATE: 14/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | **SITE 30: MORLAIS** | Figure 30.1 |




UPPER COAL MEASURES

Sw4 - SWANSEA FOUR FEET SEAM

Sw3 - SWANSEA THREE FEET SEAM

| DATE: 15/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:20000 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS<br>SRK (UK) Ltd., Summit House, 9/10 Windsor Place, Cardiff, CF1 3BX, U.K. | | SITE 30: MORLAIS<br>SW-NE SECTION | Figure<br>30b |

DISCHARGE FROM SHAFT

JUNCTION OF DISCHARGE WITH
MORLAIS RIVER

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 30: MORLAIS | Figure 30.1 D |

# Site 30, Section 4. Discharge Water Quality and Load Assessment.

Site #: 30
Site : Morlais

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.187 | 0.343 | 491 | 901 | 0.353 | 7.3 | 42.0 | 29.5 | 456.0 | 6.7 | 254.0 | 31.8 | 11.20 | 26.420 | 15.6 | 298.3 | 0.298 | 115.5 | 0.061 | 0.030 | 729.0 | 358 |
| Aug | 4.6 | 6.9 | Aug | 0.171 | 0.330 | 450 | 866 | 0.342 | 7.0 | 36.0 | 20.4 | 249.8 | 6.6 | 244.0 | 81.1 | 27.73 | 12.600 | 36.5 | 698.3 | 0.698 | 125.9 | 0.657 | 0.296 | 918.6 | 413 |
| Sep | 4.1 | 7.5 | Sep | 0.188 | 0.291 | 493 | 763 | 0.392 | | | | | | | 62.0 | 24.32 | | 30.6 | 584.5 | 0.585 | 115.0 | 0.30 | 0.149 | 902 | 444 |
| Oct | 8.9 | 7.7 | Oct | 0.193 | 0.639 | 508 | 1676 | 0.232 | | | | | | | 62.0 | 14.37 | | 31.4 | 600.2 | 0.600 | 112.0 | 0.30 | 0.153 | 902 | 456 |
| Nov | 15.0 | 9.0 | Nov | 0.225 | 1.072 | 591 | 2816 | 0.174 | | | | | | | 62.0 | 10.76 | | 36.7 | 701.3 | 0.701 | 95.8 | 0.30 | 0.179 | 902 | 533 |
| Dec | 16.5 | 9.6 | Dec | 0.241 | 1.179 | 632 | 3098 | 0.170 | | | | | | | 62.0 | 10.51 | | 39.2 | 749.9 | 0.750 | 89.6 | 0.30 | 0.191 | 902 | 570 |
| Jan | 13.4 | 11.1 | Jan | 0.277 | 0.955 | 728 | 2507 | 0.225 | | | | | | | 62.0 | 13.95 | | 43.1 | 863.4 | 0.863 | 77.8 | 0.30 | 0.220 | 902 | 656 |
| Feb | 10.4 | 10.7 | Feb | 0.267 | 0.741 | 701 | 1947 | 0.265 | | | | | | | 62.0 | 16.41 | | 43.4 | 831.1 | 0.831 | 88.9 | 0.30 | 0.212 | 902 | 632 |
| Mar | 6.8 | 7.9 | Mar | 0.198 | 0.489 | 519 | 1283 | 0.288 | 7.3 | 32.9 | 24.1 | 1057.0 | 6.7 | 222.6 | 73.1 | 21.04 | 10.360 | 37.9 | 725.5 | 0.725 | 109.2 | 0.189 | 0.098 | 1057.0 | 548 |
| Apr | 5.8 | 7.7 | Apr | 0.192 | 0.411 | 508 | 1079 | 0.318 | | | | | | | 62.0 | 19.74 | | 31.3 | 598.2 | 0.598 | 112.3 | 0.30 | 0.152 | 902 | 455 |
| May | 4.7 | 6.5 | May | 0.162 | 0.333 | 425 | 876 | 0.327 | | | | | | | 62.0 | 20.24 | | 26.3 | 503.5 | 0.503 | 133.5 | 0.30 | 0.128 | 902 | 383 |
| Jun | 5.0 | 7.9 | Jun | 0.196 | 0.356 | 616 | 936 | 0.355 | | | | | | | 62.0 | 22.04 | | 32.0 | 612.0 | 0.612 | 109.8 | 0.30 | 0.156 | 902 | 465 |
| | | | mean | 0.208 | 0.595 | 6556 | 18750 | 0.287 | | | | | | 240.2 | 62.0 | 17.692 | | 405.9 | 7768.2 | 7.768 | 106.4 | 0.30 | 1.964 | 902 | 5914 |
| | | | min. | 0.162 | 0.291 | | | 0.170 | | | | | | | | 10.508 | | | | | 77.8 | | | | |
| | | | max. | 0.277 | 1.179 | | | 0.392 | | | | | | | | 27.732 | | | | | 133.5 | | | | |

**Figure 30.4a Graph of Cumulative Probability for Fe in Receiving Water at Morlais**

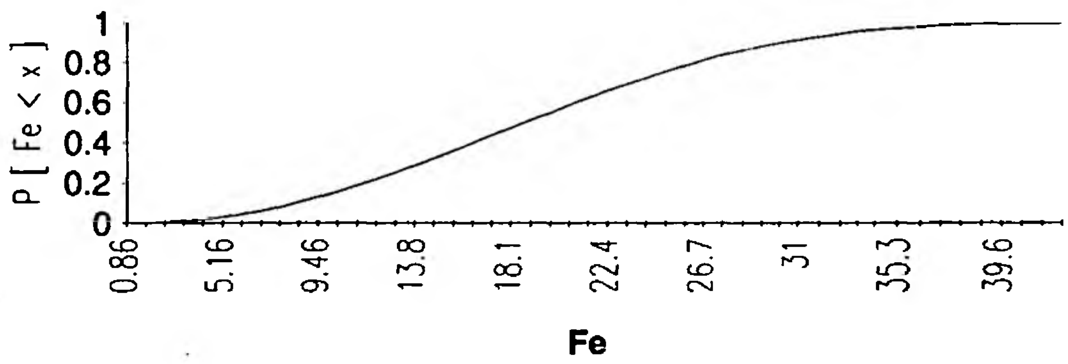
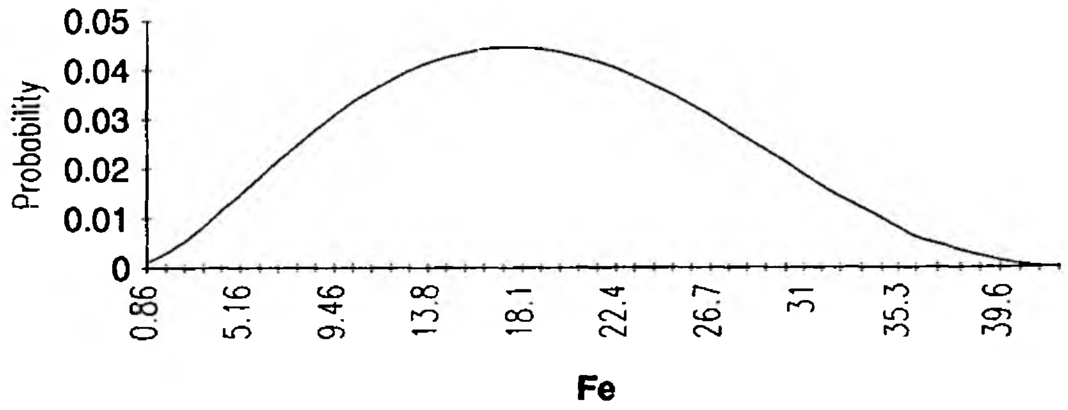



**Figure 30.4b Probability Density Graph of Fe In Receiving Water at Morlais**



13

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## SITE 31 - DUNVANT (CLYNE)

### 31.1 GEOLOGY AND MINING

A number of discharges were observed at this site. The upstream discharges (31) are situated within a wooded area and comprise a number of diffuse flows. A number of these flows pass through natural wetlands and are partially remediated before entering the River Clyne.

The second or downstream discharge (31A) is an upwelling flow that discharges from the left bank of the River Clyne at the roadside in Dunvant Square. This discharge, as shown in the photographs, appears as two distinct flows at surface but are considered to be from the same source.

The surface geology of the area comprises strata from the lower part of the Upper Coal Measures. This strata contains a number of coal seams which have formerly been mined in the area. These include the Voylart, Gleilyd, Clement, Rock, Penclawdd and Penlan. The strata dips 45° to the north, the line of full dip being about 20° east of north. A northeast-southwest trending fault traverses the area, to the west of which a number of northwest-southeast faults give rise to local dislocation of the coal seams.

Discharge 31 is related to the workings of the Killan Colliery, abandoned in 1925 soon after an inrush of water flooded the deeper workings. This mine worked the Penclawdd and Penlan Seams to the west of the major fault. In the vicinity of the discharges, Killan Colliery worked the Penlan Seam up to outcrop. The mine workings were accessed by means of a slant, situated slightly upstream from the discharge. In addition to the workings from Killan Colliery, there were many old workings from outcrop in this area, records of which have not survived.

Discharge 31A is situated to the east of the major fault, close to the outcrop of the Rock seam. Several coal seams were mined in this area by the Dunvant Colliery, abandoned in 1887. Again, plans for many of the near-outcrop workings have not survived. The geological map marks a shaft in the immediate vicinity of the discharge, however this is not shown on the plans inspected. The shaft probably accessed workings on the Rock, Clement or Gleilyd Seams.

## 31.2 CONTAMINATION SOURCES

The steep dip of the strata and relatively low topography mean that the majority of the workings will be flooded and will have been for many years. These will be small areas of mine workings along strike in the immediate areas of outcrop where active oxidation is taking place. The discharge will be a mixture of active oxidation products and remobilisation.

## 31.3 HYDROGEOLOGICAL MODEL

The rocks are a mixture of coals, mudstones and sandstones which will respond differently in terms of aquifer properties. The records show the Killan Mine closed due to a sudden water inflow at depth which could have been from a fault. Ground water levels have been recovered for many years. The western discharge is probably gravity flow spilling out of the outcrop workings due to natural recharge to the north and south. The eastern discharge appears to have a small hydraulic head due to the nearby shaft intersecting seams which outcrop at a higher elevation to the south.

## 31.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The upstream discharge (31) has a relatively high alkalinity and a neutral pH. The iron concentration is about 7mg/l, and the sulphate concentration is relatively low at about 69mg/l. This suggests that the primary mechanism contributing to the generation of dissolved iron and sulphate is the ongoing oxidation of pyrite within the mine workings, both saturated and unsaturated and possibly within the surrounding spoil tips.

The second discharge is slightly acidic, with a significantly lower alkalinity. As a consequence, it has a higher total iron concentration of about 27mg/l. Similarly to discharge 31, the sulphate concentration is relatively low at about 125mg/l. This suggests, as with site 31, that the prevailing mechanism for contaminant generation is ongoing or active oxidation. However, virtually all of the mine workings are flooded and so the oxidation is probably taking place both in unsaturated and shallow saturated workings.

The combined loading from the two discharges is estimated at about 2 tonnes per annum and the corresponding sulphate loading is about 12 tonnes. Because the flow in the River Clyne is relatively small when compared with the combined discharge flow rate, the iron concentration in the downstream receiving water environment is elevated, at about 6.5mg/l. A significant reduction in the total metal loading will be required to achieve the receiving water quality objective.

## 31.5 ENVIRONMENTAL COSTS AND BENEFITS

The river contains brown trout and occasional sea trout. The river is affected by sewage pollution. The river is too small for organised angling and it is only fished by schoolchildren from adjacent urban areas.

| Impact scores: | 31 | 31A | |
|---|---|---|---|
| Fisheries value | 4 | * | Some reduction in fish |
| Accessibility - footpaths | 5 | 5 | Path within 10m |
| Accessibility - roads | 2 | 5 | Road within 500m/10m |
| Visual impact downstream | 3 | 3 | |
| Proximity to built up area | 3 | 5 | Houses 100-300m/>500m |
| Proximity to recreation area | 1 | 3 | Recreation area>500m/100-300m |

*Not ranked as is duplication.

Site specific details: The village is on a tourist route to the Gower Peninsula, but does not appear to be 'geared up' for tourists; there are no obvious parking places by the shops or the green, therefore the discharge is probably unlikely to be seen by casual visitors. The stream valley is very badly littered otherwise it is an attractive wooded area. Local people report that the discharge has been occurring for 30-40 years at least. The upstream discharges (seeps) have less visual impact than the pipe discharge by the bridge in the village square.

The high scoring of both sites indicate that treatment of the discharge will result in significant aesthetic benefit. Fisheries benefit in financial terms will be small as there is no organised angling, but the amenity fishing value for local children should increase if remediation takes place.

## 31.6 OPTIONS FOR REMEDIATION AND COSTS

The discharges from the spoil is considered to contribute a relatively small proportion of the total loading. Covering of this spoil will probably not be cost effective. Treatment of the seeps from the spoil may be achieved by enhancing the existing wetlands.

It is considered that a installation of a bulkhead in the adit to flood the associated mine workings will not be technically feasible. It is recommended that the entrance should however be sealed to prevent oxygen entry at that point. It is probable that much of the oxygen entry is through small openings related to collapses at outcrop and mine workings for which plans do not exist and so an effective seal will be difficult to achieve.

The total loading from the upstream locations is relatively small and it is considered that these discharges could easily be treated by enhancing the existing wetlands.

It also considered that plugging the discharge point of 31A for purpose of flooding associated mine workings is unlikely to be feasible. The initial assessment suggests that there is little opportunity for source control of this discharge. The available dilution in the receiving waters is minimal. As a consequence, treatment of the discharge will be required. Because there is little available land for the construction of a wetland system, it may be necessary to intercept the flow and pipe it to a more appropriate location. It is also considered that an ALD would be required for the treatment of the discharge in a wetland system. It may be possible that this could be installed by backfilling the air shaft, but may be located at the site of the wetland provided the discharge is intercepted and piped to this location under anoxic conditions.

It is recommended that a suitable area for the location of such a system be identified. Also, all direct openings to surface should be identified and sealed.

The two discharges should be treated separately:

**Site 31:**

The upper discharges are partially treated at present in naturally developed wetlands. These should be enhanced as a priority, on the basis of a number of small lagoons.

It may be possible to partially plug the adit and any nearby ones to raise the water level by a metre or so and create height for cascading at the main discharge to enhance oxygenation.

The total area of lagoon required would be about 0.01Ha.

**Capital Costs**

| | |
|---|---|
| Wetland/lagoons | £ 7,500 |
| Plugging adits (allow 2) | £ 10,000 |
| | £17,500 |

**Operating and Maintenance**

| | |
|---|---|
| 10% of lagoon capital/annum | £750 |
| 2 man days/annum @ £250/day | £500 |
| | £1250 |

**Site 31A**

The site is inconvenient for in-situ treatment. There is an opportunity to depressurise the hydrogeological system through a borehole into the shaft area or into the adjacent workings from a more convenient location, where a wetland can be developed. The size of wetland required would be 0.1Ha.

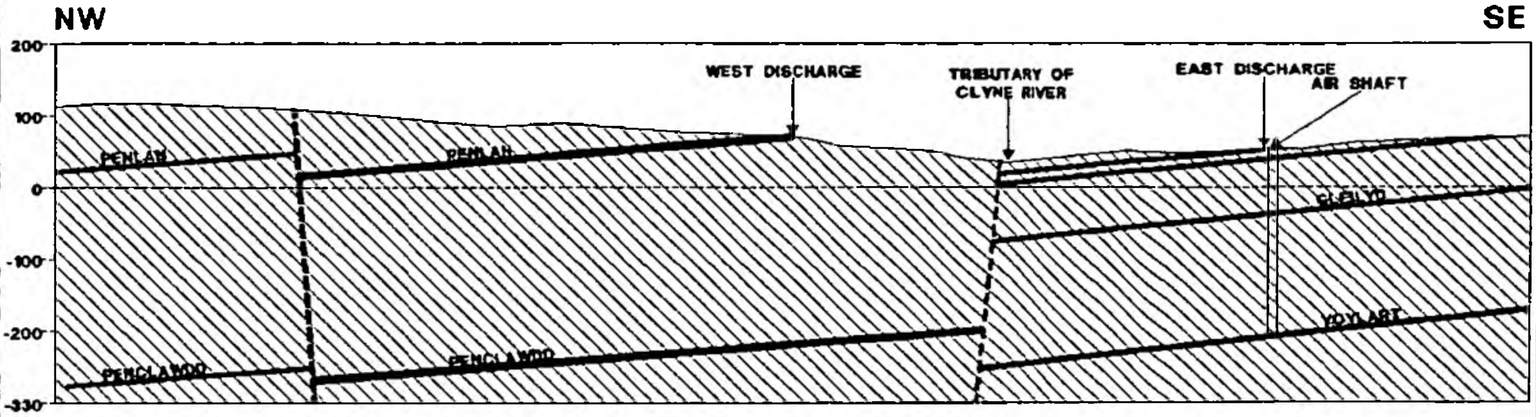
**Capital Costs**

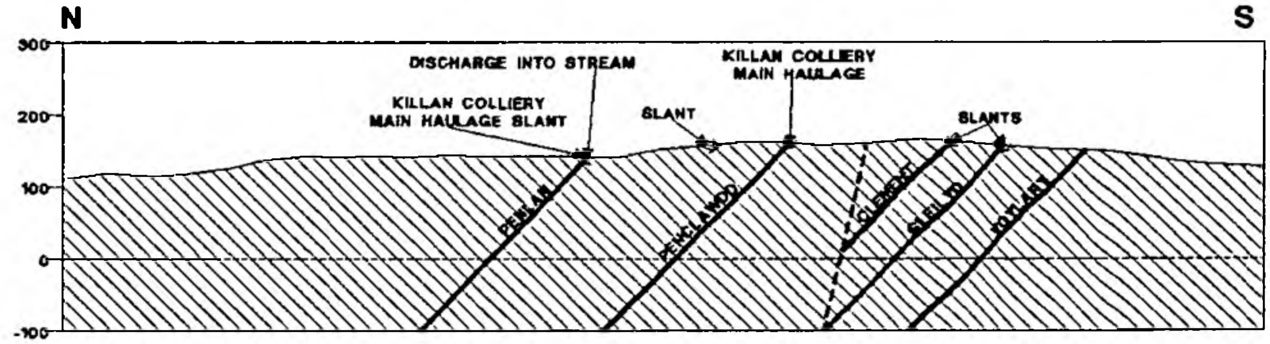
| | |
|---|---|
| Borehole | £ 9,000 |
| Headworks | £ 5,000 |
| Pipeline from shaft to wetland 400m | £ 20,000 |
| ALD | £ 2,000 |
| Wetland | £ 25,000 |
| | £ 61,000 |

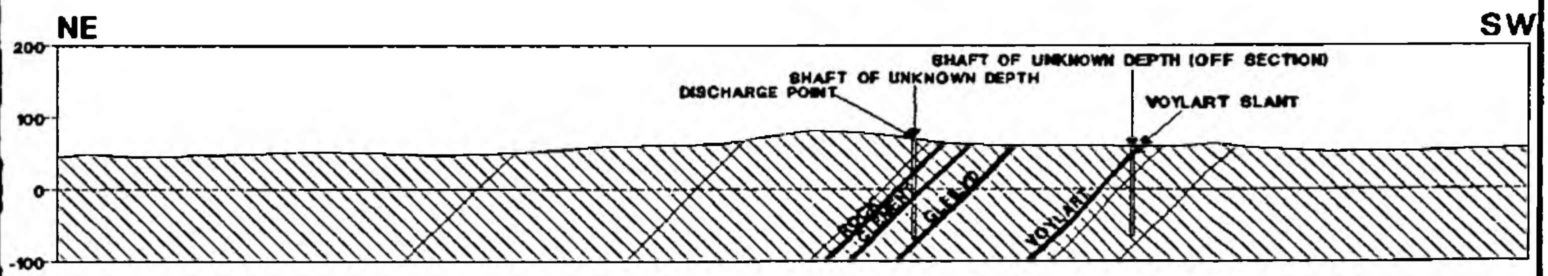
**Operation and Maintenance**

| | |
|---|---|
| 2 man days/annum @ £250/day | £500 |
| Maintenance/depreciation @ 10% | £6,100 |
| | £6,600 |


| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 31: DUNVANT | Figure 31.1 |




| DATE: 18/3/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 31 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 31: DUNVANT | |

DIFFUSE SEEPS ADJACENT TO RIVER

SEEPS JOINING RIVER

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 31A.1 D |
|---|---|---|---|
| SRK | | SITE 31A: DUNVANT | |

DISCHARGE NEAR MAIN
SQUARE IN DUNVANT

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 31B: DUNVANT | Figure 31B.1 D |

# Site 31a, Section 4. Discharge Water Quality and Load Assessment.

Site #: 31 A
Site : Dunvant / Killan

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Recelv. (1000m3/m) | Dilution Factor |
|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.002 | 0.006 | 4.6 | 15.0 | 0.235 |
| Aug | 4.6 | 8.9 | Aug | 0.002 | 0.005 | 4.2 | 14.4 | 0.227 |
| Sep | 4.1 | 7.5 | Sep | 0.002 | 0.005 | 4.6 | 12.7 | 0.267 |
| Oct | 8.9 | 7.7 | Oct | 0.002 | 0.011 | 4.7 | 27.8 | 0.146 |
| Nov | 15.0 | 9.0 | Nov | 0.002 | 0.018 | 5.5 | 46.7 | 0.106 |
| Dec | 16.5 | 9.6 | Dec | 0.002 | 0.020 | 5.9 | 51.4 | 0.103 |
| Jan | 13.4 | 11.1 | Jan | 0.003 | 0.016 | 6.8 | 41.6 | 0.141 |
| Feb | 10.4 | 10.7 | Feb | 0.003 | 0.012 | 6.6 | 32.3 | 0.169 |
| Mar | 6.8 | 7.9 | Mar | 0.002 | 0.008 | 4.9 | 21.3 | 0.186 |
| Apr | 5.8 | 7.7 | Apr | 0.002 | 0.007 | 4.7 | 17.9 | 0.209 |
| May | 4.7 | 8.5 | May | 0.002 | 0.006 | 4.0 | 14.5 | 0.215 |
| Jun | 5.0 | 7.9 | Jun | 0.002 | 0.006 | 4.8 | 15.5 | 0.237 |
| Total | 100.0 | 100.0 | mean | 0.002 | 0.010 | 61.4 | 311.2 | 0.187 |
| | | | min. | 0.002 | 0.005 | | | 0.103 |
| | | | max. | 0.003 | 0.020 | | | 0.267 |

Site #: 31 A
Site : Dunvant / Killan

| | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l) | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 7.8 | 94.0 | 8.9 | 87.0 | 7.0 | 205.0 | 6.6 | 1.56 | See D/S | 0.030 | 0.6 | 0.001 | 14.5 | 0.066 | 0.000 | 77.0 | 0.354 |
| Aug | 7.1 | 63.0 | 15.6 | 82.3 | 7.0 | 153.0 | 8.5 | 1.92 | Site 31B | 0.036 | 0.7 | 0.001 | 15.8 | 0.056 | 0.000 | 50.7 | 0.214 |
| Sep | | | | | | | 7.8 | 2.07 | | 0.036 | 0.7 | 0.001 | 14.4 | 0.04 | 0.000 | 68.1 | 0.315 |
| Oct | | | | | | | 7.8 | 1.13 | | 0.037 | 0.7 | 0.001 | 14.0 | 0.04 | 0.000 | 68.1 | 0.323 |
| Nov | | | | | | | 7.8 | 0.82 | | 0.043 | 0.8 | 0.001 | 12.0 | 0.04 | 0.000 | 68.1 | 0.378 |
| Dec | | | | | | | 7.8 | 0.80 | | 0.046 | 0.9 | 0.001 | 11.2 | 0.04 | 0.000 | 68.1 | 0.404 |
| Jan | | | | | | | 7.8 | 1.09 | | 0.053 | 1.0 | 0.001 | 9.8 | 0.04 | 0.000 | 68.1 | 0.465 |
| Feb | | | | | | | 7.8 | 1.31 | | 0.051 | 1.0 | 0.001 | 10.1 | 0.04 | 0.000 | 68.1 | 0.447 |
| Mar | 7.5 | 68.7 | 20.7 | 56.4 | 7.0 | 199.8 | 8.2 | 1.52 | | 0.040 | 0.8 | 0.001 | 13.7 | 0.010 | 0.000 | 76.7 | 0.373 |
| Apr | | | | | | | 7.8 | 1.62 | | 0.037 | 0.7 | 0.001 | 14.1 | 0.04 | 0.000 | 68.1 | 0.322 |
| May | | | | | | | 7.8 | 1.67 | | 0.031 | 0.6 | 0.001 | 16.7 | 0.04 | 0.000 | 68.1 | 0.271 |
| Jun | | | | | | | 7.8 | 1.84 | | 0.038 | 0.7 | 0.001 | 13.8 | 0.04 | 0.000 | 68.1 | 0.329 |
| mean | | | | | | 185.9 | 7.8 | 1.447 | | 0.477 | 9.1 | 0.009 | 13.3 | 0.04 | 0.003 | 68.1 | 4.194 |
| min. | | | | | | | | 0.802 | | | | | 9.8 | | | | |
| max. | | | | | | | | 2.073 | | | | | 16.7 | | | | |

# Site 31b, Section 4. Discharge Water Quality and Load Assessment.

Site #: 31 B
Site : Dunvant

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. (1000m3/m) | Dilution Factor | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l) | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Concentration (mg/L) Calculated Receiving | Fe(T) Concentration (mg/L) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.6 | 7.5 | Jul | 0.002 | 0.006 | 4.6 | 14.5 | 0.240 | 7.8 | 94.0 | 6.9 | 87.0 | 6.3 | 52.0 | 22.3 | 6.91 | 7.170 | 0.102 | 2.0 | 0.002 | 49.8 | 0.075 | 0.000 | 121.0 | 0.556 |
| Aug | 4.6 | 6.9 | Aug | 0.002 | 0.005 | 4.2 | 14.0 | 0.232 | 7.1 | 63.0 | 15.6 | 82.3 | 6.1 | 52.6 | 30.1 | 8.80 | 4.160 | 0.127 | 2.4 | 0.002 | 54.3 | 0.070 | 0.000 | 119.9 | 0.506 |
| Sep | 4.1 | 7.5 | Sep | 0.002 | 0.005 | 4.6 | 12.3 | 0.273 | | | | | | | 26.7 | 9.36 | | 0.123 | 2.4 | 0.002 | 48.6 | 0.07 | 0.000 | 124 | 0.571 |
| Oct | 8.9 | 7.7 | Oct | 0.002 | 0.010 | 4.7 | 27.0 | 0.149 | | | | | | | 26.7 | 6.11 | | 0.127 | 2.4 | 0.002 | 48.3 | 0.07 | 0.000 | 124 | 0.586 |
| Nov | 15.0 | 9.0 | Nov | 0.002 | 0.017 | 5.5 | 45.4 | 0.109 | | | | | | | 26.7 | 3.73 | | 0.148 | 2.8 | 0.003 | 41.3 | 0.07 | 0.000 | 124 | 0.685 |
| Dec | 16.5 | 9.6 | Dec | 0.002 | 0.019 | 5.9 | 49.9 | 0.106 | | | | | | | 26.7 | 3.64 | | 0.158 | 3.0 | 0.003 | 38.6 | 0.07 | 0.000 | 124 | 0.732 |
| Jan | 13.4 | 11.1 | Jan | 0.003 | 0.015 | 6.8 | 40.4 | 0.144 | | | | | | | 26.7 | 4.95 | | 0.182 | 3.5 | 0.003 | 33.6 | 0.07 | 0.000 | 124 | 0.843 |
| Feb | 10.4 | 10.7 | Feb | 0.003 | 0.012 | 6.6 | 32.3 | 0.169 | | | | | | | 26.7 | 5.82 | | 0.175 | 3.4 | 0.003 | 34.9 | 0.07 | 0.000 | 124 | 0.812 |
| Mar | 6.8 | 7.9 | Mar | 0.002 | 0.008 | 4.9 | 20.7 | 0.190 | 7.5 | 66.7 | 20.7 | 86.4 | 6.3 | 90.0 | 27.6 | 6.81 | 4.780 | 0.135 | 2.6 | 0.003 | 47.1 | 0.060 | 0.000 | 129.9 | 0.632 |
| Apr | 5.8 | 7.7 | Apr | 0.002 | 0.007 | 4.7 | 17.4 | 0.214 | | | | | | | 26.7 | 7.33 | | 0.126 | 2.4 | 0.002 | 48.4 | 0.07 | 0.000 | 124 | 0.564 |
| May | 4.7 | 6.5 | May | 0.002 | 0.005 | 4.0 | 14.1 | 0.220 | | | | | | | 26.7 | 7.54 | | 0.106 | 2.0 | 0.002 | 57.5 | 0.07 | 0.000 | 124 | 0.492 |
| Jun | 5.0 | 7.9 | Jun | 0.002 | 0.008 | 4.8 | 15.1 | 0.243 | | | | | | | 26.7 | 8.33 | | 0.129 | 2.5 | 0.002 | 47.3 | 0.07 | 0.000 | 124 | 0.598 |
| Total | 100.0 | 100.0 | mean | 0.002 | 0.010 | 61.4 | 303.2 | 0.191 | | | | | | 51.5 | 26.7 | 6.536 | | 1.640 | 31.4 | 0.031 | 45.9 | 0.07 | 0.008 | 124 | 7.596 |
| | | | min. | 0.002 | 0.005 | | | 0.106 | | | | | | | | 3.635 | | | | | 33.6 | | | | |
| | | | max. | 0.003 | 0.019 | | | 0.273 | | | | | | | | 9.364 | | | | | 57.5 | | | | |

**Figure 31A.4a Graph of Cumulative Probability for Fe in Receiving Water at Dunvant**

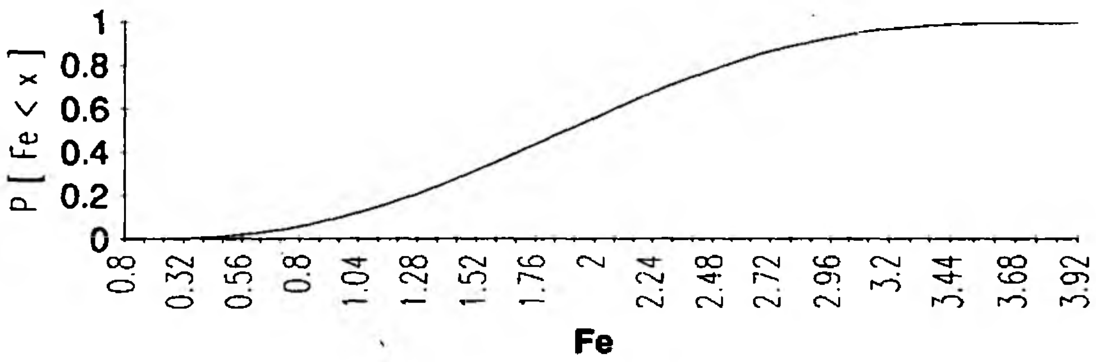
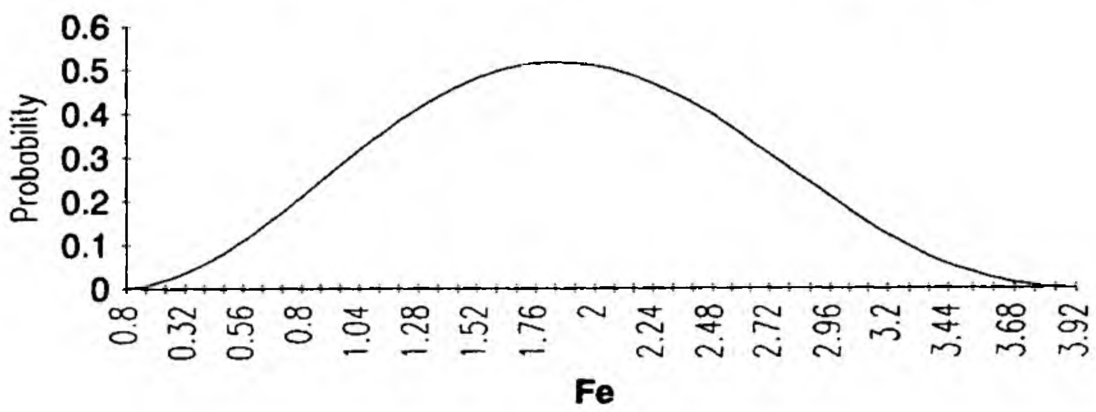



**Figure 31A.4b Probability Density Graph of Fe in Receiving Water at Dunvant**



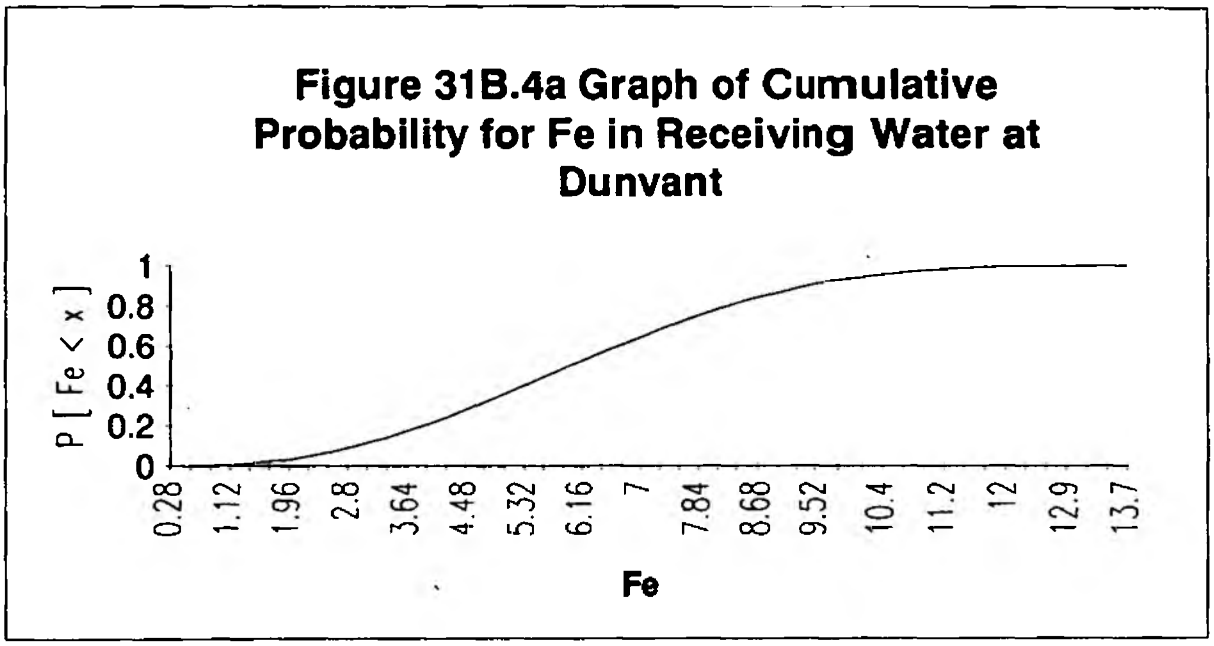


Figure 31B.4a Graph of Cumulative Probability for Fe in Receiving Water at Dunvant
P [ Fe < x ]
1
0.8
0.6
0.4
0.2
0
0.28
1.12
1.96
2.8
3.64
4.48
5.32
6.16
7
7.84
8.68
9.52
10.4
11.2
12
12.9
13.7
Fe

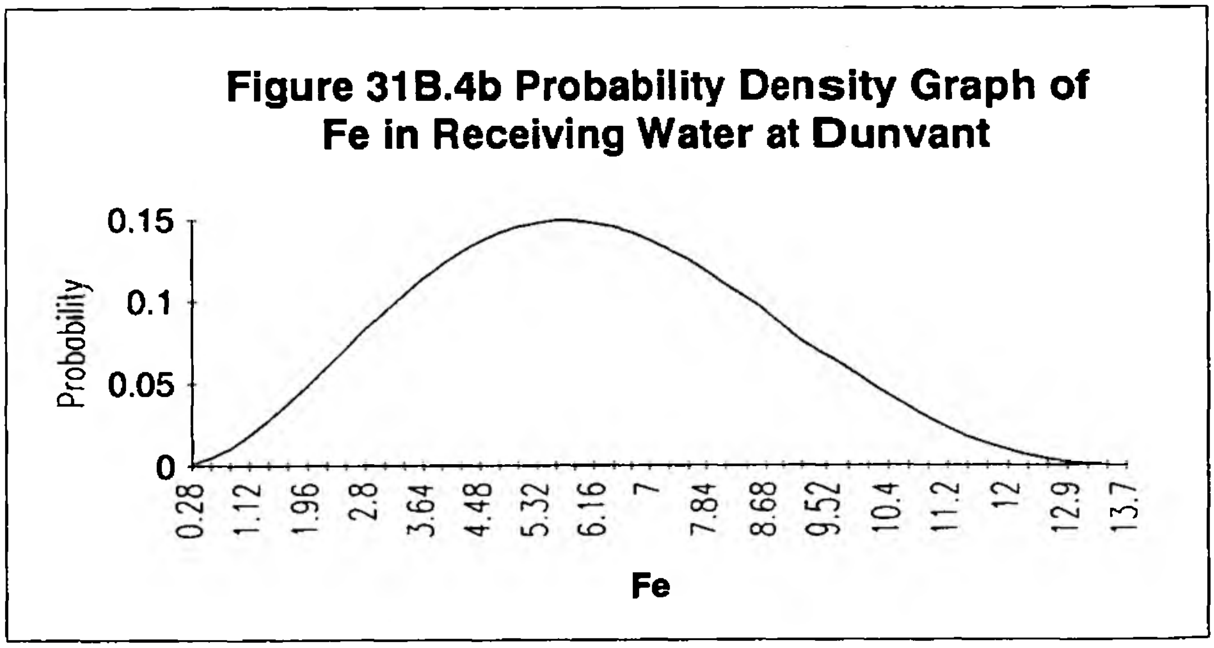


Figure 31B.4b Probability Density Graph of Fe in Receiving Water at Dunvant
Probability
0.15
0.1
0.05
0
0.28
1.12
1.96
2.8
3.64
4.48
5.32
6.16
7
7.84
8.68
9.52
10.4
11.2
12
12.9
13.7
Fe

14

14

## SITE 33 - LOWER CLYDACH (LLECHART)

### 33.1 GEOLOGY AND MINING

The site, at Llechart in West Glamorgan, drains into a tributary of the Lower Clydach River. Within the Tawe catchment one discharge enters from a small pipe on the right bank of the stream. A significant upwelling flow and a number of smaller diffuse flows are observed to enter from the left bank further upstream. The area upstream from these discharges was once worked as an open cast operation. A number of open channels still exist on the site and a diversion ditch was observed upstream of the opencast area. The site is located upstream from a small licensed coal mine.

The surface geology is of the Upper Coal Measures, here containing two seams which have been worked from outcrop, the Glyngwilym and the Hughes. The Hughes seam is situated some 28 m above the Glyngwilym seam. The strata generally dips at 5 degrees to the southwest. Both seams are cut off by the major Gardeners fault about 500 m to the west of the discharge points.

The two seams have been mined by several small licensed mines and also by the Daren Colliery on the Hughes Seam. There have been some small opencast mines on the outcrops.

The piped discharge coincides with the position of the entrances to the Llechart Colliery, which worked the Hughes Seam and was abandoned in 1980. The apparently derelict mine opposite on the left bank (Llechart No.2 Colliery) was also mining the Hughes Seam. Other discharges in this area are from old workings from Evans No.3 and No.4 Collieries (closed in 1976 and 1988 respectively). Daran Colliery (closed by the NCB in 1964) mined the Hughes seam on the left bank, but appears to drain to the south-east, away from the site. The Llechart No.2 Colliery is probably linked underground to old workings from Daren Colliery, which may explain the minimal discharge from that site.

Some seeps noted upstream are likely to be the result of workings on the Glyngwilym seam from Cwmbryn Colliery, closed in 1987.

An application has recently been made to reopen this colliery and the National Rivers Authority was asked to comment on the application. A discharge license will be required which will require mine water and surface water contaminated by passing through the site to be treated. It is unlikely that the proposed reopening will affect these current discharges as it will be up dip of the present discharges. However, the licence extends down dip.

## 33.2 CONTAMINATION SOURCES

The sources will comprise active oxidation in the old workings of the Llechart Colliery as well as backfilled spoil in the opencast area of Cwmbryn Colliery.

## 33.3 HYDROGEOLOGICAL MODEL

The catchment area will be very small as it is in the headwaters of the stream. The Brithdir and Hughes beds are well known aquifers and the old workings will receive active recharge from rainfall. The opencast area has been restored and has a surface water diversion trench around it. Direct precipitation is likely to infiltrate the spoil material and it is likely there are openings to the Llechart Mine.

The system is in equilibrium at present therefore the discharge can be expected to continue.

## 33.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharges exhibit a marginally acidic pH of less than 6 and a relatively elevated iron concentration in the order of 20 to 40mg/l. The sulphate concentration is relatively low at an average of about 244mg/l.

A strong seasonal fluctuation in concentrations and loads is anticipated for this site since it is located within the headwaters of the stream. Also, because the discharges form part of the headwaters, the iron concentration immediately downstream from the site is relatively elevated, even though the total loading of less than 1 tonne per annum is relatively small by comparison with other sites. The sulphate loading is estimated to be in the order of 6-7 tonnes per year.

## 33.5 ENVIRONMENTAL COSTS AND BENEFITS

This is a small stream so it is of no interest for angling. Obstructions on the Lower Clydach prevent access to migratory fish for spawning. The area is locally important for brown trout spawning.

Impact scores:

| | | |
|---|---|---|
| Fisheries value | 2 | Possible impact on spawning |
| Accessibility - footpaths | 2 | Path within 500m |
| Accessibility - roads | 2 | Road within 500m |
| Visual impact downstream | 3 | Slight staining to narrow channel |
| Proximity to built up area | 1 | Houses >300m |
| Proximity to recreation area | 1 | Recreation area >500m |

Site specific details: The main discharge point is by a recently abandoned private mine. It is an untidy derelict site with litter, wrecked vehicles, abandoned sheds, buildings and caravans, adjacent to an empty derelict farmhouse and buildings. It is very unlikely to be seen by casual visitors. The discharge may detract from the value of the farmhouse and buildings which are for sale.

The low scoring indicates a low level of benefit accruing from any remediation.

## 33.6 OPTIONS FOR REMEDIATION AND COSTS

The total loading from this site is relatively small. It is also located in the headwaters of the stream and consequently very little dilution is available in the receiving waters.

Based on the discharge water quality, an ALD would be beneficial for the treatment of the discharge in a wetland treatment system. However, the discharges are diffuse along the banks of the stream and the area is in close proximity to a private mine which although apparently not working at present, may be reactivated. There is unlikely to be sufficient surface area to construct an adequate settling basin.

Load reduction through source control where possible is recommended. However, due to the shallow depth of the workings flooding is unlikely to be effective. The recommended approach for remediation is a combination of oxygen exclusion and wetland treatment, although these measures should not be expected to fully remediate the discharge.

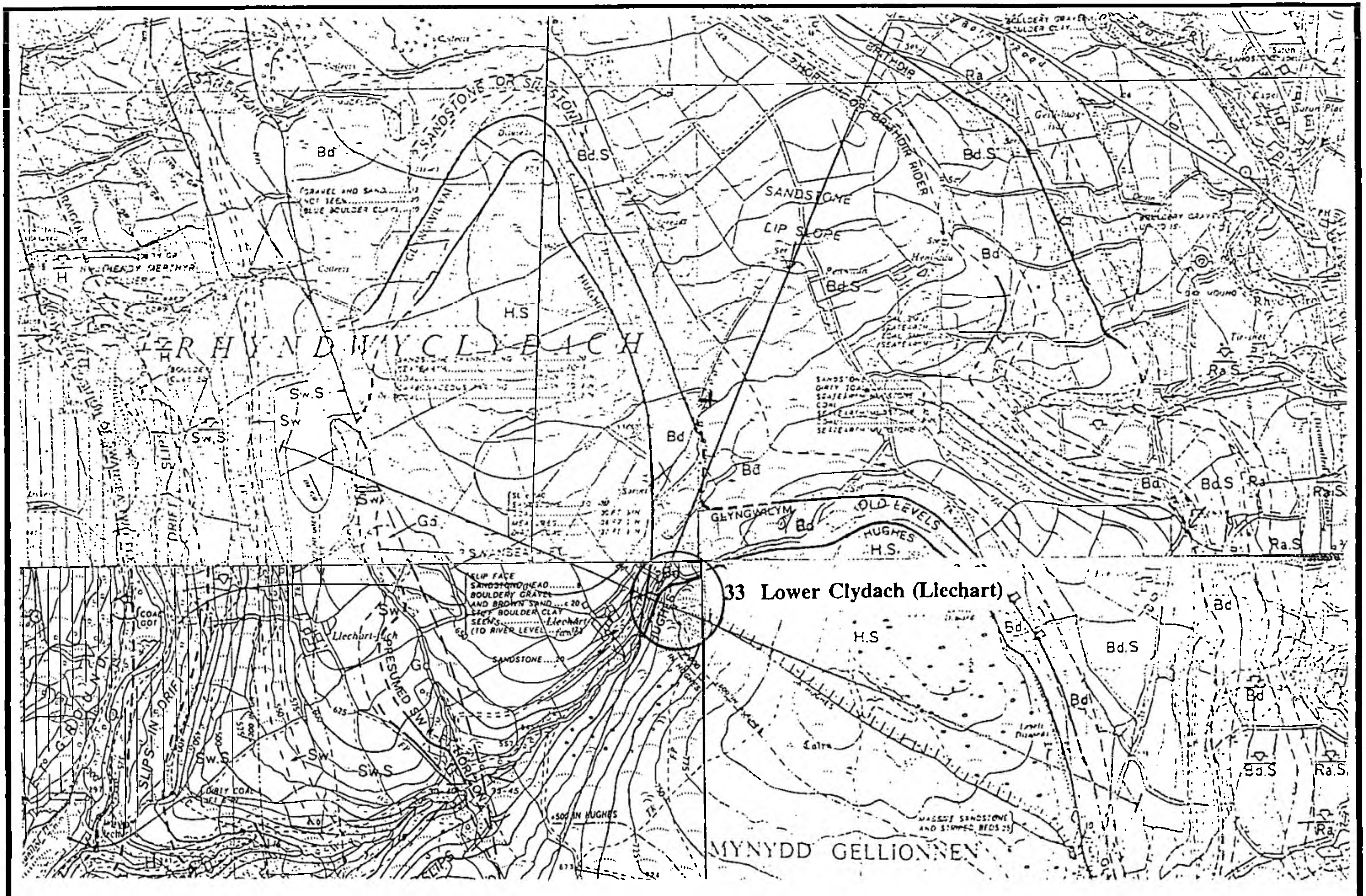
**Capital Costs**

| | |
|---|---|
| Oxygen plugs x 3 | £20,000 |
| (Combined with increase in head to create cascade) | |
| Wetland/settlement 0.02Ha | £10,000 |
| Pipeline 400m | £20,000 |
| | £50,000 |

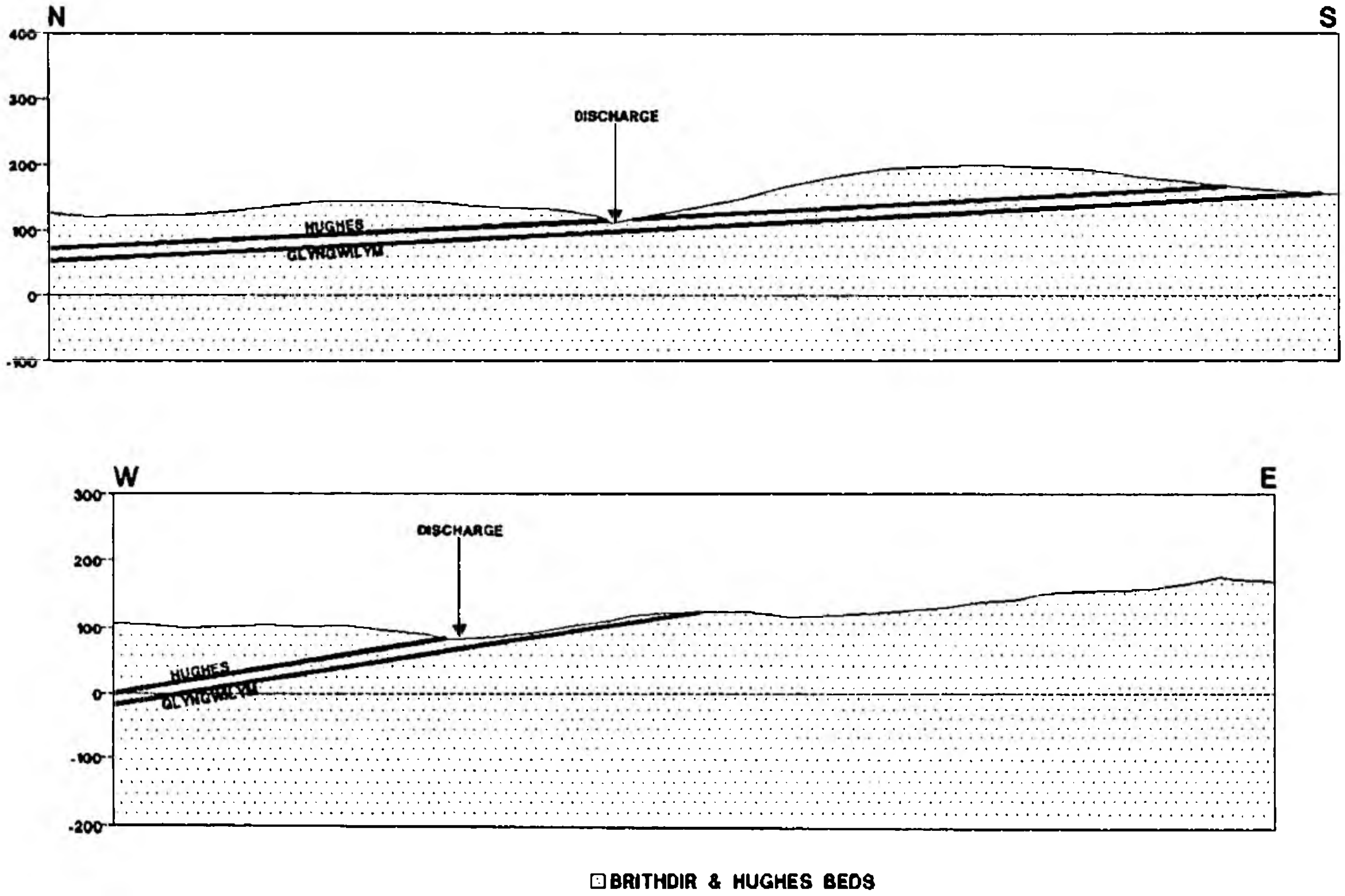
**Operating/Maintenance Costs**

| | |
|---|---|
| 2 Mandays/Year | £500 |
| Depreciation/maintenance @ 10% | £5,000 |
| | £5,500 |

It may be possible to utilise the lower abandoned mine site near the road as a treatment area, at the same time reclaiming this derelict site.




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 33.1 |
|---|---|---|---|
| SRK | | SITE 33: LOWER CLYDACH (LLECHART) | |




| DATE: 25/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 33: LOWER CLYDACH (LLECHART)<br>N-S & E-W SECTIONS | Figure<br>33.1 b/c |

UPSTREAM SEEP FROM LEFT BANK

DIFFUSE SEEPS FROM RIGHT BANK

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 33: CLYDACH (TAWE) | Figure 33.1 D |

# Site 33, Section 4. Discharge Water Quality and Load Assessment.

Site #: 33
Site : Clydach Tawe

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Synthesized U/S Receiving (m3/s) | Monthly Flow 1000m3/m | U/S Receiv. 1000m3/m) | Dilution Factor |
|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.5 | Jul | 0.001 | 0.011 | 2.0 | 29.9 | 0.063 |
| Aug | 4.6 | 6.9 | Aug | 0.001 | 0.011 | 1.9 | 28.8 | 0.061 |
| Sep | 4.1 | 7.5 | Sep | 0.001 | 0.010 | 2.0 | 25.3 | 0.074 |
| Oct | 8.9 | 7.7 | Oct | 0.001 | 0.021 | 2.1 | 55.7 | 0.038 |
| Nov | 15.0 | 9.0 | Nov | 0.001 | 0.036 | 2.4 | 93.5 | 0.025 |
| Dec | 16.5 | 9.6 | Dec | 0.001 | 0.039 | 2.6 | 102.8 | 0.025 |
| Jan | 13.4 | 11.1 | Jan | 0.001 | 0.032 | 3.0 | 83.2 | 0.035 |
| Feb | 10.4 | 10.7 | Feb | 0.001 | 0.025 | 2.9 | 64.6 | 0.043 |
| Mar | 6.8 | 7.9 | Mar | 0.001 | 0.016 | 2.1 | 42.6 | 0.048 |
| Apr | 8.8 | 7.7 | Apr | 0.001 | 0.014 | 2.1 | 35.8 | 0.055 |
| May | 4.7 | 6.5 | May | 0.001 | 0.011 | 1.8 | 29.1 | 0.057 |
| Jun | 6.0 | 7.9 | Jun | 0.001 | 0.012 | 2.1 | 31.1 | 0.064 |
| Total | 100.0 | 100.0 | mean | 0.0009 | 0.020 | 27.0 | 622.4 | 0.049 |
| | | | min. | 0.0007 | 0.010 | | | 0.025 |
| | | | max. | 0.0011 | 0.039 | | | 0.074 |

Site #: 33
Site : Clydach Tawe
Discharge

| | Receiving water pH | Receiving water Alkalinity (mg CaCO3/l) | Receiving water SO4 (mg/l) U/S | Receiving water SO4 (mg/l) D/S | Discharge pH | Discharge Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Fe(T) Calculated Receiving | Fe(T) Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 6.9 | 15.3 | 284.0 | 274.0 | 5.8 | 49.0 | 21.3 | 1.35 | 4.068 | 0.043 | 0.8 | 0.001 | 67.7 | 0.420 | 0.001 | 163.0 | 0.330 |
| Aug | | | | | | | 36.3 | 2.20 | | 0.067 | 1.3 | 0.001 | 73.8 | 0.32 | 0.001 | 244 | 0.453 |
| Sep | 6.7 | 22.3 | 148.0 | 163.6 | 5.7 | 73.0 | 42.8 | 3.18 | 3.000 | 0.087 | 1.7 | 0.002 | 67.4 | 0.113 | 0.000 | 366.0 | 0.744 |
| Oct | | | | | | | 36.3 | 1.31 | | 0.076 | 1.4 | 0.001 | 65.6 | 0.32 | 0.001 | 244 | 0.510 |
| Nov | | | | | | | 36.3 | 0.82 | | 0.088 | 1.7 | 0.002 | 56.2 | 0.32 | 0.001 | 244 | 0.596 |
| Dec | | | | | | | 36.3 | 0.90 | | 0.095 | 1.8 | 0.002 | 52.5 | 0.32 | 0.001 | 244 | 0.637 |
| Jan | | | | | | | 36.3 | 1.26 | | 0.109 | 2.1 | 0.002 | 45.6 | 0.32 | 0.001 | 244 | 0.733 |
| Feb | | | | | | | 36.3 | 1.55 | | 0.105 | 2.0 | 0.002 | 47.4 | 0.32 | 0.001 | 244 | 0.706 |
| Mar | 6.9 | 11.7 | 132.0 | 138.0 | 5.8 | 47.6 | 44.7 | 2.14 | 2.120 | 0.096 | 1.8 | 0.002 | 64.0 | 0.420 | 0.001 | 204.0 | 0.436 |
| Apr | | | | | | | 36.3 | 1.99 | | 0.076 | 1.4 | 0.001 | 65.9 | 0.32 | 0.001 | 244 | 0.508 |
| May | | | | | | | 36.3 | 2.06 | | 0.063 | 1.2 | 0.001 | 78.3 | 0.32 | 0.001 | 244 | 0.428 |
| Jun | | | | | | | 36.3 | 2.33 | | 0.077 | 1.5 | 0.001 | 64.4 | 0.32 | 0.001 | 244 | 0.520 |
| mean | | | | | | | 36.3 | 1.765 | | 0.981 | 18.6 | 0.019 | 62.4 | 0.32 | 0.009 | 244 | 6.601 |
| min. | | | | | | | | 0.897 | | | | | 45.6 | | | | |
| max. | | | | | | | | 3.177 | | | | | 78.3 | | | | |

**Figure 33.4a Graph of Cumulative Probability for Fe in Receiving Water at Lower Clydach (Llechart)**

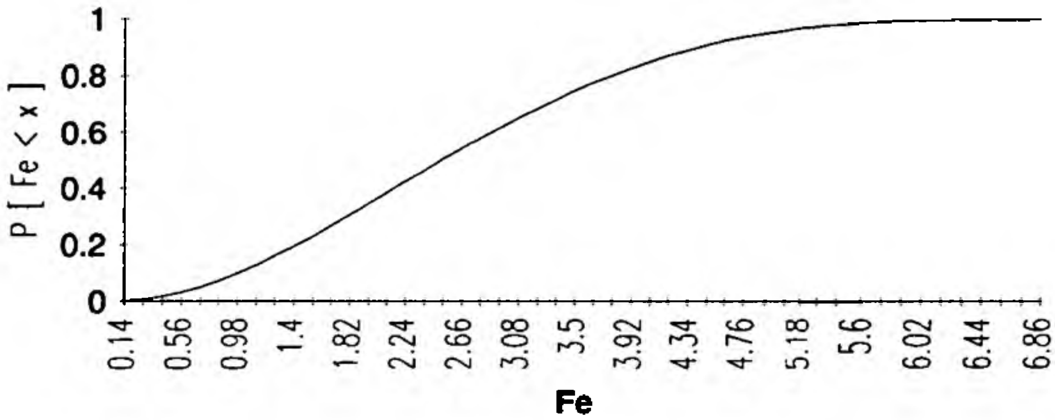
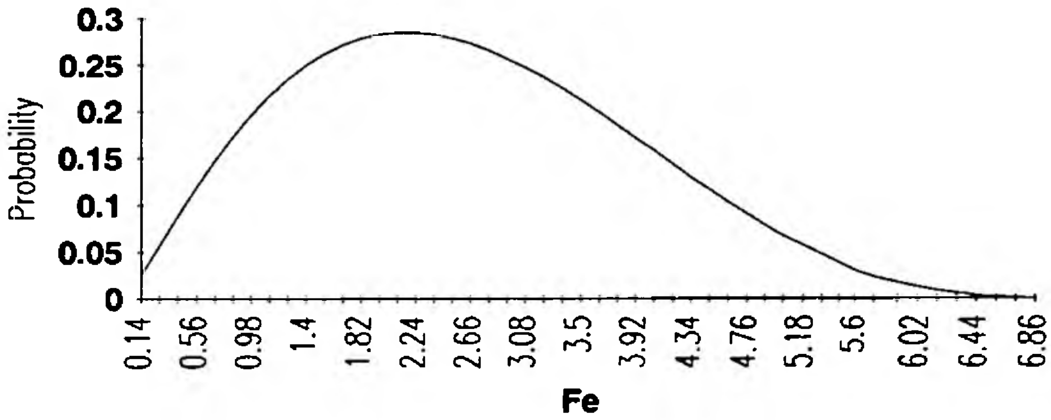



**Figure 33.4b Probability Density Graph of Fe in Receiving Water at Lower Clydach (Llechart)**



15

## SITE 62 YNYSARWED/BLAENANT

### 62.1 GEOLOGY AND MINING

A composite plan has been produced, showing mine workings on the No.2 Rhondda Seam with elevations (Fig 62.1b). Mine entrances (drifts, adits and shafts) to workings on that seam have also been shown. The information has been combined from the 1:10560 scale geological maps and from available Abandonment Plans relating to coal mining in the area. It should be noted that plans were not available for all of the workings, in particular for those immediately to the north of the Ynysarwed discharge point.

Topographically, the area is characterised by steep sided narrow valleys separating larger upland areas rising to more than 300m AOD. Of particular importance in the area are the Vale of Neath and the Dulais Valley.

The outcropping geology of the area of interest mainly comprises thick massive Pennant sandstones of the Rhondda and Brithdir beds of the Upper Coal Measures. These sandstones are interrupted by thin but persistent mudstones, many associated with thin coals. There are several outcropping coal seams which have been mined, but only the No.2 Rhondda has been exploited to any extent. This seam is typically 0.6m to 1.5m thick and is overlain by a massive coarse sandstone (+60m thick).

The area is geologically and (probably) hydrogeologically limited to the south and east by the Neath Disturbance, a 1km wide zone of shattered rock which effectively divides the coal seams and workings to the west and east of the Vale. Apart from the Neath Disturbance, there is relatively little faulting of sufficient magnitude to influence mining. The faults that have been found are mostly aligned north-south although other orientations exist.

The general dip of the strata is from north-east to south-west at about 6 degrees, steepening to 10 degrees in the west.

Some small scale working still continues in the north-east of the area from several licensed mines, notably Crugau and Ivy Rock Mines. The major mines in the area which worked the No.2 Rhondda were Upper and Lower Ynysarwed and Blaenant

Collieries. The No.2 Rhondda workings in Ynysarwed were abandoned in 1938 and Blaenant was finally abandoned in 1990.

Whilst this seam has been mined extensively, there still remain some large pillars. In particular, there is an un-mined pillar of at least 90m width separating the workings of Blaenant from Ynysarwed, in the southern part.

The mines were known to be wet and Blaenant and Cefn Coed pumped more than 7 megalitres of water per day from workings in the No.2 Rhondda. Pumping in the area ceased with the closure of Blaenant Colliery in 1990. The rise in water level following cessation of pumping was measured in the Cefn Coed shafts by British Coal.

At closure, the following pumping systems were discharging at surface:

| Location | Amount (Ml/day) |
|---|---|
| Cefn Coed Shafts | 2.95 |
| Blaenant New Drift (W) | 2.45 |
| Blaenant Drift (E) | 1.72 |
| TOTAL | 7.12 |

Rainfall in the area averaged 1749 mm (Dulais) and 2003 mm (Neath).

There has been some mining of seams several hundred metres below the No.2 Rhondda but it is unlikely that this has any effect on the discharges, other than that this mining may have caused some fracturing of the overlying strata.

## 62.2 CONTAMINATION SOURCES

The south eastern area of Blaenant Mine adjacent to the Ynysarwed workings was known to be particularly acid generating during operation, to the extent that stainless steel pipes and pumps were used for dewatering.

There will be a combination of sources from active oxidation in the extensive, unflooded workings to the north above the 23m level of the Ynysarwed discharge and remobilised iron precipitated during active mining.

## 62.3 HYDROGEOLOGICAL MODEL

The discharge at Ynysarwed (NRA Site Number 62) is coming from an adit of the Lower Ynysarwed Colliery. On the abandonment plans, the adit is marked as a "water level". From the composite plan, it can be seen that this adit is in fact the lowest point of access to workings on the No.2 Rhondda Seam in the area. It is likely to be at least 100 years old, as the level is shown and the area served by it is marked as "coal exhausted" on a plan dated March 1893. A small discharge has been known here intermittently over a long period, indeed the fact that it is marked on old plans as a "water level" may indicate that it was always intended to act as a drain for the workings. However, the amount of water discharged increased substantially in early 1993, when it came to the attention of the NRA as being a major source of pollution.

Site 62A is located on the left bank of the Dulais River. Although a channel has been prepared for the discharge of mine water from the Blaenant Colliery, the water level in the shaft remains below this point. Instead a minewater discharge is occurring from within the river bed, approximately 200 to 300 downstream from the shaft.

This discharge was first noted in February 1994, and does not appear to be directly linked to any mine workings as there are no coal seams outcropping in the immediate vicinity and the shallowest known workings are some 150m below.

However, the geological map for the area does note that massive sandstones are exposed in the bed of the river and the mine plans indicate faulting in the coal seam directly below this position.

Some diffuse seeps have also been observed on the left bank at the toe of the recently contoured spoil tip. Inspection of the spoil reveals a significant sulphide mineral content; it is considered likely that an increase in ferruginous seeps from the spoils may result from the re-contouring activities.

The accompanying graph shows the rise in water level with time at the Cefn Coed shafts (adjacent and linked to Blaenant Colliery). In addition, the elevation and approximate date of discovery are shown for the discharges at Ynysarwed and Blaenant. It can be seen that these events are probably linked, although neither discharge can be directly linked through known mine workings to Blaenant Colliery. It would seem likely that, although there are no mined connections, hydraulic links exist between:

- Blaenant and Ynysarwed Collieries, through or around the 90 m barrier and
- Blaenant Colliery and the river bed, possibly through faulting.

The elevation of the Ynysarwed discharge is 21m AOD and the water level elevation in the Cefn Coed shaft is at 95m AOD. There is no direct mining link between the Blaenant Colliery and the Ynysarwed workings except in the North at about 150m elevation on the No 2 Rhondda seam. It is probable that the 90m sandstone pillar between the two workings is hydraulically conductive and a significant part of the polluted discharge load is derived from flow through and under the barrier. If this were not the case, the ferruginous discharge would have been flowing from Ynysarwed for many years.

The discharge at Site 62 is acid, which could reflect the flushing of the initial oxidation products from both the Blaenant Mine and the now flooded parts of the Ynysarwed Mine.

The plot of ground water recovery in the Cefn Coed shaft shows that water levels are still recovering. Continued recovery can still be expected for another few metres but forced discharges are likely to occur to limit full recovery.
From the graph, a lowering of the water level to approximately the +65m to 70m level would stop the uncontrolled discharge in the river.

The recovery graph shows a straight line recovery up to the approximate elevation of the Ynysarwed discharge after which the recovery rate progressively decreased. This suggests that the major source of water to the system is the No 2 Rhondda Seam and above, rather than deeper workings.

During operating conditions the mine was pumping around 7Ml/day for an effective drawdown of approximately 60m. This is equivalent to a specific yield of 0.12Ml/day/m. Therefore 1.2Ml/day would have to be pumped to maintain the water level below the current discharge elevation (70m AOD, for a drawdown of 10m).

## 62.4 DISCHARGE WATER QUALITY AND LOAD ASSESSMENT

The discharge at Site 62 is characterized by elevated iron (30-260mg/l) and sulphate (983-3232mg/l) concentrations, and an acidic pH (5.9-3.2). It is anticipated that the ongoing oxidation occurring within the unflooded mine workings is the primary mechanism for the elevated contaminant concentrations. It is apparent from these conditions that there is insufficient calcareous host rock along the flow path of the mine waters to ensure neutral pH conditions at the point of discharge.

It is estimated that the annual iron loading is in the order of 110 tonnes and the sulphate loading is about 1,300 tonnes. The receiving water concentration profile was prepared for the flows in the Neath Canal. It is anticipated that the downstream receiving water quality exceeds the criterion of 1.0mg/l for total iron.

Very little water quality or flow data are available for Site 62A. Loading calculations have been carried out on the available data but should be treated with caution. It is considered that the discharge water would probably be similar to that observed for the Ynysarwed discharge since both originate from the No.2 Rhondda Seam, although the available data shows lower Fe concentrations.

## 62.5 ENVIRONMENTAL COSTS AND BENEFITS

The Neath Canal supports a coarse fishery and a put and take trout fishery. The fishing rights are leased by the Neath and Dulais Angling Club from the Neath Canal Company for a peppercorn rent. Over the past year part of the fishery has been lost due to the ferruginous discharge at Ynysarwed. An electrofishing survey on 15 to 17 December 1993 indicated a healthy fish population upstream of the discharge and no fish nor negligible fish populations for 3Km downstream, and a depressed fish population for a further 2Km downstream.

It is believed that this effect is due not to the direct toxic effect of iron on fish but rather on the invertebrate food of fish. Fish removed from the canal by electrofishing were found to be in poor condition indicating starvation. The fish removed included brown trout, tench, perch, roach, gudgeon, bream and eels.

The Neath and Dulais Angling Club have fishing rights on the Dulais River and the secretary estimated that 3Km of river is affected by iron deposits. It is difficult to value the fishery separately from the rest of the angling club waters. The club has approximately 6 miles of fishery on the River Neath, 4 miles on the River Dulais and 7 miles on the Neath Canal. The number of members has declined from 611 in 1991 to 540 in 1993 (figures for 1992 not available) and it is believed that this is influenced by the perception of poorer quality fishing due to the ferruginous pollution. Coarse fishermen, on the Neath Canal in particular, feel it is not worth taking on a licence, having heard the considerable publicity about the pollution.

| Impact scores: | 62 | 62A | |
|---|---|---|---|
| Fisheries value | 5 | 5 | 50% loss of fishery |
| Accessibility - footpaths | 4 | 1 | Path within 50m/1km |
| Accessibility - roads | 5 | 3 | Road within 10m/100m |
| Visual impact downstream | 5 | 1 | |
| Proximity to built up area | 4 | 1 | Houses/factories 100m />300m |
| Proximity to recreation area | 5 | 4 | Recreation facility <100m/100-200m (Neath Canal/Mining museum) |

Site specific details: 62: The discharge is very likely to be seen by passers by on the A465 trunk road to Neath and Swansea, and holiday makers to the area who may be using the canal and surrounding areas for recreation The site is close to Melincourt Waterfall.

Site specific details: 62A: The discharge and downstream impact are unlikely to be seen at present but the discharge may be expected to worsen slightly until water levels in the Cefn Coed shaft reach equilibrium. It is close to a forest walk, picnic area and mining museum at old Cefn Coed Colliery and 4-5km upstream of Aberdulais Falls which are owned by the National Trust and a Wildlife Park. Sarn Helen Roman Road (used as part of an unofficial long distance footpath) runs along the top of the hill between the two discharges and follows the Neath Canal along part of its polluted length.

The high scores of the Ynysarwed discharge indicates that the greatest benefit will be accrued from remediation at this site. As the two discharges are linked hydrogeologically and the Blaenant discharge may be expected to worsen, a solution should look at treating both, even though Blaenant at present does not rank so highly. The impact, should the discharge worsen, is probably greater than that for the Ynysarwed Site.

## 62.6 OPTIONS FOR REMEDIATION AND COSTS

The Ynysarwed and Blaenant (Dulais) workings are separated by a 90 m pillar that was left in place during mining operations. Currently a hydraulic gradient exists across this pillar and it is probably sufficiently permeable that mine water from the Dulais side is able to pass through it or round it, through the sandstones, to the Ynysarwed side.

At the Blaenant Mine a ferruginous discharge is occurring in the river bed some 200m downstream, and our analysis suggests that this discharge is a result of the rise in the water table, possibly through a hydraulic link such as a fault, and is acting as the discharge for the mine waters in the Blaenant Colliery. Sealing of such a fault could be achieved by grouting it, but the effectiveness will probably be small. It is therefore considered that, in order to eliminate this discharge, hydraulic balancing may be required to reduce the hydraulic gradient that is causing the discharge to the river bed. This in effect will require a lowering of the water table in the Blaenant Colliery to the level of the river bed. This could theoretically be achieved by:

- pumping approximately 1.2Ml/day from the shaft
- drilling from below the present discharge site, into the old workings and draining water under its own pressure. This should only be into the western workings
- creating an underground connection between Blaenant and the lower Ynysarwed Colliery, though this may be impractical due to access difficulties.

The decision will be somewhat governed by the available treatment options. If water is drained in the Dulais Valley then a suitable site for a wetland has to be identified for a higher load than is presently discharging into the river.

If water is drained to the Ynysarwed side, there is space available to develop a wetland.

It is known that the mining area to the south of the Blaenant drift was particularly high in sulphide. Hydraulic balancing between this area and the lower Ynysarwed Colliery should reduce the iron load currently discharging at both sites, by eliminating through-flow in this area.

On the Ynysarwed side, the adit from which the discharge is currently being discharged should be plugged with a bulkhead to flood the mine workings to the level of about 60m AOD. This would represent a flooding head of about 40m. This would, in effect, balance the heads on the Blaenant side and reduce the flow at Ynysarwed. It would be important to maintain some hydraulic gradient from West to East to avoid aggravating the problem on the Dulais. There is a probability of some leakage in the exposed rock face around the adits but this would have to be assessed by trial and error.

- A pressure regulator could be installed in the bulkhead to maintain a steady head; or,
- an overflow could be installed by drilling a sufficiently sized drill hole at one of the higher adits.

This option will result in flow-through conditions, in other words, mine water be continuously displaced through the mine workings. Under these controlled flow-through conditions, there is a good potential for implementing an internal sulphate reduction system if the workings can be entered. The effective clean-up could be significant reducing the need for treatment and sludge management in a wetland.

The second alternative could represent a decant system, i.e. mine water from the active recharge would be discharged without being displaced through the mine workings.

If the primary mechanism for iron release is dissolution of stored oxidation products, this discharge could be of a significantly better quality than that currently being discharged and may be the preferred option.

Such a decant option could also be designed to intercept the mine workings at depth, such that the first option can be emulated.

The costs would be somewhat conjectural at present due to uncertainties in the system as well as the ongoing rise in water levels, creating an initial flush of oxidation products. The discharge problem has become critical and some short term contingency solutions are required. Where possible these should be used to enhance knowledge or form part of a long term solution.

The significance of the potential impacts also requires more confidence in the final solutions which in turn will require some detailed investigations to reduce uncertainties.

The following costs are provided as a broad guideline based on present flows and iron loads.

**Long Term Solution Costs**

**Ynysarwed**

**Capital Cost**

| | | |
|---|---|---|
| Adit bulkheads | 6 @ £15,000 | £90,000 |
| ALD | | £ 5,000 |
| Pipeline under Neath Canal | | £12,000 |
| Wetland | | £500,000 |
| A sulphate reduction system has not been costed but implementation may significantly reduce the wetland requirement. | | |
| | | £607,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation @ 10% of capital cost | £60,700 |
| Maintenance 6 man days/year @ £250/day | £ 1,500 |
| | £62,200 |

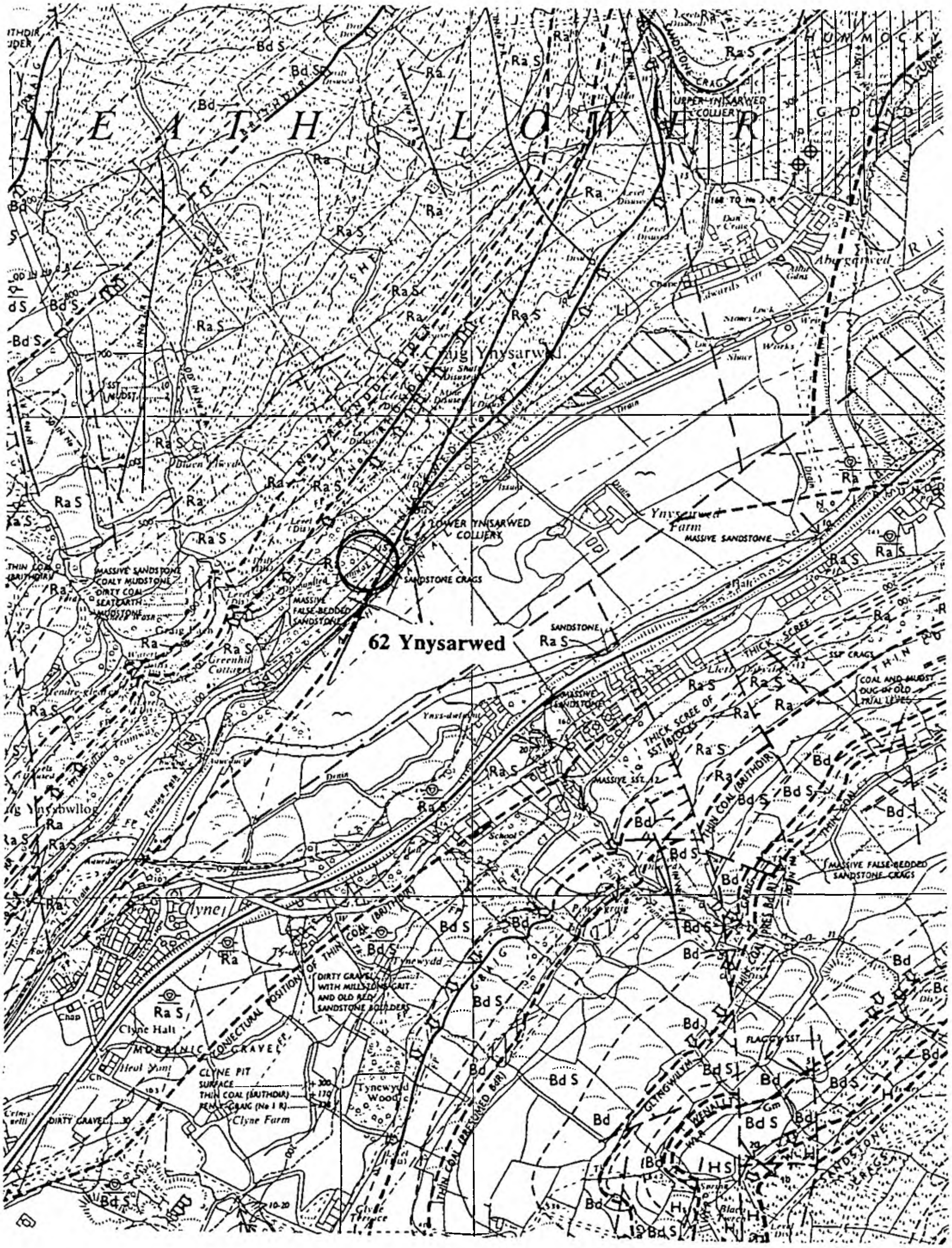
**Dulais**

**Capital Costs**

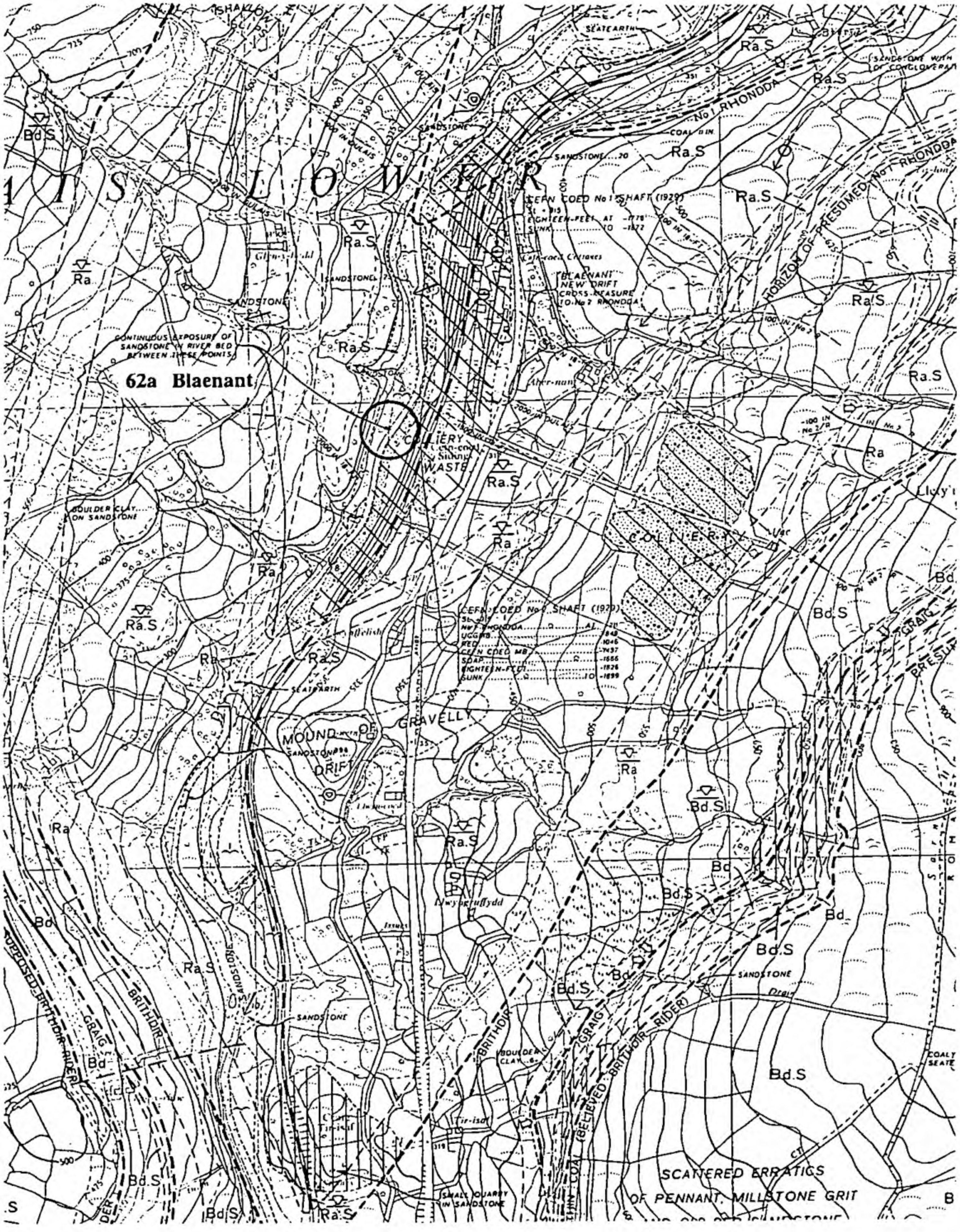
| | |
|---|---|
| Angled Boreholes: | |
| 1 x investigation borehole (250m) | £35,000 |
| 1 x production hole (250m) | £65,000 |
| Pipeline approx 1km | £75,000 |
| Wetland approx .2Ha | £50,000 |
| | £225,000 |

**Operating/Maintenance Costs**

| | |
|---|---|
| Depreciation 10% of capital cost | £22,500 |
| Maintenance 6 man days/year @ £250/day | £ 1,500 |
| | £24,000 |




| DATE: 13/04/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | Figure 62.1 |
|---|---|---|---|
| SRK | | SITE 62: YNYSARWED | |

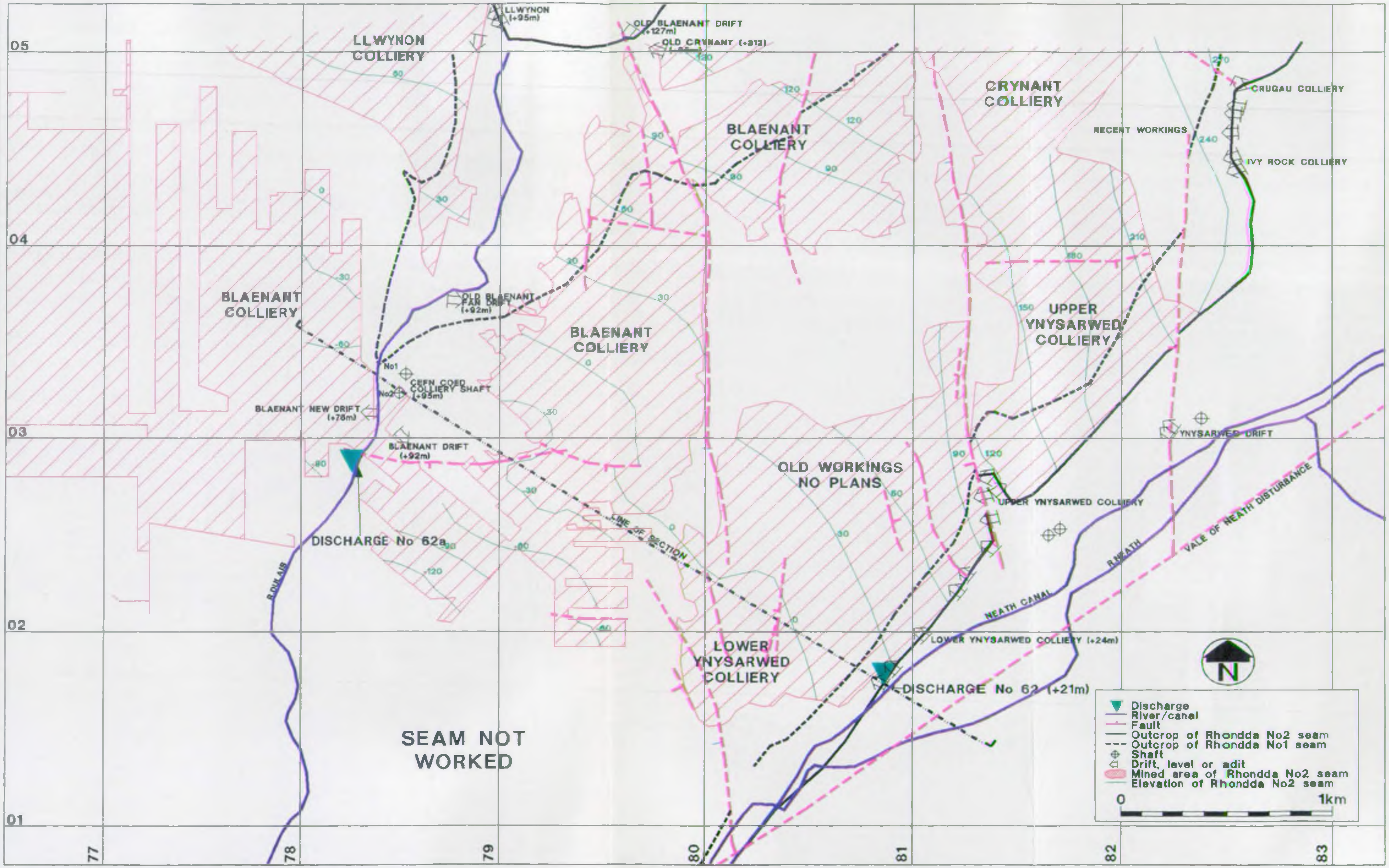



DATE: 14/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE

SRK

SITE 62a: BLAENANT

Figure 62a.1




DATE: 13/4/94 | PROJ. No: U489

SRK/NRA ACID ROCK DRAINAGE

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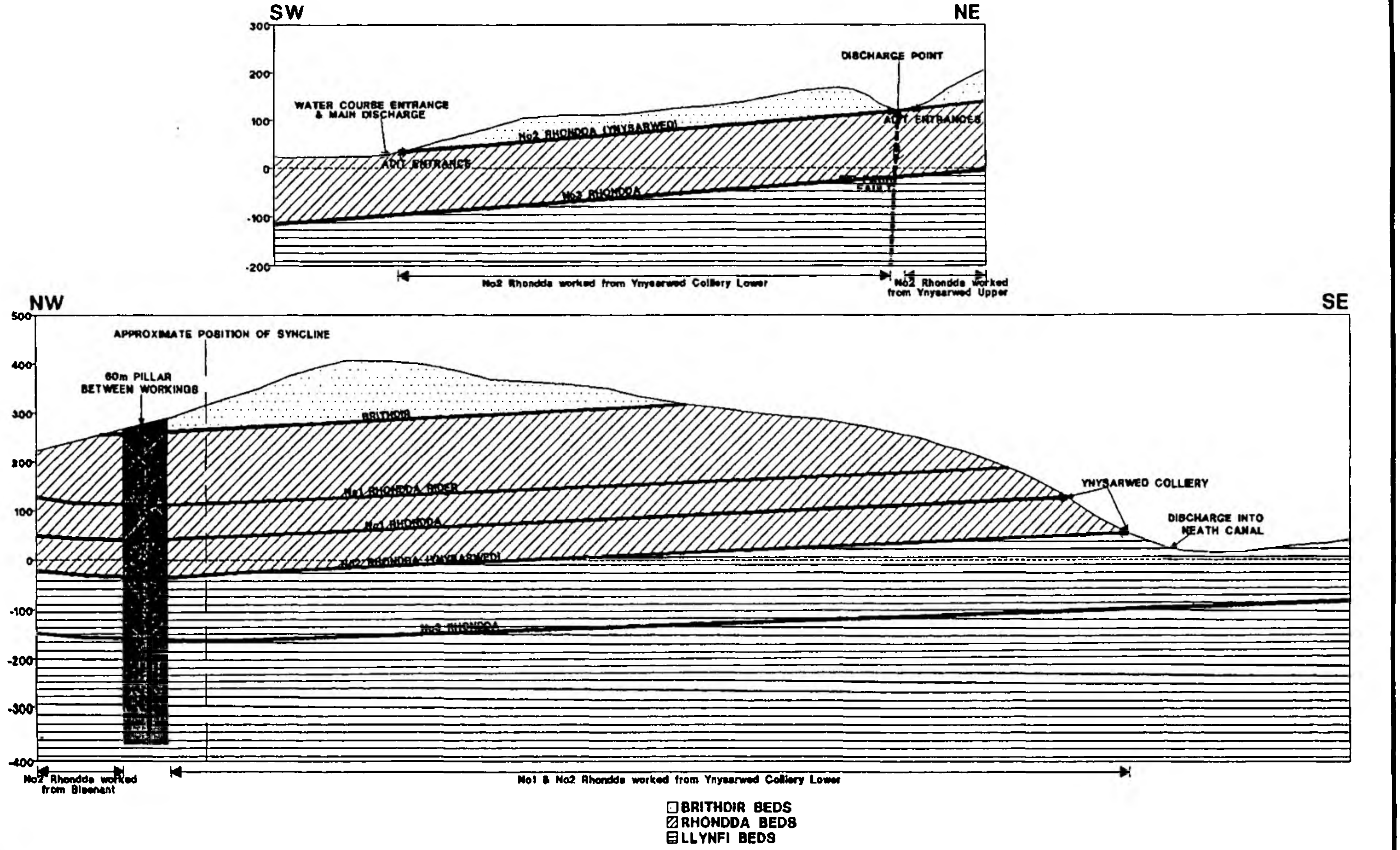
SRK (UK) Ltd, Summit House, 9/10 Windsor Place, Cardiff, CF1 3BX, U.K.

PLAN SHOWING MINEWORKINGS ON RHONDDA No2 SEAM ASSOCIATED WITH MINEWATER DISCHARGES AT YNYSARWED (Site 62) AND BLAENANT (Site 62a)

Figure 62.1b




| | | | |
|---|---|---|---|
| DATE: 5/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS | | SITE 62:YNYSARWED<br>SW-NE & NW-SE SECTIONS | Figure<br>62.1b/c |

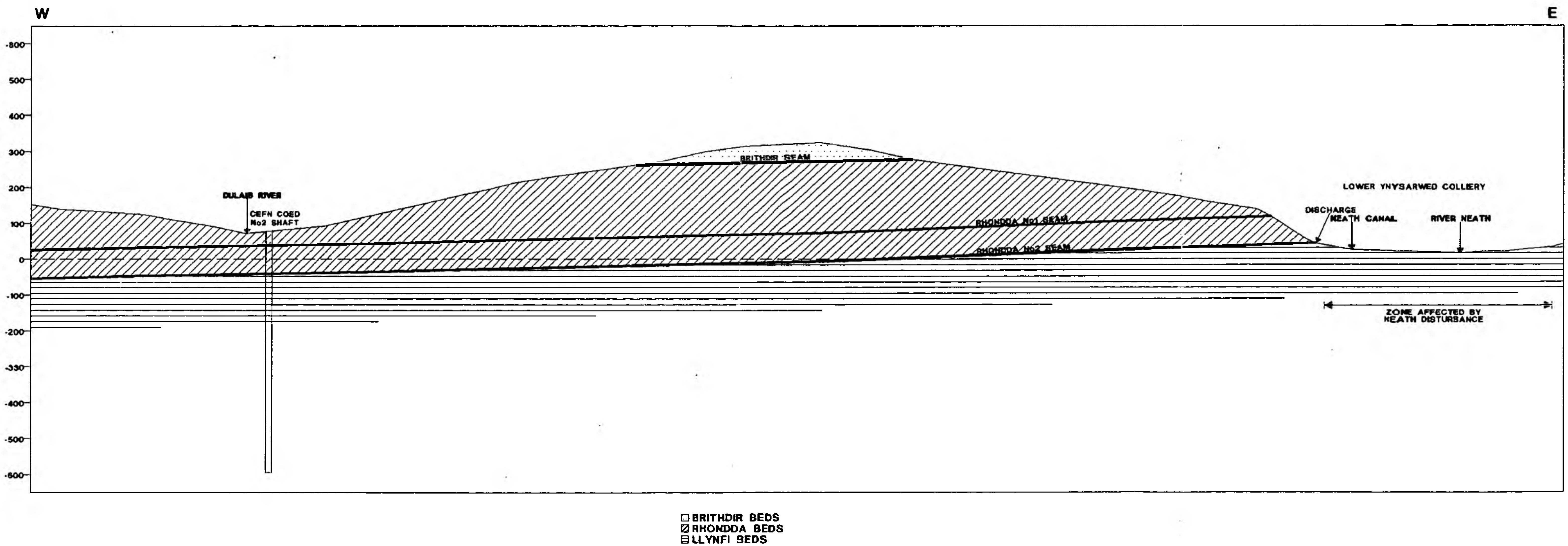
DISCHARGE FROM ADIT ON A465

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 62: YNYSARWED | Figure 62.1 D |

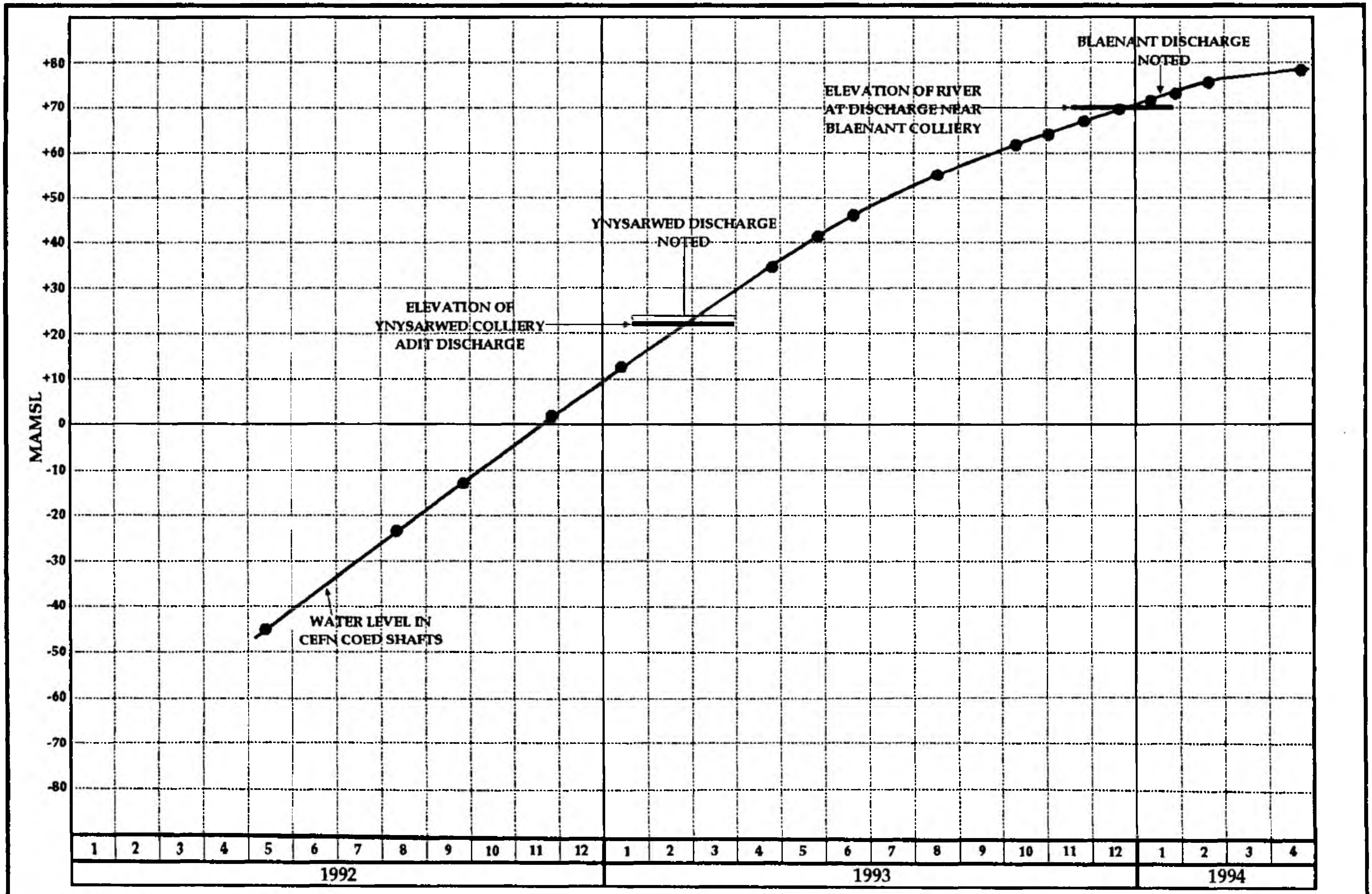
OVERFLOW FROM NEATH CANAL

OVERFLOW REACHING RIVER NEATH

| DATE: 11/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| SRK | | SITE 62: YNYSARWED | Figure 62.1 D |




| DATE: 15/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | SCALE 1:10560 |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS<br>SRK (UK) Ltd., Summit House, 9/10 Windsor Place, Cardiff, CF1 3BX, U.K. | | SITE 62a<br>BLAENANT-YNYSARWED SECTION | Figure<br>62a.1d |




| DATE: 8/4/94 | PROJ. No: U489 | SRK/NRA ACID ROCK DRAINAGE | |
|---|---|---|---|
| STEFFEN, ROBERTSON & KIRSTEN<br>CONSULTING ENGINEERS<br>SRK (UK) Ltd., Summit House, 9/10 Windsor Place, Cardiff, CF1 3BX, U.K. | | **RISE IN WATER LEVEL IN CEFN COED SHAFTS WITH TIME**<br>**ALSO SHOWN: DATE & ELEVATION OF MINEWATER DISCHARGES IN AREA** | **Figure 62a 1e** |

# Site 62, Section 4. Discharge Water Quality and Load Assessment.

Site #: 62
Site : Ynysarwed

Receiving water

| | River Distr. (%) | Discharge Distr. (%) | | Synthesized Discharge (m3/s) | Neath Canal U/S Receiving (m3/s) | Discharg Monthly Flow (1000m3/m | Neath Canal Monthly Flow (1000m3/m) | Dilution Factor | pH | Alkalinity (mg CaCO3/l) | SO4 (mg/l) U/S | D/S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | 4.8 | 7.8 | Jul | 0.019 | 0.131 | 51 | 344 | 0.129 | | | | |
| Aug | 4.6 | 6.9 | Aug | 0.018 | 0.126 | 47 | 331 | 0.124 | | | | |
| Sep | 4.1 | 7.5 | Sep | 0.020 | 0.111 | 51 | 292 | 0.150 | | | | |
| Oct | 8.9 | 7.7 | Oct | 0.020 | 0.244 | 53 | 641 | 0.076 | | | | |
| Nov | 15.0 | 9.0 | Nov | 0.023 | 0.410 | 62 | 1076 | 0.054 | 7.5 | | | |
| Dec | 16.6 | 9.6 | Dec | 0.025 | 0.451 | 66 | 1183 | 0.053 | | | | |
| Jan | 13.4 | 11.1 | Jan | 0.029 | 0.365 | 78 | 958 | 0.073 | | | | |
| Feb | 10.4 | 10.7 | Feb | 0.028 | 0.283 | 73 | 744 | 0.089 | 7.1 | | | |
| Mar | 6.6 | 7.9 | Mar | 0.021 | 0.187 | 54 | 490 | 0.099 | | | | |
| Apr | 5.8 | 7.7 | Apr | 0.020 | 0.157 | 53 | 412 | 0.113 | | | | |
| May | 4.7 | 6.5 | May | 0.017 | 0.127 | 44 | 334 | 0.117 | | | | |
| Jun | 5.0 | 7.9 | Jun | 0.020 | 0.136 | 54 | 357 | 0.131 | | | | |
| SUM | | 100.0 | mean | 0.029 | 0.227 | 683 | 7162 | 0.101 | | | | |
| Avg | | | min. | 0.017 | 0.111 | | | 0.053 | | | | |
| TOTAL ANNUAL FLOW | | | max. | 0.029 | 0.451 | | | 0.150 | | | | |

Site #: 62
Site : Ynysarwed

Discharge

| | pH | Alkalinity (mg CaCO3/l) | Fe(T) Concentration (mg/L) Discharge | Calculated Receiving | Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | Eq. Sludge Area (ha) | Est. Retention (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Sulphate (mg/l) | Monthly Loading (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul | | | 159.7 | 20.65 | | 8.2 | 156 | 0.156 | 300.4 | 0.6 | 0.032 | 1937 | 99 |
| Aug | | | 159.7 | 19.81 | | 7.5 | 143 | 0.143 | 327.6 | 0.6 | 0.029 | 1937 | 91 |
| Sep | 5.2 | | 134.0 | 20.07 | | 6.9 | 132 | 0.132 | 299.1 | 0.48 | 0.025 | 1670 | 81 |
| Oct | 3.7 | | 30.6 | 2.33 | | 1.6 | 31 | 0.031 | 291.2 | 0.5 | 0.026 | 1962 | 103 |
| Nov | 5.9 | | 259.0 | 14.03 | | 16.0 | 305 | 0.305 | 249.3 | 0.26 | 0.016 | 3232 | 199 |
| Dec | | | 159.7 | 8.42 | | 10.5 | 201 | 0.201 | 233.1 | 0.6 | 0.041 | 1937 | 128 |
| Jan | | | 159.7 | 11.72 | | 12.1 | 232 | 0.232 | 282.5 | 0.6 | 0.047 | 1937 | 147 |
| Feb | | | 159.7 | 14.28 | | 11.7 | 223 | 0.223 | 210.3 | 0.6 | 0.045 | 1937 | 141 |
| Mar | | | 159.7 | 15.86 | | 8.6 | 165 | 0.169 | 284.1 | 0.6 | 0.034 | 1937 | 105 |
| Apr | | | 159.7 | 18.05 | | 8.4 | 161 | 0.161 | 292.2 | 0.6 | 0.033 | 1937 | 102 |
| May | | | 159.7 | 18.65 | | 7.1 | 135 | 0.135 | 347.2 | 0.6 | 0.028 | 1937 | 86 |
| Jun | 3.2 | | 215.0 | 28.11 | | 11.6 | 221 | 0.221 | 285.7 | 1.25 | 0.067 | 963 | 53 |
| mean | | | 159.7 | 15.998 | | 110.0 | 2105 | 2.105 | 276.9 | 0.6 | 0.423 | 1937 | 1334 |
| min. | | | | 2.326 | | | | | 202.5 | | | | |
| max. | | | | 28.115 | | | | | 347.2 | | | | |

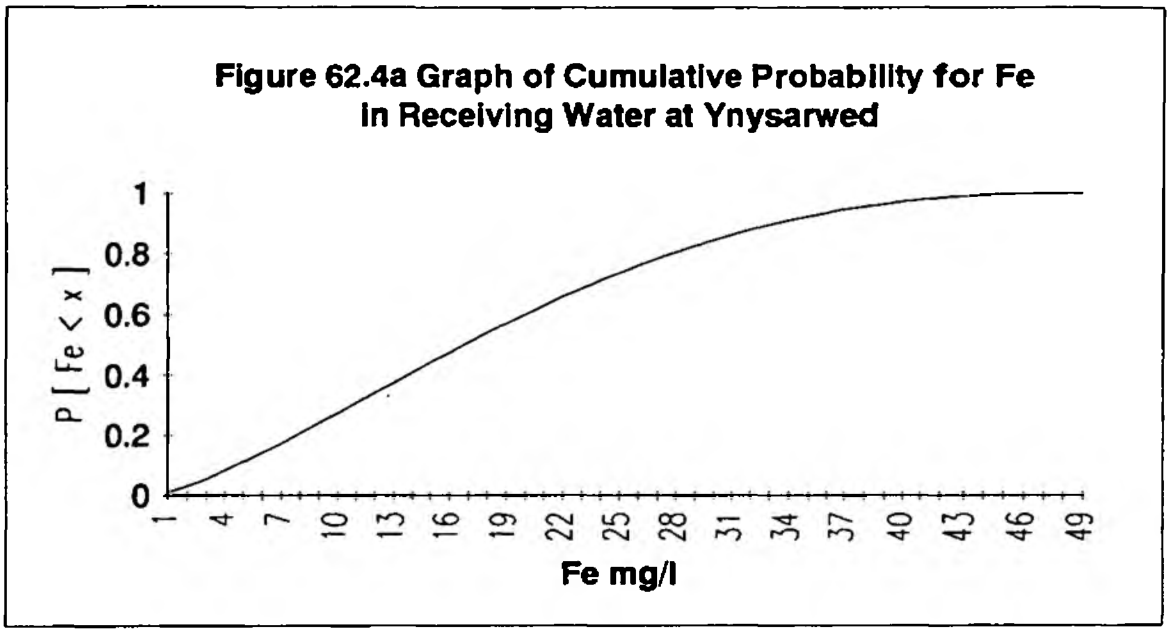


Figure 62.4a Graph of Cumulative Probability for Fe in Receiving Water at Ynysarwed
P [ Fe < x ]
1
0.8
0.6
0.4
0.2
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49
Fe mg/l

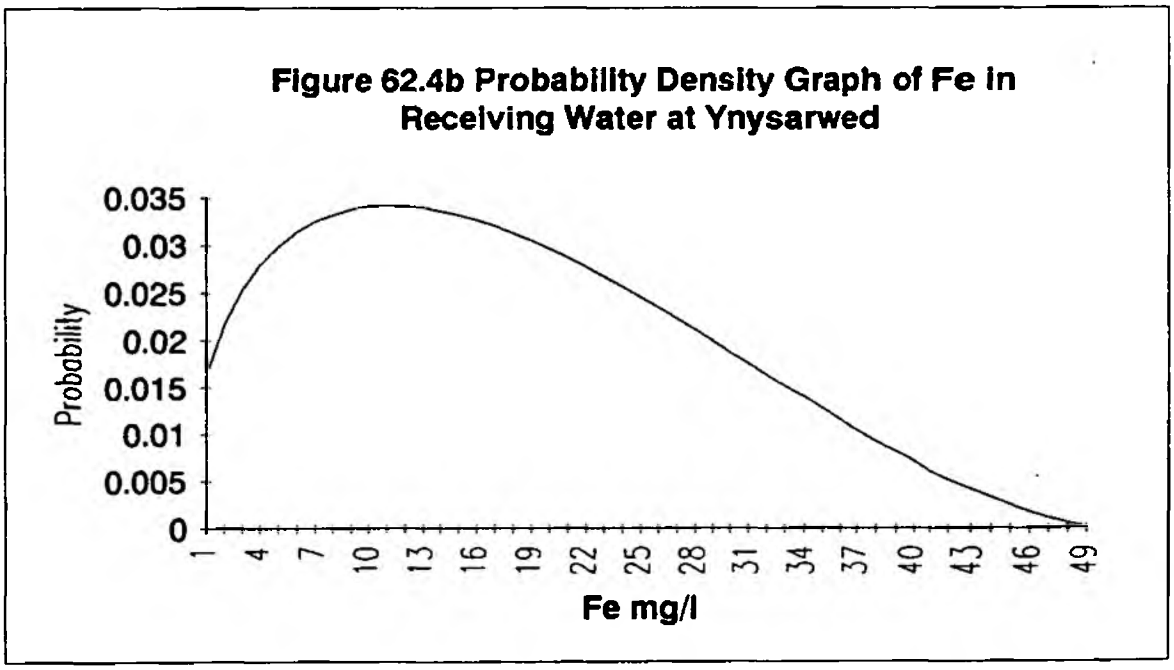


Figure 62.4b Probability Density Graph of Fe in Receiving Water at Ynysarwed
Probability
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49
Fe mg/l

Note: The data for the Dulais was taken directly from the date provided by the NRA
Flowrate estimate from discharge concentration and mass balance in the Dulais - likely an overestimate since the discharge sample is probably diluted
The Distribution for the discharge as before

Site #: 62 A
Site : Blaenant - Dulais

| | River Distr. (%) | Discharge Distr. (%) |
|---|---|---|
| Jul | | 7.5 |
| Aug | | 6.9 |
| Sep | | 7.5 |
| Oct | | 7.7 |
| Nov | | 9.0 |
| Dec | | 9.8 |
| Jan | | 11.1 |
| Feb | | 10.7 |
| Mar | | 7.9 |
| Apr | | 7.7 |
| May | | 6.5 |
| Jun | | 7.9 |
| SUM | | 100.0 |
| Avg | | |
| TOTAL ANNUAL FLOW | | |

Site #: 62 A
Site : Blaenant - Dulais

| | | | | | | Receiving water | | | | Discharge | | Fe(T) Concentration (mg/L) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Synthesized Discharge (m3/s) | River Dulais U/S Receiving (m3/s) | Discharge Monthly Flow 1000m3/m | eath Canal Monthly Flow 1000m3/m) | Dilution Factor | pH | Alkalinity (mg CaCO3 | SO4 (mg/l) U/S | D/S | pH | Alkalinity (mg CaCO3/l | Discharge | Calculated Receiving | Observed Receiving | Monthly Loading (ton) | Eq. Vol. Sludge (m3) | q. Sludg Area (ha) | Est. etentio (h) | Al Conc. (mg/l) | Monthly Loading (ton) | Calculate Receiving (mg/l) | Sulphat (mg/l) | Monthly Loading (ton) |
| Jul | 0.038 | 1.726 | 101 | 4539 | 0.022 | | | | | | | 5.5 | 0.12 | | 0.556 | 11 | | | | | | | |
| Aug | 0.035 | 1.132 | 93 | 2973 | 0.030 | | | | | | | 5.5 | 0.17 | | 0.510 | 10 | | | | | | | |
| Sep | 0.039 | 1.150 | 102 | 3021 | 0.033 | | | | | | | 5.5 | 0.18 | | 0.559 | 11 | | | | | | | |
| Oct | 0.040 | 1.400 | 104 | 3677 | 0.028 | | | | | | | 5.5 | 0.15 | | 0.574 | 11 | | | | | | | |
| Nov | 0.046 | 1.992 | 122 | 5232 | 0.023 | | | | | | | 5.5 | 0.13 | | 0.671 | 13 | | | | | | | |
| Dec | 0.050 | 5.499 | 130 | 14443 | 0.009 | | | | | | | 5.5 | 0.05 | | 0.717 | 14 | | | | | | | |
| Jan | 0.057 | 4.506 | 150 | 11835 | 0.013 | | | | | | | 5.5 | 0.07 | | 0.825 | 16 | | | | | | | |
| Feb | 0.055 | 0.803 | 144 | 2109 | 0.064 | | | | | | | 5.5 | 0.35 | 0.320 | 0.785 | 15 | | | | | | | |
| Mar | 0.041 | 0.503 | 107 | 1321 | 0.075 | | | | | | | 5.5 | 0.41 | | 0.588 | 11 | | | | | | | |
| Apr | 0.040 | 1.566 | 104 | 4113 | 0.025 | | | | | | | 5.5 | 0.14 | | 0.572 | 11 | | | | | | | |
| May | 0.033 | 0.978 | 88 | 2569 | 0.033 | | | | | | | 5.5 | 0.16 | | 0.481 | 9 | | | | | | | |
| Jun | 0.041 | 1.275 | 108 | 3349 | 0.031 | | | | | | | 5.5 | 0.17 | | 0.585 | 11 | | | | | | | |
| | 0.043 | 1.878 | 1351 | 59182 | 0.032 | | | | | | | 5.5 | 0.176 | | 7.433 | 142 | | | | | | | |
| | 0.033 | 0.503 | | | 0.009 | | | | | | | | 0.049 | | | | | | | | | | |
| | 0.057 | 5.499 | | | 0.075 | | | | | | | | 0.412 | | | | | | | | | | |
| | 0.515 | | | | | | | | | | | | | | | | | | | | | | |

| | u/s | d | d/s | Flow for 17 Feb 1994 | g/s | |
|---|---|---|---|---|---|---|
| Mn (mg/l) | 0.17 | 1.3 | 0.23 | 1.197 | 0.0716 | 0.055 |
| Fe (mg/l) | 0.32 | 5.7 | 0.56 | 1.197 | 0.2873 | 0.050 |
| | | | | | 9.0597 | |

## APPENDIX A

## ASSESSMENT OF FISHERY VALUES

**Site 5 Blackwood**

The character and value of the fishery on the River Sirhowy is very similar to that on the River Rhymney. The main angling club is the Islwyn and District Angling Club and about half the sport is based on put and take fishing for trout.

The area of river affected by ferruginous discharges is about half that of the River Rhymney. The value of the fishery lost would, therefore, be about half of the figure calculated for the River Rhymney, i.e. £1600 ÷ 2 = £800 p.a.

On similar pro rata basis £200 can be attributed to the River Sirhowy at Blackwood and £600 attributed to the river at Pontllanfraith. It should be noted, however, that the electrofishing survey showed no reduction in fish population downstream.

**Site 6 Pontllanfraith**

The character and value of the fishery on the River Sirhowy is very similar to that on the River Rhymney. The main angling club is the Islwyn and District Angling Club and about half the sport is based on put and take fishing for trout.

The discharge is similar in size and nature to Site 5. The summary of the costs and benefits for that site therefore apply to this as well. On a pro-rata basis, £200 can be attributed to the River Sirhowy at Blackwood and £600 attributed to the Sirhowy at Pontllanfraith. It should be noted, however, that the electrofishing survey showed no reduction in fish population downstream.

**Site 7 Tir-y-Berth**

The Royal Oak Angling Club has fishing rights in the river from the springs to Ystrad Mynach.

The economic value can be said to be equivalent to the subscription income which in 1989 was £2174. Half of the fishing depends on wild trout and half depends on restocking for put and take fishing.

The electrofishing survey indicates that wild fish population may be reduced by about half. Thus,

£2174 x 50% wild fishery x 50% reduction = £543

Whether or not they catch fish, anglers enjoy the amenity of walking the river. This is difficult to value but courts have in the past accepted that 50% over and above a fisheries value could be attributed to the value of amenity. If one assumes that half of the amenity value has been lost due to iron staining and deposition, then the following applies for the Royal Oak Angling Club :

£2174 x 50% amenity value x 50% reduction = £543

Thus loss of sport was valued at £543 and loss of amenity valued at £543, making a total of £1086 p.a. This is very similar to the sum of about £1000 p.a. in lost subscription income in the three years following the emergence of the springs. No other reason for the loss of membership is known other than the perception that iron pollution has adversely affected the fishery.

Lower down the river, the Maesycymmer Angling Club and Llanbradach Angling Club did not suffer any biological impact but they did suffer loss of amenity due to iron deposition. This can be valued as :

| | |
|---|---|
| Maesycymmer | £450 income x 50% amenity x 50% reduction = £112 |
| Llanbradach | £891 income x 50% amenity x 50% reduction = £223 |

The river, in general, is recovering from past pollution and salmon and sea trout populations had been gradually improving year by year. The 1.5 km downstream of the springs is unlikely to provide suitable conditions for spawning migratory fish. Therefore, part of the potential for recovery has been lost for all anglers in the river system.

The losses estimated for the three angling clubs amounts to £1421 p.a. If one makes an allowance for other riparian losses and the loss of potential recovery of migratory fish, then this sum could be rounded up to £1600 per annum.

**Site 10 Blaenavon**

The Afon Lwyd is a small stream at the top of the catchment. Lower down, the river is fished by Cwmbran Anglers and Pontypool Anglers. It is a brown trout fishery with some potential for improving salmon and sea trout runs. The ferruginous impact is small in area (500m$^2$) and it has a small impact on trout spawning.

**Site 12 Y Ffrwd (Llanwonno)**

The discharge is at the top of a tributary in forestry and it is of no angling value. The lowest part of the Nant Clydach is probably fished by members of the Pontypridd and District Angling Club. The Y Ffrwd Tributary is a trout spawning stream but as electrofishing showed a high population downstream of the discharge, there is no fishery impact.

**Site 15 Llynfi**

The stream is too small for any angling interest. The tributary would be of moderate value for brown trout spawning. The River Llynfi has considerable scope for improvement for salmon and sea trout and a restocking programme is in progress by the NRA. A replacement value for the loss of spawning grounds is valued at £233.

**Site 16 Craig Yr Aber**

The stream, known downstream as Nant Iorweth Goch (Red Stream) is too small for any angling interest. The tributary is of high value for brown trout and to a lesser extent for sea trout spawning. Some obstructions inhibit access by salmon and sea trout. The replacement value of the loss in spawning is calculated at £92.

**Site 17 and 17A Afon Corrwg**

The stream is too small for any angling interest. The stream is of moderate value for brown trout spawning. A small fish pass is being considered to improve access for brown trout and sea trout at a point where a culvert takes the stream past the old mine workings. There is, therefore, scope for a modest improvement in migratory fish spawning. The replacement value of the loss in spawning is calculated at £91.

**Site 18 Afon Corrwg Fechan**

The stream is too small for angling interest. Limited suitability for brown trout spawning. There is a low potential for improved salmon and sea trout spawning.

**Site 19 Gwynfi**

The site is a small stream in an afforested area with no angling interest. Because of steep flow and being sited at the top of the tributary, this is only of very limited brown trout spawning value.

**Site 29 Cathan**

Although there are about two miles of stream above the discharge, the local water bailiffs have not noted this as a spawning area. It is too small for any angling interest and it is of limited spawning value. The replacement value for loss of spawning ground is estimated as £56.

**Site 30 Morlais**

There may be some informal or casual angling on this small river but it is not sufficient for an angling club to take an interest. There is some concern that the ferruginous area may pose a barrier to the migration of salmon and sea trout. Some fish do get past, however, for small numbers of salmon par have been caught by electrofishing and there have been some cases of poaching for salmon and sea trout. Perhaps adult migration takes place during high flows in autumn and early winter. The river certainly has scope for improvement as a sea trout fishery.

One option for treatment is to divert the ferruginous discharge for treatment and settlement in reed beds and then discharge direct to the estuary. This would have the benefit of removing any barrier to migratory fish entering the River Morlais. In the estuary, any treated ferruginous discharge would possibly have an effect on the food of estuary birds and on the shellfish exploited by the Penclawd/Bury inlet fishermen. As the load of iron discharged to the estuary would be reduced, however, then the settlement of iron in the estuary mud should be less than that which occurs at present.

If the water quality improvement resulting from minewater treatment allowed access to migratory trout and occasional salmon, then about two miles of river would be worth renting to anglers. This may produce an income of say £1000 for riparian owners.

**Site 31 Dunvant**

The river contains brown trout and occasional sea trout. The river is affected by sewage pollution. The river is too small for organised angling and it is only fished by schoolchildren from adjacent urban areas.

**Site 33 Llechart (Lower Clydach)**

This is a small stream so it is of no interest for angling. Obstructions on the Lower Clydach prevent access to migratory fish for spawning. The area is locally important for brown trout spawning.

**Site 62 and 62A Ynysarwed and Blaenant**

The Neath Canal supports a coarse fishery and a put and take trout fishery. The fishing rights are leased by the Neath and Dulais Angling Club from the Neath Canal Company for a peppercorn rent. Over the past year part of the fishery has been lost due to the ferruginous discharge at Ynysarwed. An electrofishing survey on 15 to 17 December 1993 indicated a healthy fish population upstream of the discharge and no fish nor negligible fish populations for 3Km downstream, and a depressed fish population for a further 2Km downstream.

It is believed that this effect is due not to the direct toxic effect of iron on fish but rather on the invertebrate food of fish. Fish removed from the canal by electrofishing were found to be in poor condition indicating starvation. The fish removed included brown trout, tench, perch, roach, gudgeon, bream and eels.

The Neath and Dulais Angling Club have fishing rights on the Dulais River and the secretary estimated that 3 Km of river is affected by iron deposits. It is difficult to value the fishery separately from the rest of the angling club waters. The club has approximately 6 miles of fishery on the River Neath, 4 miles on the River Dulais and 7 miles on the Neath Canal. The number of members has declined from 611 in 1991 to 540 in 1993 (figures for 1992 not available) and it is believed that this is influenced by the perception of poorer quality fishing due to the ferruginous pollution. Coarse fishermen, on the Neath Canal in particular, feel it is not worth taking out a licence, having heard the considerable publicity about the pollution. The indications are that licence sales are down in 1994 compared with the same time last year. If the membership is down by 100 compared with 191, then one can estimate a loss of £1,500 in subscription income, of which £1,200 can be attributed to the Neath Canal and £300 to the River Dulais.