

# A metal mines strategy for Wales

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## Abstract

The mid-Wales orefield was extensively worked during the 17<sup>th</sup> to 19<sup>th</sup> centuries and there are many mines and trial workings in the area. Alongside the present day archaeological, historical and mineralogical aspects of each site is the legacy left by the exposure of waste at surface and the discharge of mine waters from abandoned underground workings. Many mine sites are currently having an impact on watercourses, contributing to the failure of at least 108km of rivers to meet their water quality objectives in Wales.

This paper describes the approach taken in developing a strategy for dealing with the management of abandoned mine sites in Wales. Fundamental to the management plan was engagement with relevant stakeholders at an early opportunity, identification of issues that would prevent or limit the potential timescales for remediation and a forum to enable viewpoints to be gathered. Once this information was brought together it was possible to progress to developing feasibility studies and remedial design works for the priority sites, taking into account the value of the sites as an archaeological and ecological resource.

## 1. Introduction

The varied geology of Wales and in particular the late stage hydrothermal mineralisation of the Caledonian Orogeny (George 1970) has resulted in the presence of many non-ferrous metalliferous ores considered worthy of extraction. The metal bearing lodes of mid and north Wales have been exploited since the Bronze Age for silver, lead, copper, zinc and gold with the result that there are a considerable number of mines in the principality. Their heyday was the 17<sup>th</sup> to 19<sup>th</sup> centuries, following the Industrial Revolution.

As with coal mines, discharges from the mines and leaching of metals from spoil heaps has resulted in considerable pollution of watercourses,

causing failures to achieve chemical and biological water quality targets. Particularly impacted are the three rivers draining the North Ceredigion orefield: the Rheidol, Clarach and Ystwyth (Figure 1). This amounts to one fifth of all river quality objective failures in Wales.

The most common cause of failure is for the zinc component of the River Ecosystem class, part of the Environment Agency's General Quality assessment scheme for watercourses. The Environmental Quality Standard (EQS) for zinc is derived from the Freshwater Fish Directive standards and is dependent on hardness as per Table 1. The rivers of mid and North Wales tend to rise on base poor geology such as the Silurian and Ordovician Grits and Shales and are susceptible to acid deposition. Often the valleys are afforested with conifers which can exacerbate the problem. There is therefore very little alkalinity in either the minewaters or the receiving rivers making the impact of the discharges all the more significant.

**Table 1.** River Ecosystem Zinc Standards

Hardness (mg CaCO <sub>3</sub> l <sup>-1</sup> )	Zinc EQS (µg l <sup>-1</sup> )
0-10	30
10-50	200
>50-100	300
>100	500

Of the 5042 km of monitored river stretches in Wales, in 1999, 506 Km failed to comply with their River Ecosystem objectives and of those 108Km were directly attributable to mine pollution.

In some instances considerable lengths of rivers are believed to be impacted by single mines. The extensive workings along the Afon Twymyn at Dylife for example cause the river to fail for 20Km. The Cwmrheidol Mine complex contributes at least 40% of the metal load of the Afon Rheidol, contributing to 16Km of failures. (Mullinger, 2004)

The EC Water Framework Directive (2000/60EC) has reformed European Union water legislation and will require compliance with "Good" water quality in all water bodies. Failure to achieve such good status will require the production of river basin management plans to implement improvements.

It is important to note that the mines do not simply contribute to failures on paper, the discharges have a very real impact on the ecology of rivers. Invertebrate fauna can be impoverished, fish populations are reduced and watercourse can suffer from blooms of blue green algae which thrive in the

adverse conditions. Zinc, copper and cadmium all affect fish gill tissue, with the added effect that fish can be more susceptible to episodes of low dissolved oxygen. Exposure to sub lethal levels of lead in particular has been noted to result in blackening of the body in Salmonids, with higher concentrations causing dorsal and lateral curvature of the spine and erosion of fins. (Milne et al 1982)

## **2. The Strategy**

### **2.1 Background**

Wales has a history of leading on minewater issues; the initial ranking exercise which led on to the national scheme to address coal mine discharges and eventually the partnership with the Coal Authority was initiated by the Welsh Region of the National Rivers Authority. It has long been recognised that some of the most significant impacts of metalliferous mining were in Mid and North Wales so it is appropriate again that Environment Agency Wales has produced the initial template for addressing the problem.

A notable difference between coal and metal mines in the UK is that there is no overall body with any responsibility for the liabilities associated with metal mines. When the Coal Authority were given British Coal's responsibilities in 1994, a specific part of their remit and funding was to deal with the legacy of minewater impacts affecting the rivers of coal field areas. Metal mines have no such history of public ownership or control.

The need for a metal mines strategy at this time should not be taken to indicate that no remediation works are being undertaken, many have been, and with much success. The 1998 scheme to encapsulate the fines dumps at Cwmbwyno resulted in a significant reduction in zinc and lead loadings to the Afon Melindwr, a tributary of the Rheidol (Robinson 2001). The major land reclamation scheme at one of Wales's most productive mines, Van, near Llanidloes has also been successful.

What these schemes did highlight was the need to take account of the diverging issues of other statutory bodies and interested parties to obtain the best environmental and social outcome. They also showed the potential for any remediation scheme undertaken with the best intentions to impact on other important features of the site. For example the antiquity of many sites, and their importance to the communities and landscape has resulted in their being of significant archaeological interest, with many being designated as Scheduled Ancient Monuments. The geology which resulted in the exploitation of the minerals has led to many of the sites being valuable as Sites of Special Scientific Interest (SSSIs) or Regionally Important Geological Sites (RIGS) for the mineralogical or geological features. That

same geology and the specialised flora that has adapted to tolerate it results in the sites being important ecologically with further SSSI designations. These issues were clearly brought to the Agency's attention at the Cwmbrwyno site where the availability of a funding source for remediation was short lived and required rapid planning and execution to take advantage of it. The statutory archaeological and conservation bodies were consulted and the result was probably the quickest SSSI designation in the UK (10 days) because the site was very important for several features including the rare lichen population living on the spoil heaps. The project was able to progress to a satisfactory conclusion with the encapsulation of the fine spoil and the preservation of the coarse spoil on which the lichens were present, but the knowledge of those issues in advance of the detailed planning stage would have been beneficial to all parties. (Robinson 2000)

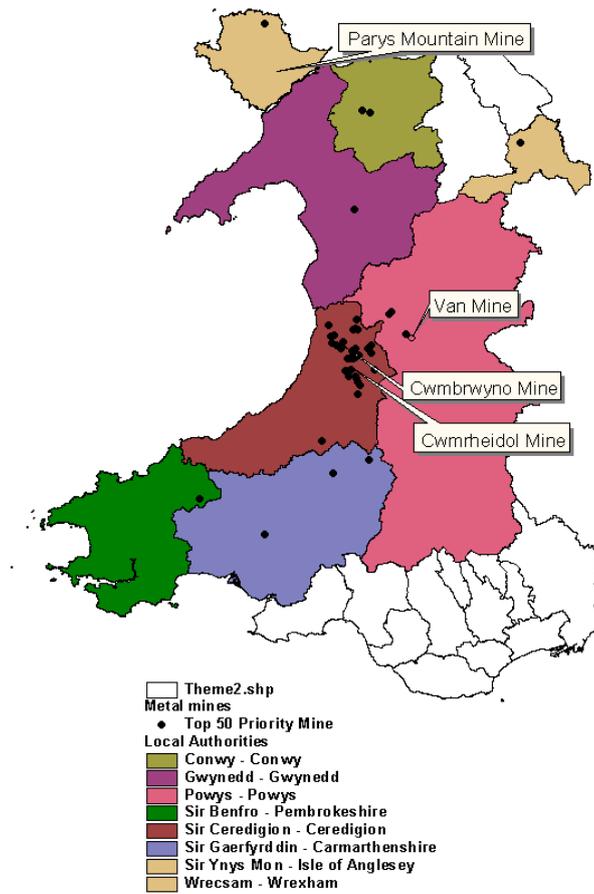
## **2.2 Phase I**

With this in mind the Environment Agency Wales secured funding from National Assembly for Wales to fund a Metal Mines Strategy which would seek to identify the priority sites for remediation and to obtain the views of all the major stakeholders. This information would allow better planning of any remediation works including feasibility studies and design works for the priority sites.

In order to identify which sites were important the Agency relied upon a Database of Metal Mines in Wales commissioned in 1996 by the National Rivers Authority (Kitts & Smith 1996). This database contains the records of 1,337 metal mines in Wales, with additional data on 204 sites believed to be causing an impact on water quality. The database includes a considerable amount of information and is an amalgamation of several datasets including information from the Department of the Environment, Welsh Office Contaminated Land Database, mine information consultants and the Agency's own archives. Impacts on the watercourses are estimated from known information including age and size of the mine. The sites can be ranked according to the perceived scale of their impact. For the strategy it was decided to commence with the top 50 sites from this database, this being considered a workable number. Local Agency officers were consulted regarding the appropriateness of these 50 sites for inclusion on the list. The result was that some mines were removed (due, for example, to the recent installation of remediation schemes), and other sites were added to the priority list.

The locations of those top 50 sites are indicated on Figure 1. It was clear that the majority of the most polluting mines were in the County of Ceredigion (with 38 of the 50).

**Figure 1.** Locations of Metal Mines in Wales



The next task was to engage with the stakeholders for each mine and seek their comments on the importance of the site and their views on the potential impact of any remedial scheme. This task was undertaken by questionnaire and 587 were sent out to 46 individuals representing 20 distinct stakeholder organisations. An indication of the interest in these sites within the wider community is that 582 responses were received, a 99% response rate.

The findings of the consultation exercise are reported in detail in the report: A Metal Mines Strategy for Wales, which was published in 2002. A copy can be viewed on the Agency's website at:

[http://www.environment-agency.gov.uk/regions/wales/426317/393155/?version=1&lang=\\_e](http://www.environment-agency.gov.uk/regions/wales/426317/393155/?version=1&lang=_e)

This document reported all of the responses received both generally and detailed by individual mine.

The most important finding of the strategy was that the sites are held to be very important not only for their archaeological or ecological interest but also as an integral part of the landscape. They are seen to be a resource for the local community with potential for inclusion in any regeneration for tourist or educational facilities rather than as an indicator of industrial dereliction requiring reclamation or restoration. This finding was to be key in progressing the project to its next phase.

It was possible from the responses received to divide up the mines into four broad categories based not on their environmental impact but on the ease with which remediation could be progressed. These groups are summarised in Table 2.

The 50 sites were classified into these groups which made it easier to consider progressing them through to remediation by identifying possible constraints at an early stage. Of the 50 sites 1 fell into Group 1, 7 in Group 2, 23 in Group 3A, 7 in Group 3B, and the remaining 12 in Group 4. This indicated that 31 of the sites could be progressed towards remediation without significant conflicting issues arising.

The strategy went on to recommend the progression of feasibility studies and outline design options at all of the Group 1 and 2 sites and at four sites in each of groups 3A and 3B. It also recommended that further investigations be undertaken to assess the real impact of group 4 mines.

**Table 2. Metal Mine Site groups**

<b>Group</b>	<b>No. of Sites</b>	<b>Interpretation</b>
1	1	No diverging issues - It appears that there are no diverging issues at this site, the Agency could therefore pursue the remediation relatively easily, but still taking into account intrinsic historic interests and still requiring a complete desk study and scope of works and possible impacts.
2	7	Converging issues – It appears that the Agency and one or more stakeholders have a shared interest in the remediation of the site and therefore it may be possible to develop a collaborative project. For example, there could be a combined interest to install a water clean-up scheme at the same time as the development of the site as a tourist attraction or the water remediation scheme could be extended to address issues of public health and safety.
3a	23	Diverging issues - It appears that the Agency and the views of one or more stakeholders diverge at this site, however, it is considered that the differences could be resolved subject to careful negotiations and sympathetic design
3b	7	Diverging issues - It appears that the Agency and the views of one or more stakeholders diverge at this site, it is considered that the differences are so great that it would be extremely difficult to progress any remediation scheme. For example sites extensively designated as SSSI.
4	12	Further information – During the review of data it appears that these sites may not be presenting such an impact to the water environment as previously understood or data on sites outside the top 50 has come to light that indicates that they should be included within the top 50. Further monitoring and data review required.

With this information to hand it was possible to approach the Welsh Assembly Government for funding to progress taking a certain number of sites forward for further investigation of the feasibility for provision of remedial schemes. The Agency was successful in this bid and obtained an initial sum of £136 000 to run Phase II of the project over the following two years.

### **2.3 Phase II**

Having identified the priority sites for remediation in Phase I, the next task was to refine these priorities by using recent and additional data. Given the value of these sites as a resource for the local communities we could not justify remediation solely on environmental terms without considering the wider social and ecological benefit.

Once this process was commenced it rapidly became clear that the level of environmental data available for most of the sites was not sufficient to make real decisions of priority so in the first year of the project the focus was on obtaining those data. In many cases some chemical data was available but there was very little reliable flow data, hence it was not possible to consider the loadings of metals and the contribution of individual mines to the metals load in the rivers. A monitoring programme was set up to collect chemical and flow data for many of the mine sites and receiving watercourses to fill those gaps.

#### **2.3.1 Case Study, Parys Mountain Copper Mine**

A major commitment was given to monitoring the Parys Mountain Copper Mine drainage scheme. Parys Mountain was always known to be a high priority site within the strategy due to its known impact on two Anglesey watercourses, both appropriately named Afon Goch which translates from Welsh as red river. Due to the history of the site and its international recognition, there has always been a high level of interest at this site with plans to develop it as an educational and tourist facility by the Amlwch Industrial Heritage Trust. The site is also a Scheduled Ancient Monument and SSSI.

Following an inspection of the mine in 2000 it was determined that there was a major risk of acute flooding and pollution from the Dyffryn Adda adit which was dammed at an unknown time, probably in the early part of the 20<sup>th</sup> Century, though underground mining ceased in the 19<sup>th</sup> Century. The dam was installed to allow the acid minewater to dissolve the remaining copper in the worked out areas of the mine. The water was then drained in a controlled manner into an extensive system of precipitation ponds where the very pure metallic copper was collected by addition of zero valent iron. Since the cessation of solution mining there still remains

a very large volume of acid, metal-rich minewater being held in the mine-workings within the mountain by an old and decaying concrete dam. The stream to which the adit discharged ran through the town of Amlwch and there was an identified risk of a major incident should the dam fail with the catastrophic release of an estimated 270,000 cubic metres of minewater.

A collaborative working group was set up by interested public bodies including Anglesey County Council and the Environment Agency Wales to investigate the problem and make recommendations for remedial works. The result of this was a project to proactively drain down the mine by pumping it to the Afon Goch Amlwch. This river was already significantly impacted by discharges from the mine. The dam could then be removed so allowing any further minewaters to drain freely. This activity was successful with the benefit that discharges from other adits were greatly reduced so improving water quality in another watercourse, the Afon Goch Dulas, significantly.

The pumped minewater was discharged through one of the original precipitation ponds to allow attenuation and precipitation of metals as far as possible. The rate of discharge was controlled by means of a discharge consent to minimise the impact of the increased flow. The results of that exercise showed that there was no significant change of pH or metal content in the coastal waters. The Afon Goch Amlwch itself was already significantly impacted by discharges from the mine.

### **2.3.2 Case Study 2 Cwmrheidol Lead Mining Complex**

In the second year of Phase II the attentions of the Metal Mines Project were focussed on interpreting the data collected and setting priorities for remediation. However, as with Parys Mountain in Anglesey, a number of Mid Wales lead mines have always been known to be significant contributors to the failures to achieve water quality targets, amongst these is the complex of mines at Cwmrheidol.

At this site a pair of adits connects six mines and the combined discharges contribute at least 40% of the metal load in the Afon Rheidol. The six mines were representative of three of the five groups determined in Phase I of the project, and it was decided that we should progress the sites through a feasibility study to a stage which would allow us to explore potential funding and for a contractor to price detailed design works. It was concluded that the problems associated with the site could be remediated by a combination of surface water diversions, to reduce the volume of water discharging from the adits, and by provision of a Reducing and Alkalinity Producing System (RAPS) (Rees 2004).

### **2.3.3 Stakeholders**

Throughout the feasibility study process an important part of this project was the stakeholder engagement that occurred. From the outset the views of the relevant bodies and local people were sought on their aspirations for the site. The feedback received from the consultations was designed into the scheme with the result that when presented with the conclusions and remedial plans the stakeholders felt that their views had been taken seriously and were generally positive about the scheme as a whole. This approach is integral to the strategy, as without the support of the local community it is unlikely that any remediation scheme will accomplish its aims.

## **3 Challenges for the Future**

In the coming two years the Environment Agency Wales has three major objectives, to progress Parys Mountain and Cwmrheidol to a stage whereby remediation schemes can go ahead, to undertake scoping and feasibility studies at another ten mine sites, and to identify funding streams to allow remediation to happen.

Following on from the successful drain down project at Parys Mountain, the provision of a treatment system for the free flowing minewater is considered to be a priority. In 2004/05 we will be commissioning consultants to investigate the feasibility of providing such a system and investigating options for design of such a works. The Amlwch Industrial Heritage Trust have already been successful in providing facilities for research and tourism with heritage trails and an information centre. A field study centre and better tourist facilities are also planned.

We will also be commencing a more strategic approach to the remaining high priority mine sites with scoping and feasibility studies being commissioned at a further five sites. Whilst we can take steps to carry out these investigations our current funding and the terms of the project do not cater for the provision of the remedial schemes themselves. To carry out these presents a major challenge in identifying funding streams and partners to allow construction to occur. The majority of the mines are within the Wales Objective 1 area so allowing access to European Structural funding. Indeed there is a specific measure built into these funds for minewater treatment. However this will provide only 40% of the total cost with a requirement for match funding to be obtained from other sources. A further concern is that Objective 1 funds will only pay for capital works. Design and maintenance costs must be funded from elsewhere. With remedial schemes costing hundreds of thousands of pounds, if not millions then this remains a significant challenge for the Agency and also for governments to overcome.

## 4 Conclusions

The non-ferrous metal mines of Wales are an important part of our industrial heritage but also a significant contributor to environmental pollution. In order to progress making improvements in the environment the diverging issues associated with the mine sites must be both understood and incorporated into any remedial design. The engagement of stakeholders is integral to this process and remediation works are unlikely to proceed successfully without the inclusion of both the local community and the wider archaeological and ecological parties.

The Wales Metal Mines Strategy has proceeded with the support of stakeholders due to the effort that has been put in from the outset to understand their views and the important place the sites hold in the local community. There are some significant challenges to overcome in the future, notably the need for funding to allow any remediation scheme to proceed and these will be approached robustly to ensure that the environment of Wales is improved for current and future generations, whilst preserving the heritage of our past.

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