June 2016

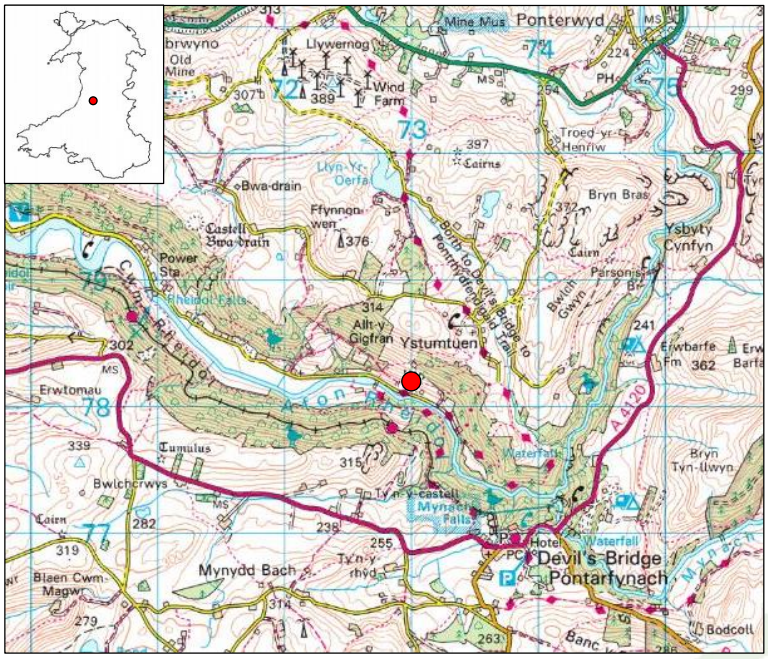
Abandoned Mine Case Study: Cwm Rheidol Lead & Zinc Mine

The Cwm Rheidol mining complex is 15km east of Aberystwyth, Ceredigion, and includes the mines of Ystumtuen, Penrhiw, Bwlchgwyn and Llwynteifi. The earliest definitive reference to mining in the area dates from 1698 at Ystumtuen, and over the following centuries the mines were developed and worked intermittently under numerous owners and various combinations. By the late 19th century these four mines were all connected underground, enabling the extensive workings to drain to the River Rheidol via adits No. 6 and No. 9, which emerge on the steep valley slopes at Cwm Rheidol. Here, a mill processed the ore to remove the waste rock before it was carried on an aerial ropeway to the Vale of Rheidol Railway on the opposite side of the valley, and then on to Aberystwyth.

Today the underground workings continue to drain from adits No. 6 and No. 9, both of which are highly acidic and contain significantly elevated concentrations of metals including zinc, lead and cadmium. These discharges are subsequently contributing to the River Rheidol failing European Water Framework Directive (WFD) standards for zinc and cadmium for 18km downstream of the mine to its tidal limit. The Rheidol catchment is impacted by many other abandoned metal mines and also fails WFD standards for zinc and cadmium upstream of Cwm Rheidol. The results of ecological impact assessments to date have been equivocal with fish population studies showing surprising tolerance of salmon to zinc concentrations in the Rheidol, which average more than ten times WFD standards in places.

In 2007 we diverted a stream to prevent it flowing into a shaft, reducing the volume of contaminated discharge. This was followed in 2008 by the draining down of adit No. 9 to reduce the risk of a catastrophic minewater blow-out, which has occurred periodically in the past. In 2009 we captured the discharges from both adits in pipes, preventing them from eroding the spoil tips and mobilising more metals. The pipes transfer the discharges to a pilot-scale Vertical Flow Pond (VFP) passive treatment system.

We commissioned the HERO Group at Newcastle University to carry out laboratory trials to assess the suitability of various substrates for the pilot VFP. These included ochre pellets (from coal minewater treatment residues) and paper waste, but the best results were obtained using mixtures of farm manure, woodchip and digested sewage sludge with crushed whelk shells or limestone. This combination successfully promoted microbial reduction of sulphate and precipitated metals as sulphides, but required "feeding" with methanol to sustain performance in the longer term. A similar mixture, with cockle shells, is being used in the pilot VFP treatment system, which has been in operation since September 2010. Removal rates of up to 99% have been achieved for zinc, lead and cadmium, although there is significant fluctuation in zinc removal, which averages ~60%.



Impact on receiving watercourses

Length impacted:	18km
WFD water body ecological status:	
• Lower Rheidol to tidal limit	Moderate

We have periodically removed the build-up of ochre from the surface of the treatment media to maintain flow through the system. It may therefore be preferential to pre-treat the adit discharges to remove iron before they enter a full-scale VFP. We have calculated the size of a full-scale VFP required to treat the two discharges, and in 2014 commissioned CH2M Hill Ltd to assess the availability of land to construct such a treatment system as well as a pre-VFP ochre treatment pond. We are continuing to monitor the site to better understand the long-term performance and maintenance requirements of the VFP, and to reduce the risk of any future minewater blow-out.

Monitoring data

	Adit No. 6	Adit No. 9
Flow (L/s)	8.3	0.6
pH	3.9	3.0
Zinc (mg/L)	13	81
Lead (mg/L)	0.73	0.01
Cadmium (mg/L)	0.03	0.12
Iron (mg/L)	7.3	101
Zinc load (kg/yr)	2,680	1,490
Lead load (kg/yr)	195	0.3
Cadmium load (kg/yr)	7.3	2.3
Iron load (kg/yr)	1,650	1,710

Benefits of remediation

- Approximately 8 tonnes of harmful metals would be prevented from entering the River Rheidol each year.
- The River Rheidol will be more likely to achieve Good Ecological Status, although there are other mining pressures on the catchment that will need to be addressed.
- Reduced metal load to the Cardigan Bay Special Area of Conservation.
- The stream diversion has reduced surface water ingress to the mines, reducing the volume of contaminated discharge.
- The pipeline has reduced erosion and the mobilisation of metals from the spoil tips.
- The pilot VFP will further our understanding of passive treatment for heavy metals removal.

For more information on Cwm Rheidol Mine contact Paul Edwards or Tom Williams:
paul.edwards@naturalresourceswales.gov.uk tom.williams@naturalresourceswales.gov.uk