2021 River Basin Management Plan

Mine waters challenge | Published: 22/10/2019

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1. Summary

Mining played a major part in Britain’s rich industrial history, but this also led to thousands of abandoned mines left scattered across our landscape. Most of these mines closed well over 100 years ago but they still pollute our rivers, harm fish, river insects and ecosystems and can have an adverse impact on economic activity. Discharges from abandoned mines continue to pollute over 1,500km (3%) of rivers in England.

Pollution from coal mines is easy to see, because the iron rich water they discharge causes rivers to turn orange. The ochreous deposits smother river beds, impacting the ecosystem with significant localised harm. In some coalfield areas mine waters pollute groundwater and threaten drinking water supplies.

Figure 1. Point source: Kibblesworth coal mine water discharge before it was remediated.

Pollution from abandoned metal mines isn't always obvious; it may not be visible and we can only tell metals are present in rivers by measuring water quality. Abandoned metal mines are responsible for over half the metals such as cadmium, zinc, lead and copper found in our rivers (Mayes et al, 2013), causing significant harm to fish and river insects.

Figure 2. Old Gang Mill mine site, Swaledale, North Yorkshire. Metal rich mining wastes form the river bank next to the abandoned smelt mill; in the foreground, the "Hard Level" mine water causes severe pollution.

Abandoned mines and waste heaps do provide benefits to society. Hundreds are protected for their heritage value as Scheduled Monuments and UNESCO recognises parts of the Cornwall and West Devon mining landscape as a World Heritage site. The high metal concentrations left in some mining wastes and river sediments downstream of abandoned mines have encouraged distinctive metallophyte floras, many of which are protected as 'Sites of Special Scientific Interest (SSSI)', and represent an important part of Britain's biodiversity.

The vast majority of polluting mines were abandoned long before 2000, when operators became liable for the long-term environmental impacts of their activities. When deep coal mines were privatised in 1994, the Government took responsibility for managing pollution from this formerly nationalised industry. Metal mines were always privately owned however, and since no one can be held legally responsible for the ongoing pollution it falls to Government to take action.

2. Mine water pressures

2.1 History

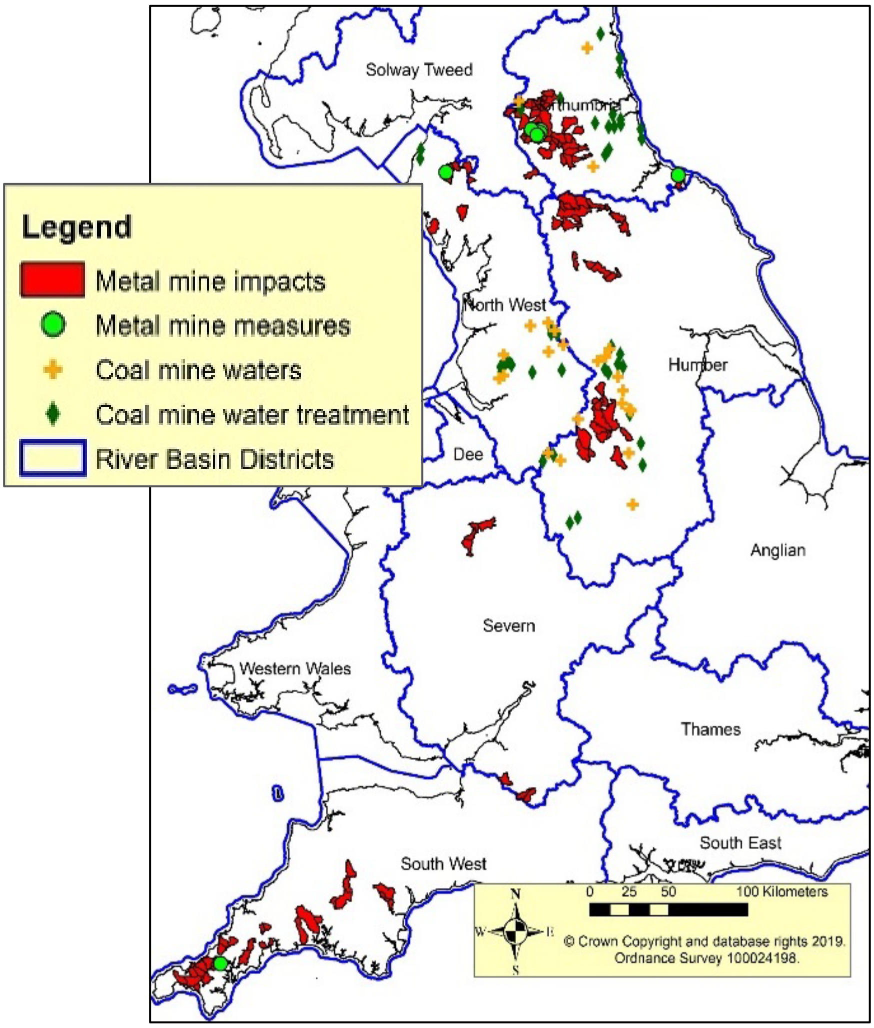
Coal, metal ores and other minerals have been mined in Britain since the Bronze Age. The potential for mining to cause serious pollution of rivers and adjacent agricultural land was recognised as long ago as 1874, especially from lead mines (Erichsen Jones, 1964).

Mining output peaked in the eighteenth and nineteenth centuries after the industrial revolution, and as a result there are thousands of abandoned coal, metal and other mines with a vast network of underground mine workings. These mines remain the biggest source of water pollution by the metals cadmium, lead, iron, copper and zinc. Pollution from mining activities is particularly difficult to deal with because it lasts for such a long time – ancient mines are still discharging highly polluting metal-rich waters today.

2.1 River basin districts

Most river basin districts in England are affected to some extent by pollution from abandoned mines (see Figure 3). The main impacts are in the Northumbria, North West, Humber and South West. An interactive map is available on the Coal Authority website[i].

Figure 3. Catchments impacted by pollution from abandoned mines (April 2019).



The mining and quarrying sector (abandoned mines) is responsible for the majority of chemical failures (349), followed by the agricultural and rural land management sector (146). Urban and transport, industry and water industry all record similar levels of chemical failures at 46, 45 and 43 respectively (data source: Environment Agency Catchment Planning System, 14 August 2015).

2.3 Sources of pollution

Pollution from abandoned mines comes from:

- ‘Point sources’ where drainage tunnels or mine entries discharge metal rich mine waters all year round. These cause the most severe river pollution, particularly at lower river flows when there’s less dilution (see Figure 4).
- ‘Diffuse sources’ such as mine wastes, metal-contaminated sediments and groundwater contribute increasing amounts of metals as river flows increase, for example after heavy rainfall (see Figure 5 and Gozzard et al, 2011).
- Impacts on groundwater and aquifers. Where mines were sunk through aquifers, groundwater flowed down from the aquifers into the mine workings below. After a mine closed, the pumps used to control groundwater levels were switched off and the mine workings flooded. As groundwater levels recover within the mines, contaminated mine water can rise up into the overlying aquifers, especially where connections like mine shafts were built for access to the mine workings. This type of pollution is generally irreversible and can cover a very large area.

Figure 4. Point source: the Barney Craig mine water in Northumberland pollutes 40km of river with cadmium and zinc.

Figure 5. Diffuse sources: the first mining wastes at Nenthead (Cumbria) were left by the Romans. As well as causing pollution, this site is designated a Scheduled Monument and Site of Special Scientific Interest (for geology and metal tolerant plants).

3. Addressing the challenge

3.1 Dealing with abandoned metal mines

Work on cleaning up pollution from abandoned metal mines in a strategic way across England started in 2004, when the Environment Agency and Newcastle University assessed the scale and nature of this type of pollution (see Mayes et al, 2009). About half the cadmium, lead and zinc in our rivers comes from these mines, as much as from all industrial discharges, and more than 1,500km of rivers are polluted. In 2011, the Environment Agency secured funding from the Department for Environment, Food and Rural Affairs (Defra) to set up the Water and Abandoned Metal Mines (WAMM) programme[ii] in partnership with the Coal Authority.

Under the WAMM programme, the Environment Agency identifies the main sources of metals in affected catchments and assesses whether cleaning up point and/or diffuse sources will improve water bodies to good status. Most affected water bodies should be assessed by 2021. We also assess the significant biological harm caused by pollution from abandoned metal mines (for more information on these impacts, see Jones et al, 2018 in the reference section).

The Coal Authority leads studies to identify feasible remedial measures at priority sites, supported by the Environment Agency. We work closely with other stakeholders like Natural England, Historic England, National Parks, Areas of Outstanding Natural Beauty, the National Trust and Rivers Trusts to develop cost-effective measures which are sympathetic to rural landscapes, and may enhance archaeological and ecological features. Where funding allows and the environmental and economic benefits outweigh the costs, the Coal Authority carries out the clean-up works.

The scale of these interventions vary from multi million pound mine water treatment schemes and substantial civil engineering projects for large waste heaps to much smaller scale ‘green’ interventions and other softer measures to minimise erosion of mine wastes by streams and rivers.

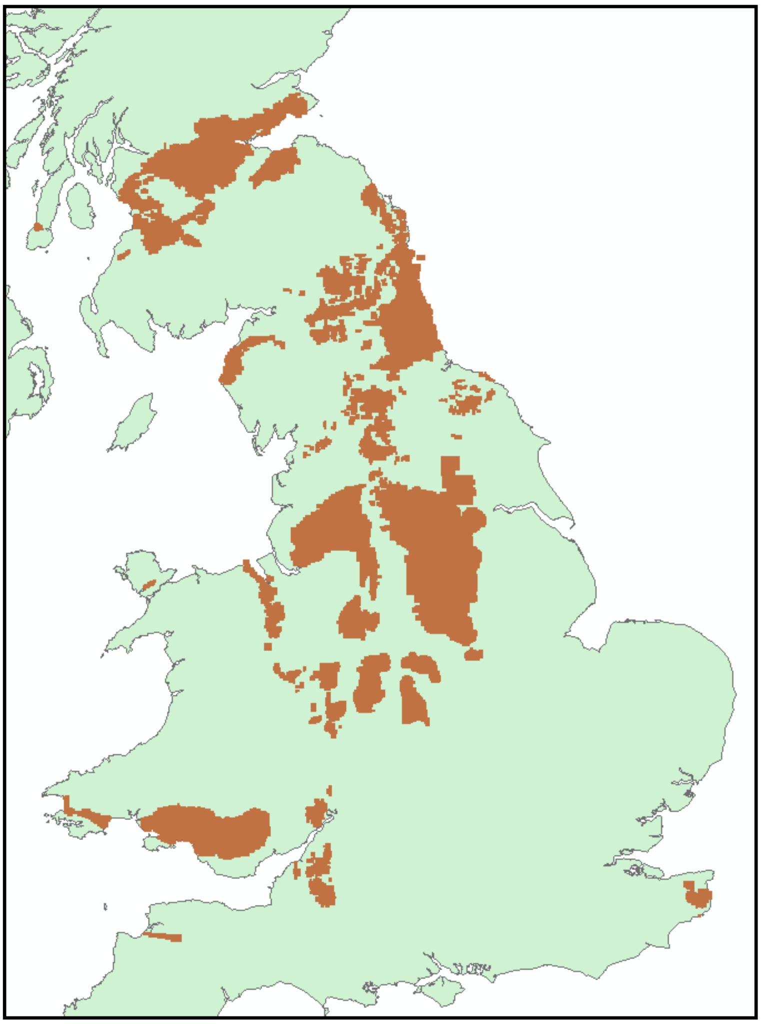
The benefits are clear: cleaner rivers for us and an improved environment for flora and fauna. This will also stimulate economic growth through increased tourism and wider opportunities for industries which rely on clean water.

So far, WAMM has improved water quality in over 100km of rivers and demonstrated that focusing on pollution from abandoned mines is a proven and effective measure to decrease chemical contamination in our waters; and reducing mine water pollution emerged as one of the Government’s priorities in the 25 Year Environment Plan.

3.2 Dealing with abandoned coal mines

British coal mining peaked in 1913, when a million people worked in 1,600 mines producing almost 300 million tonnes of coal a year. But after centuries of mining, around a quarter of all British households (7 million properties) are in these coalfields which cover about 25,000 square kilometres. Within these areas there are over 170,000 recorded coal mine entries (mostly former mine shafts).

Figure 6. Coalfields in Britain



In 1994, the Coal Authority was created to manage liabilities from underground coal mines, including pollution of rivers and groundwater. We assessed the environmental impacts of hundreds of existing coal mine water discharges and created a priority list of the most polluting (about 100) which the Coal Authority is addressing through its remediation programme. In addition, their preventative programme manages mine waters that are still rising so that they do not cause new pollution.

The Coal Authority now operates 44 mine water treatment plants in England (plus another 30 in Scotland and Wales), funded by the Department for Business, Energy and Industrial Strategy (BEIS). Collectively these stop over 900 tonnes of iron (as Fe) and other pollutants each year from causing pollution, helping to protect rivers as well as drinking water supplies for 500,000 people. The Coal Authority continues to invest in capital improvements to existing schemes as well as new preventative and remedial schemes. In addition to cleaning up rivers, these treatment schemes generate natural capital by providing water habitats and encouraging biodiversity in the associated wetlands.

Figure 7. Mine water treatment scheme at abandoned coal mine, including wetland

3.3 Innovation, research and development

We're continually improving ways of treating sources of mine water pollution and looking at ways of reducing costs through innovation, research and development. We do this in partnership with the Coal Authority and other experts including: alternative treatment technologies; developing uses for the waste products produced from treating mine water (iron ochre sludge has been used for land remediation and in the pigment industry); using solar panels on mine water treatment schemes to pump mine water; and investigating how diffuse metals enter rivers so we can improve the effectiveness of remedial measures.

3.4 Making an inventory of closed mining waste facilities

We have identified closed and abandoned mining waste facilities (metal and coal mines) where the environmental impacts are sufficiently serious to be included on the inventory of sites causing serious environmental impacts. The majority of these sites are included because of the pollution they cause to rivers and streams. Other sites have been identified by local authorities as being 'contaminated land', on fire or posing a risk because of instability.

In January 2014, the inventory[iii] included 111 sites in England.

4. Future challenges and actions

4.1 Climate change

Our climate is changing and this is set to continue. The UK Climate Change projections (UKCP18) show that hotter drier summers, milder wetter winters, rising sea levels and more extreme weather events are expected.

Diffuse sources of metals become more significant after heavy rain and at higher river flows since more erosion of mine wastes occurs, and percolation of rain through these wastes mobilises metals. Diffuse sources contribute most of the metals found in rivers at higher river flows. Climate change is expected to make these diffuse sources even more significant causes of pollution.

Lower river flows, like those experienced in the hot summer of 2018, mean that mine water discharges (which tend to flow all year round) provide a greater proportion of baseflow, therefore the severity of pollution is increased because there is less dilution by cleaner water.

We use environment quality standards (EQS) to determine if a river is polluted: if the metal concentrations are higher than the EQS, then aquatic life is expected to be harmed. For example, during the summer of 2018, Environment Agency monitoring showed that zinc was more than 200 times the EQS in the River Nent in Cumbria, one of the most severely polluted rivers in England. At the same location in the preceding winter, monitoring showed the zinc was “only” 23 times the EQS.

The flux of metals (e.g. kg per day) increases with river flows even though the severity of pollution (metal concentrations) may decrease. For example, on average 127 tonnes of zinc and 40 tonnes of lead enters the Tyne estuary each year (all from abandoned metal mines); however 50% of this zinc and 80% of this lead flows into the estuary in the highest 5% of river flows. Intense rainfall events can cause severe erosion of spoil heaps which increases the mobilisation of metals into rivers and re-suspends metal-rich sediments that have been previously deposited in the river channel. For example, the flux of zinc in the River Nent (in Nenthead) can vary from 7 kg per day in low flows to more than 115 kg per day in high flows.

Intense rainfall events can cause more shafts to collapse at both coal and metal mines, particularly when in-filled or capped a long time ago. Also some discharges, like the coal mine water discharge at Jacksons Bridge in the Holme Valley, West Yorkshire, tend to “blow out” every couple of years, potentially in response to extra rainfall. These blow outs temporarily increase the length of orange river from 5km to up to 60km for a few days (Figure 8).

Figure 8. Discharge from abandoned coal mine, Jackson Bridge, West Yorkshire in Feb 2014 and 6km downstream (photos by Environment Agency); the pollution was visible up to 60km downstream. Normally the river is orange for 5km but after heavy rainfall, there was a severe ‘blowout’.

Therefore, we expect the effect of climate change on rainfall intensity and river flows to increase the polluting impacts of abandoned mines.

4.2 Challenges to cleaning up pollution from abandoned mines

A combination of factors might stop us from achieving the objectives of the 25 Year Plan and the next cycle of RBMPs.

Technical and practical constraints mean that it may not be possible to fully treat some discharges. The availability of suitable and sufficient land close to the discharge points is often a constraint in being able to develop sustainable passive based treatment solutions which usually require a large footprint of land to be effective.

Funding is crucial since mine operators cannot be held liable for mines closed before 2000. As a result Government is the primary source of funds for programmes of measures to clean up pollution from metal and coal mines.

Construction and operating costs are increasing, as are pressures on Government funding so we need to work with others to innovate and develop new sustainable solutions that are affordable, increase benefits and are a good use of public and private money.

Most of the abandoned metal mines are located in upland rural countryside containing many conservation designations such as Sites of Special Scientific Interest, Scheduled Monuments, and World Heritage Sites. Some designated sites only exist because centuries of pollution have allowed unusual metal-tolerant vegetation, calaminarian grassland[iv], to develop since the concentrations of metals in the soils are so high that “normal” plants cannot survive. There is a risk that cleaning up metal-polluted rivers will negatively affect these plant communities, leading to a potential conflict between the goals for a clean water environment and increased biodiversity. However there are also opportunities to enhance biodiversity and protection of industrial heritage whilst improving the water environment.

4.3 River basin planning - changes

River basin management plans (RBMP) focus on mine water pollution from metals posing the greatest risk to people and wildlife: cadmium, zinc, copper, lead and iron.

Since the 2015 RBMP we have seen some good progress in mine water pollution, with over 100 km of river improved towards good status. Most of these rivers remain polluted but to a lesser degree than previously; and more than 4,000 tonnes of cadmium, nickel, lead, zinc, copper and iron have been stopped from polluting rivers.

5. Case studies: abandoned metal mines

There are now three mine water treatment schemes and several diffuse measures to clean up rivers polluted by abandoned metal mines.

Case study: Force crag lead-zinc mine, Lake District (North West, river basin district (RBD)).

Force Crag mine, owned by the National Trust, was the last operating metal mine in the Lake District. Since 2014, ponds designed by Newcastle University for the Coal Authority and Environment Agency have begun to remove metals from the mine water discharge. The passive compost-based treatment ponds remove about 0.5 tonne of zinc, cadmium and lead each year to clean up 10km of river (see Jarvis et al, 2015 for more information).

Figure 9. Extensive spoil heaps are visible around the mine buildings, with the ponds lying beyond the buildings. Photograph © John Malley.

Case study: Saltburn Ironstone mine, Cleveland (Northumbria RBD)

The Saltburn mine water treatment scheme consists of pumped passive settlement lagoons and reed bed that remove 150 tonnes of iron each year, cleaning up 2km of polluted river and a popular surfing and bathing water beach.

Figure 10. Saltburn mine water treatment scheme (top photo), river before treatment scheme introduced (middle photo) and after treatment started (lower photo).

Case study: Wheal Jane copper-tin mine, Cornwall (South West RBD)

Installed in the early 1990s soon after the mine closed, this chemical system now treats 6 million cubic metres of water each year, removing 600 tonnes of cadmium, copper, zinc, nickel, arsenic and iron to protect 8km of the Carnon River and the Fal Estuary.

Figure 11. Wheal Jane chemical treatment plant (top photo) and tailings pond used to dispose of the treatment sludge (lower photo)

Case study: Repairs to the river bank in Nenthead, Cumbria (Northumbria RBD)

Work carried out for the Coal Authority and Environment Agency, with funding from Defra and the North East Local Enterprise Partnership, installed a new river wall and covered highly contaminated mine wastes to prevent one tonne of lead, cadmium and zinc entering the river each year.

Figure 13. September 2018, prior to work starting (top photo); March 2019 on completion of the work (lower photo).

Case study: Carrshield tailings dam, Northumberland (Northumbria RBD)

The remediation project repaired a 19th Century drystone wall and capped 48,000 cubic metres of highly contaminated mine wastes containing 100 tonnes of lead, cadmium and zinc to prevent 3 tonnes of metals entering the river each year.

Figure 12. The Carrshield tailings dam in Northumberland. The top photo (May 2017) shows severe erosion which causes diffuse pollution of the river. The lower photo (March 2019) was taken after remediation by the Coal Authority and Environment Agency, with funding from Defra and the North East Local Enterprise Partnership.

6. Choices

We have an ambitious target to improve 750km of rivers polluted by mines over the next river basin management cycle. Doing this will create:

- cleaner rivers for current and future generations
- more wildlife for people to enjoy
- more tourism and opportunities for industries which rely on clean water
- the next chapter in the mining story

We can't do this alone. We will continue to collaborate with local communities and other partners in impacted catchments so we can make better decisions by building on local knowledge and taking account of local opinions. We want to make sure people can influence, contribute to and own the outcomes of our clean-up work.

We also want to seek out opportunities to unlock additional benefits and funding streams. We've already proven that working with others through joint investment to solve a wider problem has the potential to encourage and produce greater environmental and economic benefits.

One example of this is our work with the River Tyne Steering Group, through which the North East Local Enterprise Partnership has contributed £2.6M from their Local Growth Fund. By tackling pollution from abandoned metal mines we are improving water quality in 100km of rivers, and helping to lower metal concentrations in the sediment that accumulates in shipping berths in the Tyne estuary. Our work protects existing economic activity and will encourage new investment by reducing the costs of managing sediment in the Tyne estuary.

We will continue to work with industry and academia to lower whole life cycle costs for mine water treatment and to make diffuse measures more effective, and aim to develop income streams to minimise the burden on Government.

6.1 The 25 Year Environment Plan and abandoned mines

The need to address the pollution from abandoned mines is highlighted in the Government's 25 Year Plan, where it recognises that 'cleaning up pollution from abandoned metal mines will protect aquatic organisms and deliver economic and environmental benefits for local communities'.

As no one can be held legally responsible for water pollution caused by abandoned metal mines, it falls to Government to act, taking the views of all stakeholders into consideration.

Question 1: What can be done to address pollution from abandoned mines?

7. Contacts and supporting information

If you have any feedback or comments on the evidence contained in the summary then please contact: enquiries@environment-agency.gov.uk

8. References

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[i] http://mapapps2.bgs.ac.uk/coalauthority/home.html

[ii] https://www.gov.uk/government/collections/metal-mine-water-treatment

[iii] https://www.gov.uk/government/publications/inventory-of-closed-mining-waste-facilities

[iv] http://archive.jncc.gov.uk/default.aspx?page=6332