the information provided in these reports, the main overall conclusions and recommendations regarding the future management of abandoned non-coal mines can be summarised as follows:

- It is essential to have a clear understanding of the exact sources of pollution if an effective remediation programme is to be instigated. In some instances a single source of non-coal mine water pollution is clearly the main problem, but in the majority of water bodies there are multiple sources. Diffuse sources of mine water pollution are a major contributor to overall metal flux in abandoned non-coal mine catchments. In very few water bodies is there a clear quantitative understanding of how individual sources of pollution from abandoned non-coal mines contribute to the overall metal flux in that water body. Often it appears that not all of the sources, especially where they are diffuse in nature, have been identified.

- Systematic and consistent scoping studies of water bodies impacted by abandoned non-coal mines, including detailed monitoring of water quality and flow, are therefore recommended. Detailed guidance on the approach to such investigations is provided in Report XII: *Future management of abandoned non-coal mine water discharges*. The effects on aquatic ecosystems should also be investigated. If remediation measures are implemented without understanding the dynamics of mining pollution in specific catchments, the environmental objectives for water bodies that are set out in RBMPs may not be achieved despite significant expenditure on engineering works and treatment systems.

- Although we sometimes refer to 'priority for remediation' and 'priority for further data collection' for *Impacted* and *Probably Impacted* water bodies respectively, the reality is that additional monitoring programmes will be a necessity at almost *all* of the water bodies in which non-coal mine drainage is identified as an issue. This is because data collection programmes to date have either not been systematic enough to characterise metal fluxes in water bodies, or have not been appropriately targeted to facilitate the design of a treatment system (or both).

- The passive mine water treatment technologies that have been applied with great success to the remediation of coal mine drainage (principally for the removal of iron) will not work to anything like the same degree for the metals in non-coal mine drainage (e.g. zinc (Zn), cadmium (Cd)). These metals are more soluble than iron and so it is more difficult to remove them from the mine water.

- Effective passive treatment of non-coal mine drainage to consistently meet Environmental Quality Standards (EQS), within a practical land area, is a subject of ongoing research. There are many active treatment technologies that could remediate non-coal mine drainage to the standards required to meet EQS, but they come at a high cost, and in many of the locations of major non-coal mine water discharges it appears unlikely that they would be acceptable developments.

- Irrespective of the type of technology, the management of the metal-rich sludge arising from the treatment of non-coal mine drainage remains a problem. Only active treatment technologies currently offer the possibility of recovering metals in sufficient purity that they *might* be recycled, but even for active systems it currently seems unlikely that recycling of metals from abandoned non-coal mine water

treatment will be economically viable. There may be re-use options for metal-rich media recovered from mine water treatment systems, but these need further investigation.

- There are other problems associated with former non-coal mining districts besides mine water pollution, albeit in some cases these issues may contribute to problems of water pollution. Stability concerns, safety, airborne pollution, and other human and animal health risks, may be significant, and should therefore be addressed accordingly. The level of detail of information provided with respect to these issues has been very varied. Although there are clearly important specific issues relating to these aspects of abandoned non-coal mines that need to be addressed (e.g. stability concerns at specific sites), the main conclusion of this project is that there needs to be a systematic national approach to the assessment of such problems. As well as identifying the most important problems to address, this will directly serve the requirement in the EU Mining Waste Directive to create an inventory of closed mine waste facilities causing harm to human health or the environment.

- The problems evident at abandoned non-coal mines are multifarious and complex. A chronology of environmental management activities for tackling the problems is therefore proposed (Report XII). This sets out the specific requirements of investigations of water pollution problems in abandoned non-coal mine districts, whilst also taking into consideration other potential issues that may be present in such catchments. It is estimated that it will take approximately 4.5 years to complete an individual remediation scheme, from commencement of a scoping study to completion of a full-scale treatment system. Detailed discussion is provided on the exact requirements of investigations targeted at identifying appropriate remedial strategies (i.e. scoping and feasibility stages).

- Conducting thorough investigations of environmental problems in abandoned non-coal mining districts can be expensive. This cost is minor, however, compared to the design, installation and operation of systems to remediate such pollution problems. The total cost to remediate all of the water-related environmental problems associated with abandoned non-coal mines that have been identified as part of this project, is estimated to be approximately £370 million over an initial 10 year period, at present day costs, with additional subsequent operating costs. Of this total around 90% is apportioned to mine water treatment, and 10% to mitigation of outbreak risk and diffuse pollution problems. Treatment systems are likely to be required to operate in perpetuity. There are considerable uncertainties regarding the accuracy of this estimate, due in large part to a paucity of quantitative data on abandoned non-coal mine environmental problems (especially relating to mine water discharge flow and volume).

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1. Introduction

Drainage from abandoned non-coal mines can be an acute and persistent form of aquatic pollution. The UK has a long history of mining for resources other than coal; the extraction of metal-bearing minerals in the UK dates back to the Bronze Age in some orefields. Consequently water pollution problems due to the oxidation and dissolution of metal-rich minerals, during and after mining, are widespread in the UK despite the long timescales since mine abandonment in many cases. However, at a national scale, assessment of the extent and severity of the problem has been piecemeal to date. Valuable bodies of data exist for certain areas of England and Wales, but equally there are substantial gaps in some regions. In addition, no concerted attempt has been made to either (a) collate information about environmental problems at abandoned non-coal mine sites from the various regions into a national database or (b) quantify the scale of these problems across England and Wales in order to develop a framework that will facilitate an informed strategy to address remediation of pollution from abandoned non-coal mines in a logical and cost-effective manner.

This report highlights the outputs of a project which developed and processed a methodology for identifying and prioritising the impacts of abandoned non-coal mines in England and Wales. It identifies where there is the greatest risk that water bodies (river stretches) will fail to meet the objectives of the Water Framework Directive (European Community, 2000) due to abandoned non-coal mines. This project was primarily funded by Defra, with contributions from the Welsh Government, the Environment Agency and the Department for Communities and Local Government.

The prioritisation methodology uses existing data to perform a two-stage impact assessment:

(1) national-level data collection and impact-based Geographical Information System (GIS) screening to appraise instream pollution in areas of former mining followed by
(2) collation of existing evidence and expert local opinion to assess the nature and extent of pollution by non-coal mines on a range of ecological and water resource receptors.

The assessment framework places great emphasis on the level of confidence these data provide in being able to link polluting abandoned mines with instream water quality pollution. This approach permits a broad distinction to be made between those sites that are a priority for remediation planning (where there is a sufficient body of information to accurately define the nature of the impact in *"Impacted*[1]*"* water bodies) and those that are a priority for further data collection (where additional data is needed to verify the extent and nature of impacts at a site in *"Probably Impacted*[2]*"* water bodies). However, it is important to realise that further data is likely to be required for <u>all</u> sites before detailed designs of remediation schemes can be made.

[1] *"Impacted"* = Environmental Quality Standard (EQS) failure in surface water body containing known mine sites.
[2] *"Probably Impacted"* = EQS failure in surface water body in mining area but no known mine sites or EQS failure in surface water body immediately downstream of mining area.

In addition to direct impacts on the water environment, the methodology also collated information covering a range of issues at abandoned non-coal mine sites, from mine site and mine waste hazards, to stakeholder concerns (such as conservation and mining heritage). For brevity the details of the methodology are not repeated here; the reader is referred to the detailed methodology document (Report I: *Methodology for identification and prioritisation of abandoned non-coal mines in England and Wales* - see reference list) for such information.

This is one of 13 reports that detail the final results of the implementation of the methodology across England and Wales. This particular report presents the finalisation of the categorisation of surface water bodies, and also details of mine sites and mine waters, to be used as a basis for directing future remediation planning and / or further data collection.

In every report the 13 reports that comprise the outputs of the project are listed, so that the reader may cross-reference between them at need. They are:

I. *A methodology for identification and prioritisation of abandoned non-coal mines in England and Wales*
II. *Prioritisation of abandoned non-coal mine impacts on the environment: The national picture*
III. *Prioritisation of abandoned non-coal mine impacts on the environment in the Dee River Basin District*
IV. *Prioritisation of abandoned non-coal mine impacts on the environment in the Northumbria River Basin District*
V. *Prioritisation of abandoned non-coal mine impacts on the environment in the South West River Basin District*
VI. *Prioritisation of abandoned non-coal mine impacts on the environment in the Western Wales River Basin District*
VII. *Prioritisation of abandoned non-coal mine impacts on the environment in the Humber River Basin District*
VIII. *Prioritisation of abandoned non-coal mine impacts on the environment in the North West River Basin District*
IX. *Prioritisation of abandoned non-coal mine impacts on the environment in the Severn River Basin District*
X. *Prioritisation of abandoned non-coal mine impacts on the environment in the Anglian, Thames and South East River Basin Districts*
XI. *Prioritisation of abandoned non-coal mine impacts on the environment in the Solway-Tweed River Basin District*
XII. *Future management of abandoned non-coal mine water discharges*
XIII. *Hazards and risk management at abandoned non-coal mine sites*

2. Summary of methodology

2.1 Water body prioritisation

The initial stage of the prioritisation exercise comprised use of existing data to categorise surface water bodies as *Impacted*, *Probably Impacted*, *Probably Not Impacted* and *Not Impacted*. This exercise took place in a GIS (MapInfo v9.51) and comprised a number of spatial analyses to describe mining history, instream Environmental Quality Standard (EQS[3]) failures, and their spatial inter-relation. Resultant categories were then defined to describe the impact of the water pollution problem being associated with former non-coal mining activity. The impact categories produced from this screening of metal pollution and non-coal mining activity grade from *Impacted* where water quality failures are coincident in a water body with former mine sites, to catchments where the quality failures are either not associated with any former mining areas, or there are no reported water quality issues (*Not Impacted* water bodies). The risk categories prefixed "probably" are there to indicate uncertainty in the nature and extent of the link between mining and pollution. *Probably Impacted* describes a water body where there is a pollution problem but uncertainty persists as to whether the mining activity and downstream pollution issue are explicitly connected, either due to distance between source and receptor, or where there are no recorded mine sites in a polluted former mining area. *Probably Not Impacted* water bodies are those in mining areas where there is no water quality concern either in the host or downstream water body. A summary diagram of the assessment methodology is presented in Figure 1.

After the initial national categorisation a series of regional assessment exercises were undertaken to collate site-specific information from local Environment Agency specialists. An internet-hosted questionnaire was used as a vehicle for collection of regional data describing known mine discharges, groundwater impacts, ecological impacts and higher impacts (e.g. impacts of mine sites on water resources). The information requested during the regional assessment is detailed in Table 1. In addition to this data collation, analyses of some national datasets detailing potential ecological impact and higher impact were also undertaken. The combined outputs of these exercises were used to generate a numeric score for individual impacted (i.e. *Impacted* or *Probably Impacted*) water bodies describing the extent of the impact of abandoned non-coal mines on a range of receptors.

The scoring system is detailed at length in the *Methodology* document (Report I) and puts particular weight on the severity and number of concurrent EQS failures in individual water bodies, as this was deemed the most comprehensive available dataset in detailing actual impacts.

[3] The EQS values used for this project are detailed in the methodology report – see reference list. The metals assessed were cadmium, lead, nickel, zinc, copper, iron, manganese, and one metalloid, arsenic.

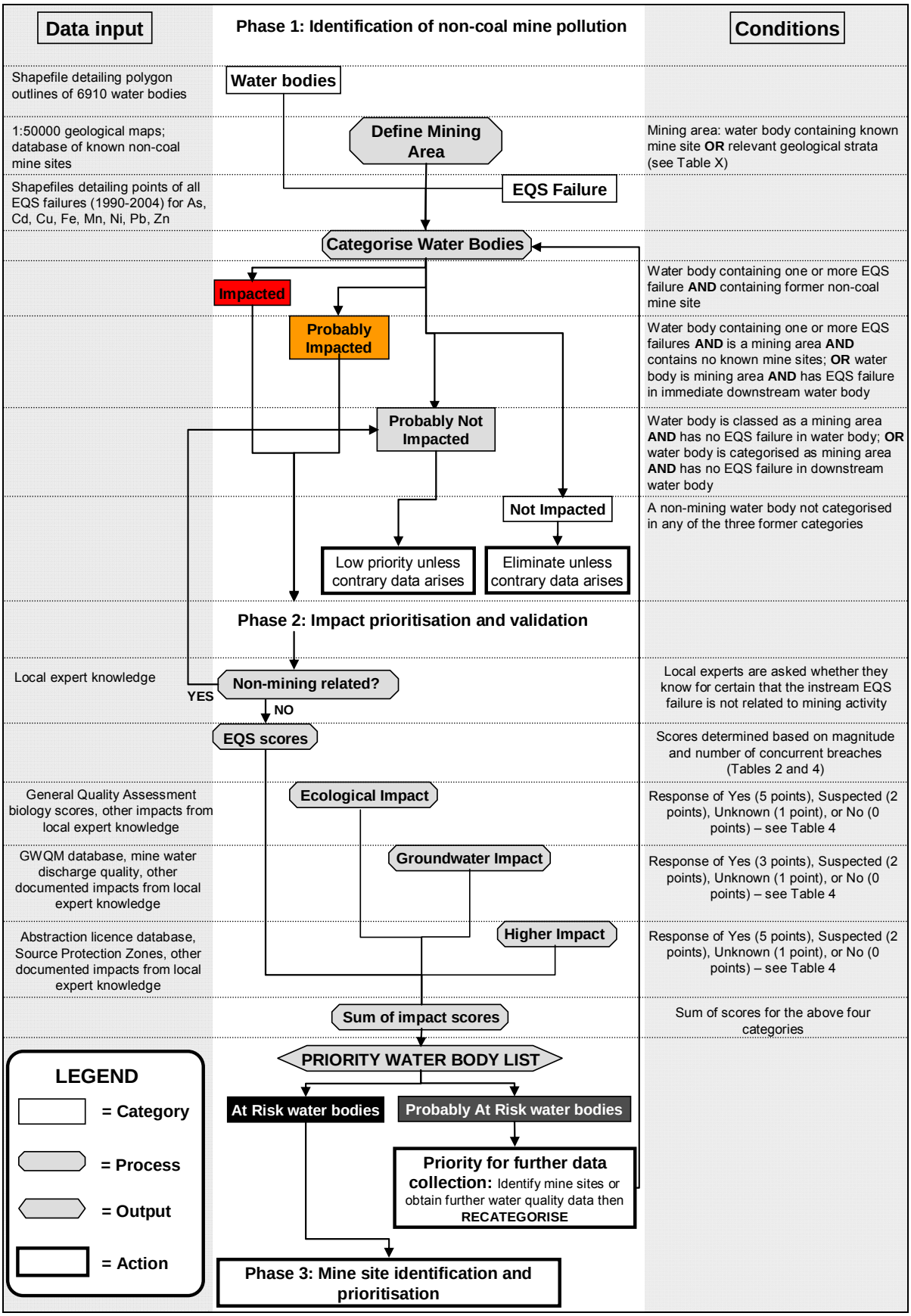

Figure 1. Schematic diagram depicting the methodology for identifying and prioritising water bodies affected by abandoned non-coal mines.

Table 1. Key information requested in Environment Agency questionnaire

Question / information requested	Comment
Water Body ID and Name	Information provided by Consortium
EQS failure co-ordinates and score	Information provided by Consortium
Categorisation (e.g. *Impacted* etc.)	Information provided by Consortium
Locations of point mine water discharges within water bodies with EQS failures, or in water bodies immediately upstream of water body with EQS failure	Required to prioritise *Impacted* and *Probably Impacted* water bodies
If there is a mine water discharge (either point or diffuse) known or suspected then further information on the discharge is required (e.g. quality, flow, impacts)	Including receiving watercourse name, groundwater, ecological and higher impacts, stakeholder information, and water quality
Knowledge of historical mines, irrespective of water pollution issues	Including mine location and name (if known), airborne pollution risk, safety concerns, stability concerns and outbreak risk

2.2 Mine site impact validation and prioritisation

At the same time as collating the water body level information, details of the mine sites within them, along with the nature and extent of any pollution concern, were also gathered. The aim of this component of the exercise was to identify the mine sites within impacted water bodies that are likely contributors to the instream pollution. It has always been recognised that for many of the mine sites / mine water discharges there may only be limited or no information available. Data has been input by Environment Agency staff between December 2007 and March 2009. In addition some of the mine site information, particularly solid waste issues, has been populated via an email survey of all district and county councils. Populating the database with additional information will be an important process beyond the timescale of this project. One particular example is the lack of flow-rate data for many mine water discharges, which renders design of remediation schemes impossible. This is not the only area in which further data will need to be gathered; further details of the requirements are provided in reports XII and XIII.

This mine site information is all held within the geodatabase and will be an essential tool in informing future catchment-scale scoping studies at impacted sites.

3. Results

3.1 Water body prioritisation

A summary of the outputs from the prioritisation are shown in Tables 2-4. These tables contain only a selection of the results with the full details available in the

geodatabase and associated GIS (Geographical Information System) layers. The tables show:

- Figure 2 – the geographic distribution of different risk categories across England and Wales
- Table 2 – categorisation by River Basin District
- Table 3 – the top thirty of the prioritised list of *Impacted* water bodies,
- Table 4 – the top thirty of the prioritised list of *Probably Impacted* water bodies,

It is important to note that not all of the data are shown in the tables. This is simply because it is not possible to present all of this information in a written report such as this. In the database and accompanying GIS layers all data are presented. The main items that have been omitted here are:

- Water quality and flow-rate data for discharges where it is available (key data are provided in the Report XII: *Future management of abandoned non-coal mine water discharges*)
- Text comments relating to evidence of impacts and risks, and whether stakeholder issues are converging or diverging
- Detailed geographical references, such as grid references and water body identifier codes.

Table 2. Summary statistics showing final categorisation of water bodies across England and Wales (Stage 4, March 2009)

River Basin District (RBD)	Impacted	Probably Impacted	Probably Not Impacted	Not Impacted	Total
Anglian	0	1	181	831	**1013**
Dee	9	10	10	71	**100**
Humber	13	18	151	734	**916**
North West	15	27	63	427	**532**
Northumbria	28	39	38	262	**367**
Severn	31	32	89	599	**751**
Solway-Tweed	3	6	29	149	**187**
South East	0	0	88	308	**396**
South West	57	73	325	680	**1135**
Thames	0	0	154	490	**644**
Western Wales	70	37	143	619	**869**
Grand Total	***226***	***243***	***1271***	***5170***	***6910***

The tables provide detailed information about the impacts associated with the most polluting abandoned non-coal mines in England and Wales. The reason for reporting the *Impacted* and *Probably Impacted* water bodies separately in Tables 3 and 4 is due to our confidence in attributing the observed EQS failures to abandoned non-coal mines. In the *Impacted* category there is coincidence of former mine sites and instream metal pollution in relatively small catchments and a lack of other known major sources of metal pollution. As such, there exists a high degree of confidence that mining activity is significantly contributing to the instream pollution. For the *Probably Impacted* category, there is a greater degree of uncertainty that instream pollution and former mining activity are related due either to spatial separation of polluted stream reaches and mining areas, or incomplete mining records in remote locations.

The prioritised lists of water bodies in Tables 3 and 4 should be considered in parallel when planning investigations to identify potential programmes of measures to address these impacts. It should be emphasised that any prioritisation exercise will inherently contain some degree of subjectivity over the weighting applied to different elements. Therefore whilst Tables 3 and 4 identify the rivers most impacted by pollution from abandoned non-coal mines, the prioritised list should be considered as a guide to which surface water bodies should be investigated first rather than a definitive list that should be slavishly worked through from 1 to 469.

An encouraging validation of the methodology is that many of the well-studied and notorious polluting non-coal mine sites in the UK occur towards the summit of the prioritised list. A large number of the top priority water bodies are situated within Wales, where 12% and 19% of water bodies in Western Wales and Dee RBDs respectively fall within the top two impact categories. All the main Welsh orefields are represented in the top priority list, which include the Afon Goch Amlwch and Afon Goch Dulas (which drain the Mynydd Parys copper mine complex on the Isle of Anglesey), the rivers Conwy, Gain and Mawddach (draining Llanwrst-Harlech in North Wales), the Clywedog and Alyn (draining Minera-Halkyn in the Dee RBD) and the Melindwr, Rheidol, Teifi, Twymyn, Tywi and Ystwyth in Mid-Wales.

The South West RBD, which contains the Cornwall and West Devon tin mining district, has 4 water bodies listed in Table 3. These include the Carnon River, which drains the 65 km long County Adit which itself drains a large number of mines in the catchment, as is evidenced by a mean reported flow rate of >450 L/s. Other impacted catchments in the South West RBD include the Hayle and Lanivet Streams.

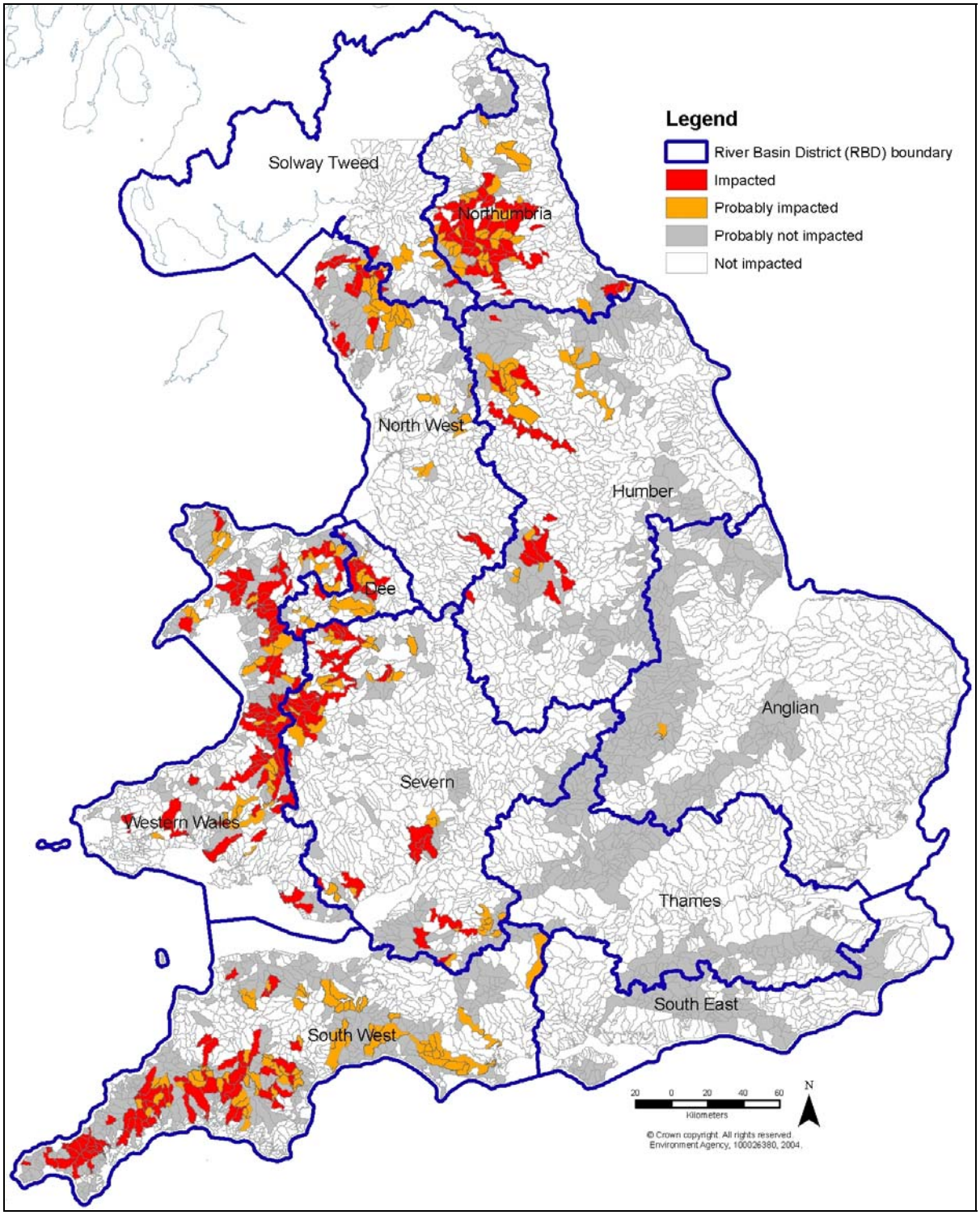

Figure 2. Categorisation of water bodies with respect to pollution impact from abandoned non-coal mines in England and Wales.

The Northumbria RBD is also well-represented in the top priority list. Streams draining parts of the north Pennine lead-zinc (Pb-Zn) orefield, in which specific point mine water sources and impacts have been well-studied, such as the River Nent, the River West Allen and the Rookhope Burn, appear alongside the Saltburn Gill catchment which receives two severely polluting iron (Fe)-rich discharges from

former ironstone mines in Cleveland. Amongst the other priority water bodies are the Newlands Beck in Cumbria (North West RBD) which receives drainage from the Force Crag lead-baryte Mine in its headwaters and the Yewdale Beck which drains a complex of copper (Cu) mines at Coniston in the central Lake District (North West RBD). In the Solway-Tweed RBD, the Glenridding Beck is impacted by discharges from the Greenside Mine. One water body draining the South Pennines (Humber RBD), the River Loxley from Strines Dyke to Rivelin, also features in the top 30 list (Table 3) due to the impacts of ferruginous discharges from former iron workings.

The regional assessments in the Anglian, South East and Thames RBDs were focussed at downgrading sites where precautionary screening early in the project left a large number of *Probably Impacted* water bodies. Only one water body in the Anglian, Thames and South East RBDs, the River Ise (GB105032045140) near Northampton (Anglian) remained as *Probably Impacted* due to a downstream iron failure being caused by an abandoned ironstone mine complex (note that the iron EQS failure is in the water body downstream of that in which the mine is located; the EQS failure and mine would need to be in the same water body for it to be *Impacted*).

3.2 Mine sites and discharges

The exercise has identified an additional 202 mine sites to the 4706 listed in the original mine site database. Of this total of 4908, 257 mine sites have known polluting discharges with an additional 81 sites where polluting discharges from mines are suspected to exist. Populating mine site information in the database provides the crucial link between impacted water bodies and mine discharges themselves. An important note here is that for some of the high priority *Impacted* water bodies there are multiple mine sites and discharges for which data have been collected. For example, in the top priority Rheidol catchment there are 22 discharges for which summary information has been added to the database. For many of these discharges in high priority water bodies, a reasonable level of detail has been provided in terms of mean water quality parameters and mean flow rates. Some 23 sites provide flow rates, and water quality data is available for 96 sites. Populating these data beyond the timescale of the project would be a valuable step in determining the most significant contributors to instream pollution in the top priority water bodies, and will be essential for remediation planning.

Table 3. National categorisation and prioritisation of *Impacted* water bodies (top 30) following implementation of Stages 2, 3 and 4 of the methodology in all RBDs .

Overall priority rank[2]	River Basin District	Water body ID	Water body name	EQS Score	Ranked EQS Score	Ecological Impact score	Higher Impact score	Ground-water Impact score	Overall Impact score[1]
1	Western Wales	GB110063041570	Rheidol - Castell to tidal limit	18	8	5	5	3	21
2	Western Wales	GB110060036350	Tywi - Doethie to Gwydderig	17	8	5	5	3	21
3	Western Wales	GB110064054640	Gain	19	9	2	5	3	19
=	Western Wales	GB110102059230	Goch Amlwch	19	9	2	5	3	19
5	Dee	GB111067051720	Clywedog – above Black Brook	12	6	5	5	3	19
6	Western Wales	GB110063041590	Melindwr – to confluence with Rheidol	10	6	5	5	3	19
=	Western Wales	GB110063041650	Llechwedd-Mawr – to Nant y Moch res.	10	6	5	5	3	19
8	Western Wales	GB110064054620	Mawddach - upper	19	9	1	5	3	18
9	South West	GB108048001160	Upper Carnon River	17	8	2	5	3	18
10	Western Wales	GB110062043550	Meurig – to confluence with Teifi	12	6	5	5	2	18
11	Western Wales	GB110102059000	Goch Dulas	15	7	2	5	3	17
12	Western Wales	GB110064048320	Twymyn - upper	14	7	5	5	0	17
13	South West	GB108049000380	Hayle	6	4	5	5	3	17
=	Western Wales	GB110062043540	Teifi – to confluence with Meurig	6	4	5	5	3	17
=	Northumbria	GB103025071960	Saltburn Gill	6	4	5	5	3	17
16	Western Wales	GB110063041630	Bow Street Brook – to Clarach	5	4	5	5	3	17
=	North West	GB112075070440	Newlands Beck	5	4	5	5	3	17
18	South West	GB108049000030	Lanivet Stream	4	4	5	5	3	17
=	Humber	GB104027057370	River Loxley – Strines Dyke to Rivelin	4	4	5	5	3	17
=	North West	GB112073071210	Yewdale/Church Beck	4	4	5	5	3	17
21	Northumbria	GB103024077460	Wear – Swinhope to Browney	13	7	1	5	3	16
22	Northumbria	GB103023075420	Nent	12	6	2	5	3	16
23	Western Wales	GB110063041710	Ystwyth – Cwmnewydion to sea	10	6	2	5	3	16
=	Western Wales	GB110066060030	Conwy – tidal limit to Merddwr	10	6	2	5	3	16
=	Northumbria	GB103024077530	Rookhope Burn	10	6	2	5	3	16
26	Dee	GB111067051810	Alyn – upper river above Rhydymwyn	3	3	5	5	3	16
=	Northumbria	GB103023074680	West Allen – source to Wellhope Burn	3	3	5	5	3	16
28	South West	GB108048001230	Lower River Carnon/Perranwell Stream	17	8	2	5	0	15
29	Western Wales	GB110065053720	Goedol	15	7	2	5	1	15
30	Northumbria	GB103023075530	South Tyne – Black Burn to Allen	13	7	0	5	3	15

Note: 1. Overall impact score = Ranked EQS + Ecological Impact + Higher Impact + Groundwater Impact. 2. EQS Score used to determine Overall priority rank where Overall impact scores are equal

Table 4. National categorisation and prioritisation of *Probably Impacted* water bodies (top 30) following implementation of Stages 2, 3 and 4 of the methodology in all RBDs

Overall priority rank[2]	River Basin District	Water Body ID	Water body name	EQS Score	Ranked EQS Score	Ecological Impact score	Higher Impact score	Groundwater Impact score	Overall Impact score[1]
1	Northumbria	GB103025071880	Leven from Tame to River Tees	4	4	5	5	3	17
2	Western Wales	GB110063041560	Mynach – to confluence with Rheidol	18	8	1	5	2	16
3	Northumbria	GB103023075560	Newbrough Burn (trib of South Tyne)	10	6	1	5	3	15
4	Northumbria	GB103024077480	Middlehope Burn	5	4	1	5	3	13
5	North West	GB112075070470	Glenderamackin d/s Trout Beck	4	4	2	5	2	13
6	North West	GB112075070490	Glenderamackin u/s Trout Beck	2	3	2	5	3	13
7	Northumbria	GB103023074760	Burnhope Burn – to River Derwent	11	6	1	5	0	12
8	Western Wales	GB110063041690	Llanfihangel – to conf with Ystwyth	10	6	1	5	0	12
9	Severn	GB109054049910	Sundorne Brook – to River Severn	7	5	2	5	0	12
10	Northumbria	GB103023074740	Horsleyhope Burn (trib of Derwent)	11	6	0	5	0	11
11	Western Wales	GB110066060040	Ddu	10	6	0	5	0	11
12	North West	GB112071065140	Sabden Brook	8	5	1	5	0	11
13	South West	GB108047007680	Withey Brook	7	5	1	5	0	11
14	Severn	GB109057027100	Nant Clun – source to conf Ely R	4	4	2	5	0	11
=	Severn	GB109055042300	Afon Elan – source to Pont ar Elan	4	4	2	5	0	11
=	Severn	GB109054044870	Afon Clywedog – source to Afon Lwyd	4	4	2	5	0	11
=	North West	GB112071065510	Mearley Brook	4	4	2	5	0	11
=	Northumbria	GB103025072480	Hudeshope Beck (trib of Tees)	4	4	1	5	1	11
19	Western Wales	GB110060036370	Gwenffrwd – source to conf with Tywi	17	8	2	0	0	10
20	South West	GB108043022390	Bourne	8	5	0	5	0	10
=	Western Wales	GB110065053610	Dwyryd – upper	8	5	0	5	0	10
22	South West	GB108047007890	Lower River Inny	7	5	0	5	0	10
=	Northumbria	GB103023074870	Erring Burn (trib of Tyne)	7	5	0	5	0	10
=	Northumbria	GB103023075640	Stocksfield Burn (trib of Tyne)	7	5	0	5	0	10
=	Northumbria	GB103023075650	March Burn (trib of Tyne)	7	5	0	5	0	10
26	Dee	GB111067056870	Dolfechlas Brook	6	4	1	5	0	10
27	Humber	GB104028053460	River Lathkill from R Bradford to R Wye	5	4	1	5	0	10
=	Humber	GB104027068790	Birdforth/Green's Brooks (trib of Swale)	5	4	1	5	0	10
=	Humber	GB104027068820	Cod Beck – Spital Beck to River Swale	5	4	1	5	0	10
30	South West	GB108049000050	Lower River Ruthern	4	4	1	5	0	10

Note: 1. Overall impact score = Ranked EQS + Ecological Impact + Higher Impact + Groundwater Impact. 2. EQS Score used to determine Overall priority rank where Overall impact scores are equal

Using the data currently available, and additional data collated by Newcastle University outside this project, it is possible to make a highly precautionary estimate of the known pollutant burden arising from non-coal mine sites into surface waters in England and Wales. This must be viewed as the absolute lower bound of the total metal flux arising from abandoned non-coal mines because of the limited data availability. Particular reasons why the estimate is likely to be conservative are:

- there are likely to be many more than 257 mine discharges nationally,
- less than half the known mine discharges have reported flow rates, and even where flow and quality data are coincident these are likely to reflect baseflow conditions; many metal mines are known to be prone to ingress of surface waters in high flow conditions and thus display quite flashy behaviour. During these high flows flushing of contaminants from hitherto unsaturated areas may lead to short term episodes of very high metal release,
- mean values were provided for flow and water quality which may underestimate the range and maximum metal release,
- the contribution of diffuse non-coal mine water pollution, particularly during high flow conditions, is not accounted for, and yet Section 3.3 indicates that such sources may make significant contributions to total metal flux from many water bodies.

With these important qualifications in mind, Table 5 provides the estimated cumulative flux totals for cadmium, lead and zinc (the metals for which there is most information).

Table 5. Total annual flux of selected metals from all abandoned non-coal mine sites for which coincident flow and water quality data are available (figures are likely to be underestimates for reasons discussed in text)

	Cd	Pb	Zn
Number of discharges on which total based	37	44	48
Flux (tonnes/ year)	0.48	17.2	173.1

Table 6 lists the main point source discharges of these metals.

Table 6. Major national point sources of cadmium, lead and zinc (tonnes/yr)

Site	Cd	Pb	Zn
Frongoch Stream (Afon Ystwyth)	0.15	1.8	15
Frongoch Adit (Nant Cwmnewydion)	-	11.8	11
County Adit (Carnon River)	0.06	0.07	34
Dyffryn Adda adit (Parys Mountain)	0.05	0.01	23
Milwr Tunnel (Halkyn Mountain/Minera)	0.05	1.3	9

3.3 Diffuse Pollution

Information on the presence and impacts of diffuse pollution was collected for each of the mine discharges. An understanding of the diffuse pollution impact and extent is crucial in remediation planning, i.e. is remediation of point sources alone likely to lead to desired improvements in instream water quality where there are significant diffuse contaminant inputs into surface waters? A total of 187 mine sites reported a "Suspected" (75) or "Yes" (112) for the possible impacts of diffuse metal pollution in their vicinity. The full range of diffuse pollution issues reported is displayed in Table 7. This highlights that affirmative responses were predominantly related to exposed spoil or tailings. In numerous cases water quality or contaminant loadings data have shown increasing contaminant concentrations not attributable to point sources (the sort of data valuable in catchment scoping studies). Surface water-groundwater interaction is at least suspected as a mode of contaminant transfer at several sites (e.g. due to geological faulting, disappearing streams / ingress into workings), while identifiably diffuse seepages (usually at the base of spoil heaps) have been reported at 7 sites.

Table 7. Responses received for abandoned non-coal mine sites where there are diffuse pollution concerns.

Response	Yes	Suspected
Total number of mine sites	112	75
No details given	5	6
Exposed spoil heaps / tailings	73	44
Water quality data / loading increase not attributable to adits	18	20
Geological faulting	5	0
Visible diffuse discharge	5	2
Constructed mine drainage channels visibly leaking	4	0
Disappearing streams/ river flowing into workings	1	3
Mine submerged in reservoir	1	0

The location of the water bodies in which diffuse impacts have been identified at abandoned non-coal mines are shown in Figure 3. Impacted water bodies include those in which detailed studies on the nature and extent of diffuse mining pollution have, or are currently being undertaken (e.g. Newlands Beck, Nent, Tamar, Rheidol, Rookhope Burn, West Allen, Ystwyth). Catchments known to be impacted by diffuse mining related pollution are summarised in Table 8 by RBD.

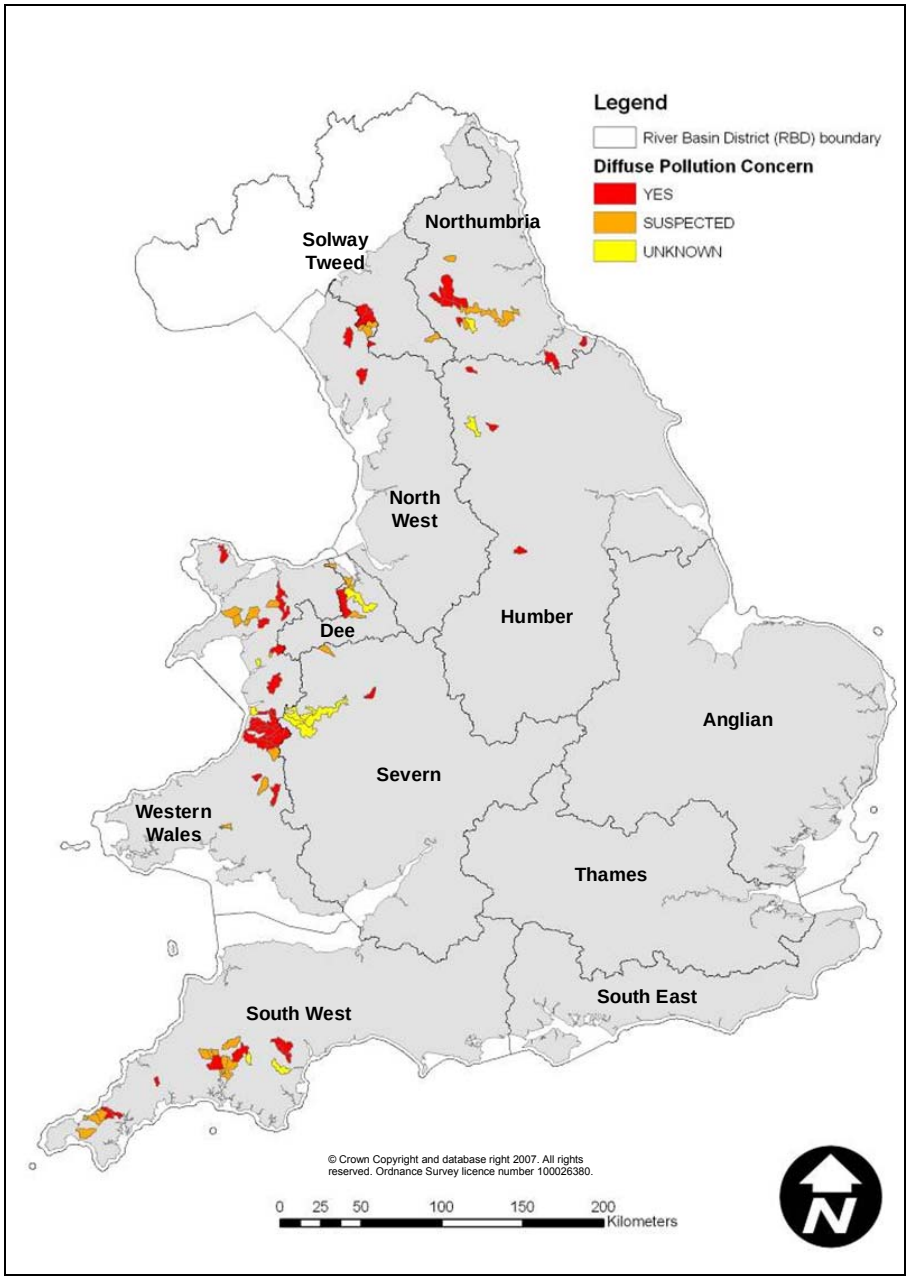

Figure 3. Water bodies within which diffuse pollution concerns have been highlighted at abandoned non-coal mines

There are still large uncertainties about the extent and significance of diffuse abandoned non-coal mine pollution, a fact evidenced by the 38 water bodies where 'unknown' responses were returned. Particular areas where large uncertainties remain include the Yorkshire Pennine area (where numerous studies have in fact been conducted on the source, dispersal and fate of metal-rich sediments in the wider Ouse basin, e.g. Environment Agency, 2008), the Upper Severn (Clywedog, Dulas and Cerist catchments) and upper Teesdale (e.g. Hudeshope Beck, Eggleston Burn) in the Northumbria RBD. As such, the data reported here are likely to represent a minimum estimate of the extent of diffuse pollution from abandoned non-coal mines in England and Wales.

Table 8. Water bodies where there are known diffuse pollution concerns from abandoned non-coal mine sites ('Yes' response returned)

RBD	Catchments
Dee	Alyn
Humber	Ashfold Side Beck, Barney Brook / Hard Level Gill, Loxley / Hobson Moss,
North West	Yewdale/Church Beck, Newlands Beck
Northumbria	Bow Lea Beck, Killhope Burn, Leven, Nent, Rookhope Burn, Saltburn Gill, West Allen
Severn	Minsterley Brook
South West	Burn (Tavy), Carnon River, Lanivet Stream, Lew (Tamar), Porthtowan Stream, Tamar, Teign, Tinney
Western Wales	Afon Goch (Amlwch), Afon Goch (Dulas), Bow Street Brook, Castell, Clarach, Clywedog, Conwy, Cwm Dwyryd / Goedol, Dulas (North), Lechen,Tywi, Llechwedd-Mawr, Magwr, Melindwr, Meurig, Mynach, Nant Cwmnewydion, Rheidol, Ystwyth

3.4 Stakeholder concerns and other issues

Stakeholder issues were also highlighted as a concern at 75 mine sites. Where detailed responses were received it was observed that at 16 of these sites, stakeholder concerns were detailed to be explicitly diverging, largely due to mining heritage issues and metallophyte-based nature conservation sites. Eight sites had issues that were explicitly converging to remedial efforts (e.g. sensitive downstream ecosystems, amenity value was impacted, or site landowners were keen for remedial efforts) and at least 5 sites had a mix of both converging and diverging issues. In addition, there were 32 sites where the Environment Agency had received public complaints about the mine discharge. This provides an illustration of the range of issues that environmental managers are faced with assimilating to inform cost-effective remedial action.

45 of the reported 257 discharges from abandoned non-coal mines were reported to have a visual impact on receiving watercourses due to the presence of ochreous precipitates. Visual impact was suspected at a further 19 mine water discharges. The most severely impacted streams include the Red River in Cornwall, up to 10 km of which is affected due to drainage from the former South Crofty tin mine (Dolcoath Adit). Also in the South West RBD, the Carnon River (receiving drainage from the County Adit) is impacted over a 4 km reach. In North Wales, the Afon Goch Amlwch is affected by ochre precipitates for up to 3 km downstream of Parys Mountain (Isle of Anglesey), while the Parc Mine has a visual impact stretching 2 km along the Nant Gwydir. The visual impact information is stored within the "mining discharge" data-table within the geodatabase.

3.5 Hazards and risk management at abandoned non-coal mines

The results of the national surveys of hazards and solid waste issues at abandoned non-coal mine sites are presented in detail in the related Report XIII: *Hazards and Risk Management at Abandoned Non-Coal Mines.* The survey sought information from local Environment Agency specialists via the internet-hosted questionnaire as well as from Local Authority specialists using an e-mail based survey. Information requested covered issues such as identifying mine sites where there was risk of sudden release of mine water, sites with stability, safety or airborne pollution issues, and sites where there was considered to be public or animal health concerns.

A summary of the collated Environment Agency and Local Authority response is provided in Table 9. The dataset must be viewed with a degree of caution owing to disparities in quantity and quality of data return between regions. Of the 387 local authorities approached, responses were received from 99 authorities, with 26 noting the presence of abandoned non-coal mines within their boundaries. Furthermore, in a small number of cases respondents appear to have misunderstood what information was required of them. This was the case for one group of responses from the Environment Agency concerning outbreak risk which appears to characterise only sites with mine water discharges as opposed to sites where there is a risk of sudden breakout events.

Table 9. The number of abandoned non-coal mine sites where various hazards were identified

Response	Sudden mine water outbreak risk	Airborne pollution	Stability concerns	Safety concerns	Public / animal health concerns	Inspections under Part 2A of EPA
Yes	18	294	26	63	42	521
Suspected	54	88	46	97	44	1

The level of detail in response for each of the different impacts varies. Some RBDs and Local Authorities provided very detailed accounts of the nature of the hazards, but in many cases a 'Yes' or 'Suspected' response was returned with no further details on the nature of the risk. This re-emphasises the uncertainty that exists in the nature of the hazards at many mine sites and the need for the database to continue to evolve beyond the timeframe of the project reported upon here. With the advent of the Mining Waste Directive (European Community, 2006) there is a particularly strong case for having a nationally systematic approach to assessing solid waste hazards and risks at abandoned non-coal mine sites.

Information on outbreak risk was collated from Environment Agency respondents only. While a total of 72 sites were identified (Table 9), detailed responses on the nature of the risk were provided in only a few cases. In addition a portion of the response from one RBD was erroneous (see above). When assessed in detail there are a total of 19 sites where sufficient detail was provided to highlight the risk of a sudden mine water outbreak. These sites, along with the nature of the risk are detailed in Table 10. A range of issues relating to outbreak risk are present that can

be roughly split between sites where there are long-standing issues of perched mine water being impounded due to blockage of adits (e.g. Cwm Rheidol, Dylife, Force Crag) and sites where there is a history or risk of outbreak associated with high flow conditions when there is rapid ingress into workings (e.g. Rispey, Nant-y-Mwyn, Caegynon). At other sites outbreak risk is largely related to risk of future collapse in workings, about which there is considerable uncertainty.

Given the considerable uncertainty surrounding the hydrogeological conditions in many of these sites, and indeed the hydrological context to previous outbreak episodes at others, management of outbreak risk in most cases would benefit from more detailed assessments of sites where issues have been raised. In some cases where there is impounded mine water, site investigations as a precursor to remedial works are taking place (e.g. Force Crag lead mine in Cumbria) to reduce risk of outbreak. Similar engineering works have been carried out by the Coal Authority at coal mine sites (e.g. Sheephouse Wood, South Yorkshire) to prevent future outbreak episodes.

Table 10. Abandoned non-coal mine sites in England and Wales where there is risk of mine water outbreak

Water body ID	RBD	Water body name	Easting	Northing	Mine name	Outbreak risk	Outbreak risk comments
GB112075070440	North West	Newlands Beck	320000	521630	Force Crag	Yes	Adit blockage, & overflowing crownhole on steep ground, minewater outbreak risk
GB103025071960	Northumbria	Saltburn Gill	467300	520200	North Skelton/ Longacres	Yes	Instability in shallow workings. Noted impact on nearby SSSI also concerns on local tourism impact
GB108046008450	South West	River Lemon	276970	72960	Stormsdown	Yes	Pollution incident logged in 2004 – ochreous slug of water released after apparent mine collapse.
GB108046008450	South West	River Lemon	277050	73200	Union	Yes	Pollution incident logged in 2004 – ochreous slug of water released after apparent mine collapse.
GB108046008450	South West	River Lemon	276800	73360	Brothers	Yes	Pollution incident logged in 2004 – ochreous slug of water released after apparent mine collapse.
GB110060036350	Western Wales	Tywi (Doethie to Gwydderig)	278200	243800	Nant y Mwyn Deep Boat Level	Yes	Adit 'fountains' to about 15ft in high flows
GB110060036350	Western Wales	Tywi (Doethie to Gwydderig)	278746	244463	Nant y Mwyn	Suspected	Deep boat level 'fountains' about 15ft in high flows
GB110063041570	Western Wales	Rheidol (Castell to tidal limit)	271800	278400	Caegynon	Yes	Suspicious upwelling in highway in high flows near buried adit
GB110063041570	Western Wales	Rheidol (Castell to tidal limit)	272919	278154	Cwm Rheidol	Yes	Adit 9 unless it is drained down, Adit 6 if stream breaks in to workings
GB110064048320	Western Wales	Twymyn – upper	286128	293957	Dylife	Yes	There is a flooded shaft on site above the level of the river
GB210064043630	Western Wales	Leri	264800	289400	Alltycrib	Yes	Only if adit does collapse - it's full of water with no outfall at present
GB103024077530	Northumbria	Rookhope Burn	390860	542920	Rispey Mine	Suspected	Outbreak history in area
GB108047007860	South West	Lower River Tamar	241380	74040	Devon Great United	Suspected	Being monitored for movement
GB109054049480	Severn	Minsterley Brook	335500	299500	Tankerville	Suspected	Possible potential of shaft fill resulting in outbreak, Concern on possible outbreak if collapse happens
GB110063041610	Western Wales	Clarach	270500	284200	Gwaithcoch	Suspected	There is a concreted off adit just below the lake. the miners blocked it
GB110063041720	Western Wales	Ystwyth	280200	274600	Cwmystwyth	Suspected	Effluent may be emerging in river bed
GB110064048730	Western Wales	Mawddach – middle	273861	322564	Glasdir Mine	Suspected	It is alleged that there is an underground dam.
GB110064054620	Western Wales	Mawddach – upper	273600	328200	Gwynfynydd	Suspected	If pipe blocks
GB110066060030	Western Wales	Nant Gwydir (Conwy)	278700	360200	Parc	Suspected	Suspected underground blockage

3.6 Estimated costs for remediation of non-coal mine water discharges

Providing an estimate of total costs for remediation of a widespread problem such as mining pollution, for an entire country, is fraught with very real potential for extremely large errors. To give an indication of the difficulty of such estimations, the Coal Authority typically spends 18 – 24 months conducting detailed investigations of a *single discharge* before accurate predictions of construction costs for a full-scale treatment system are determined. In contrast, here we have estimated the total cost of remediation of *more than 250 discharges*, with some information about approximately 10% of these discharges, and virtually no information about the remaining 90%. The estimates must therefore be viewed with considerable caution.

The details of how the costs have been calculated are provided in Chapter 7 of Report XII of this series (*Future management of abandoned non-coal mine water discharges*), and the reader is urged to consult that report to fully appreciate both the derivation of, and the potential errors in, the figures presented below.

The total cost to remediate all of the water-related environmental problems associated with abandoned non-coal mines that have been identified as part of this project, is estimated to be £372 million over an initial 10 year period, at present day costs, with additional subsequent operating costs. This total cost estimate comprises 3 elements of remediation:

- Mine water treatment
- Outbreak risk mitigation
- Diffuse pollution remediation

Table 11 summarises the costs for each element (the reader should refer to Report XII for a detailed explanation of the calculation of the unit costs for each element). It is clear from Table 11 that mine water treatment is by far the greatest cost element. It is very important to note that we have calculated mine water treatment costs for a 10 year life cycle, using present day costs. It is therefore important to keep in mind that:

(1) The figures would be subject to variation if an economic model was used to project future costs
(2) There will certainly be costs in subsequent life cycles, particularly those associated with operational expenditure
(3) It might be anticipated that costs in subsequent 10 year life cycles may be less, because construction costs would not need to be repeated. However, ongoing operational costs in future life cycles will still be substantial, and it is not possible to completely rule out the possibility of complete rehabilitation of a system (i.e rebuilding) at some sites

Table 11. Indicative estimated cost, over a 10 year life cycle, to remediate water-related environmental problems at abandoned non-coal mines in England and Wales

Item	Number	Unit cost	Total*
Mine water treatment – worst discharges	10	£10.3M	£103M
Mine water treatment – other discharges	247	£935,000	£231M
Outbreak risk mitigation	19	£150,000	£3M
Diffuse pollution remediation	112	£310,000	£35M
Total			**£372M**

* Figures are rounded

4. Conclusions and recommendations

The *Prioritisation of abandoned non-coal mine impacts on the environment* project has generated the most definitive evaluation to date of the impacts of, and risks to the water environment from abandoned non-coal mines across England and Wales. Application of the methodology developed to prioritise water bodies has, for the first time, provided the environmental regulator with an objective assessment of where pollution from these mines has the highest impact, and where there is the greatest risk that water bodies (river stretches) will fail to meet the objectives of the Water Framework Directive due to abandoned non-coal mines. The specific water bodies which should be the focus of immediate attention in River Basin Management Plans (RBMPs) have been identified, and the work needed to address mining pollution through both research into passive treatment technologies and catchment monitoring investigations is outlined.

Having rolled-out the abandoned non-coal mine prioritisation methodology to all the River Basin Districts of England and Wales it is clear that the underpinning logic and operation of the methodology is sound. The details of the methodology itself are provided in Report I: *A methodology for identification and prioritisation of abandoned non-coal mines in England and Wales*.

By assessing water bodies using water quality, ecological, groundwater and higher impact metrics it has proved possible to prioritise *Impacted* and *Probably Impacted* water bodies into ranked lists. The primary focus of the project throughout (at the request of the project sponsors) has been the impacts of polluted water discharges from abandoned non-coal mines to surface streams and rivers. Nevertheless, additional information collated and stored in the database enables environmental managers to assess what the other issues are at these sites, such as safety issues, outbreak risk and stakeholder concerns. Taken together this provides a valuable resource to assist in the long-term remediation planning at polluting abandoned non coal mine sites in England and Wales.

The absolute scale of environmental problems associated with abandoned non-coal mines has been thoroughly assessed for the first time as part of this project, and Table 12 summarises these impacts and risks.

Table 12. A summary of the impacts and risks associated with abandoned non-coal mines in England and Wales, and the frequency of their occurrence

Risk	Number
Water bodies *Impacted* by non-coal mine water pollution	226
Water bodies *Probably Impacted* by non-coal mine water pollution	243
Confirmed mine water discharges	257
Suspected mine water discharges	81
Documented evidence of outbreak risk	19
Mine sites at which there is evidence of diffuse non-coal mine water pollution	112
Definite concerns about airborne pollution, stability and safety, and / or public and animal health	425
Suspected concerns about airborne pollution, stability and safety, and / or public and animal health	275

Data such as that shown in Table 12, and indeed throughout this report (and also the assessments of individual RBDs contained within reports III to XI), provide an essential insight into the scale of environmental problems associated with abandoned non-coal mines throughout England and Wales, the specific nature of these problems, and also of the areas of England and Wales in which such problems are most acute. The logical next step is to consider how to actually address these issues, and two of the reports arising from this project are dedicated to precisely that: Report XII: *Future management of abandoned non-coal mine water discharges* and Report XIII: *Hazards and risk management at abandoned non-coal mine sites*. Those reports provide *generic* recommendations on how to manage abandoned non-coal mine drainage problems, with *specific* guidance on aspects that have not previously been addressed in published guideline documents on mine water pollution (such as that given by the PIRAMID Consortium (2003)). In light of the information provided in this report, and the guidance provided in the two reports cited above, the main overall conclusions and recommendations regarding the future management of abandoned non-coal mines can be summarised as follows:

- To manage water bodies impacted by abandoned non-coal mine water pollution it is vital to have a clear understanding of the exact sources of pollution if an effective remediation programme is to be instigated. In some instances a single source of non-coal mine water pollution is clearly the main problem, but in the majority of water bodies there are multiple sources, and diffuse sources may play an important role in the overall flux of contaminants to receiving water courses. If remediation measures are implemented without understanding the overall pollution dynamics in the catchment, the environmental objectives for water bodies that are set out in RBMPs may not be achieved despite significant expenditure on engineering works and mine water treatment systems.
- Previous research, and additional information presented here, suggests that diffuse sources of mine water pollution are a major contributor to overall metal flux in abandoned non-coal mine catchments.
- There are actually very few water bodies for which there is a clear quantitative understanding of how individual sources of pollution from abandoned non-coal

mines contribute to the overall metal flux in that water body. In many instances it appears that all of the sources, especially where they are diffuse in nature, have not even been identified.

- Systematic scoping studies of water bodies impacted by abandoned non-coal mines including detailed monitoring of water quality and flow are therefore recommended. Detailed guidance on the approach to such investigations is provided in Report XII: *Future management of abandoned non-coal mine water discharges*. The effects of discharges from abandoned mines on aquatic ecosystems should also be investigated. It is strongly recommended that a consistent, systematic approach is taken to such investigations.
- Although we sometimes refer to 'priority for remediation' and 'priority for further data collection' for *Impacted* and *Probably Impacted* water bodies respectively, the reality is that additional monitoring programmes will be a necessity at almost *all* of the water bodies in which non-coal mine drainage is identified as an issue. This is because data collection programmes to date have either not been systematic enough to characterise metal fluxes in water bodies, or have not been appropriately targeted to facilitate the design of a treatment system (or both).
- The passive mine water treatment technologies that have been applied with great success to the remediation of coal mine drainage (principally for the removal of iron) will not work to anything like the same degree for the metals in non-coal mine drainage (e.g. Zn, Cd). These metals are more soluble than iron and so it is more difficult to remove them from the mine water.
- Effective passive treatment of non-coal mine drainage to consistently meet Environmental Quality Standards (EQS), within a practical land area, is a subject of ongoing research. There are many active treatment technologies that could remediate non-coal mine drainage to the standards required to meet EQS, but they come at a high cost, and in many of the locations of major non-coal mine water discharges it appears unlikely that they would be acceptable developments.
- Irrespective of the type of technology, the management of the metal-rich sludge arising from the treatment of non-coal mine drainage remains a problem. Only active treatment technologies currently offer the possibility of recovering metals in sufficient purity that they *might* be recycled, but even for active systems it currently seems unlikely that recycling of metals from abandoned non-coal mine water treatment will be economically viable. There may be re-use options for metal-rich media recovered from mine water treatment systems, but these need further investigation.
- There are other problems associated with former non-coal mining districts besides mine water pollution, albeit in some cases these issues may contribute to problems of water pollution. In some cases issues such as stability concerns, safety, airborne pollution, and other human and animal health risks, may be significant, and should therefore be addressed accordingly. The level of detail of information provided with respect to these issues has been very varied. Although there are clearly important specific issues relating to these aspects of abandoned non-coal mines that need to be addressed (e.g. stability concerns at specific sites), the main conclusion of this project is that there

needs to be a systematic national approach to the assessment of such problems. As well as identifying the most important problems to address, this will directly serve the requirement in the EU Mining Waste Directive to create an inventory of closed mine waste facilities causing harm to human health or the environment.

- The problems evident at abandoned non-coal mines are multifarious and complex. A chronology of environmental management activities for tackling the problems is therefore proposed (see Report XII: *Future management of abandoned non-coal mine water discharges* report). This chronology sets out the specific requirements of investigations of water pollution problems arising in water bodies in abandoned non-coal mine districts, whilst also taking into consideration other potential issues (see above) that may be present in such catchments. According to this chronology it is estimated that it will take approximately 4.5 years to complete an individual remediation scheme, from commencement of a scoping study to completion of a full-scale treatment system. More detailed discussion is provided on the specific requirements of investigations targeted at identifying appropriate remedial strategies (i.e. scoping and feasibility stages).
- Conducting thorough investigations of environmental problems in abandoned non-coal mining districts can be expensive. This cost is minor, however, compared to that of the design, installation and operation of systems to remediate such pollution problems. The total cost to remediate all of the water-related environmental problems associated with abandoned non-coal mines that have been identified as part of this project, is estimated to be approximately £370 million over an initial 10 year period, at present day costs, with additional subsequent operating costs. Of this total around 90% is apportioned to mine water treatment, and 10% to mitigation of outbreak risk and diffuse pollution problems. Treatment systems are likely to be required to operate in perpetuity. There are considerable uncertainties regarding the accuracy of this estimate, due in large part to a paucity of quantitative data on abandoned non-coal mine environmental problems (especially relating to mine water discharge flow and volume).

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