Historic Mine Sites

Inventory and Risk Classification

Non-technical Summary

Department of Communications, Energy and Natural Resources
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Comhshaol, Oidhreacht agus Rialtas Áitiúil
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For a complete understanding of the work that was carried out the reader is referred to the full report which is available on the following websites:

www.gsi.ie

www.epa.ie

The Historic Mine Sites – Inventory and Risk Classification is a joint project carried out by the Geological Survey of Ireland and the Environmental Protection Agency.

Preface

Mining is one of the world's most ancient of activities. It has enriched many a nation. However, exploration of mineral resources has often been carried out without due recognition of the effects on the environment, especially prior to the 20th century. In the latter part of the 20th century the environmental impacts of mining became more apparent and regulators responded to this by enhancing legislation and permitting requirements.

In Ireland, environmental effects were recognised primarily at Silvermines, Tynagh and Avoca. Both the Environmental Protection Agency and the Geological Survey of Ireland asked the question simultaneously 'how many other sites were impacted by previous mining activity?' At the same time the European Commission, being aware of the potential of mining operations to impact on the environment through incidents at active mines in Spain at Aznalcóllar and in Romania at Bare Mare, introduced Directive 2006/21/EC on the management of waste from the extractive industries. Article 20 of the Directive requires Member States to produce an inventory of closed mine waste facilities. The combination of these events created the impetus for this project, the Historic Mine Sites – Inventory and Risk Classification.

The work has resulted in the most comprehensive inventory of past mining activity in Ireland. All of the major sites have been characterised geochemically and all major site hazards have been identified. The report classifies the sites which present the greatest threat to human and animal health and the environment. The work provides an important benchmark from which future investigations can be both directed and assessed. An important recommendation from the work is that monitoring of the various sites should be undertaken at varying intervals depending on the nature of contamination of the site.

Dr. Peadar McArdle
Director, GSI

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Director General, EPA

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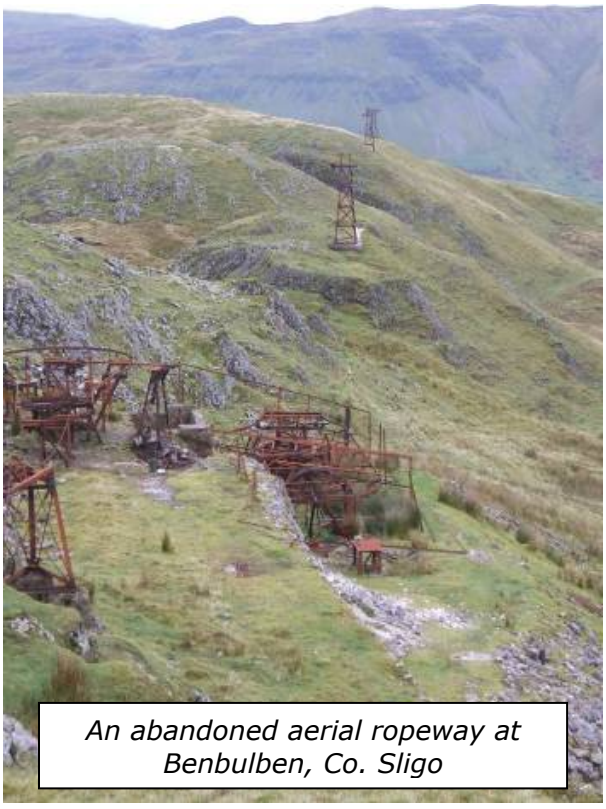
1. What is this project about?

This project sets out to:

- Make a list of the closed mine sites in Ireland.
- Identify the features and structures related to mining at each of the closed mine sites.
- Identify any waste related to mining at each of the closed mine sites.
- Describe the waste at each of the closed mine sites.
- Classify the closed mine sites in terms of the potential threat they pose to humans, animals and the environment.

The EPA (Environmental Protection Agency) and the DCENR (Department of Communications, Energy and Natural Resources) wished to find out how many closed mines there were in the country and what potential threat they posed to human and animal health, and the environment. At the same time that the project was being developed the European Union was drafting a Directive on 'waste from the extractive industries'. This became known as **Directive 2006/21/EC of the European Parliament and of the Council on the management of waste from extractive industries and amending Directive 2004/35/EC.** One of the Articles (number 20) of this Directive concerns the preparation of an **Inventory of closed waste facilities.** The article requires each Member State of the EU to draw up an inventory of closed waste facilities, including abandoned waste facilities which



An abandoned aerial ropeway at Benbulben, Co. Sligo

cause serious negative environmental impacts or have the potential of becoming, in the medium or short term, a serious threat to human health or the environment. Therefore the goals of both the EPA/DCENR and the EU would be met at the same time by carrying out this project.

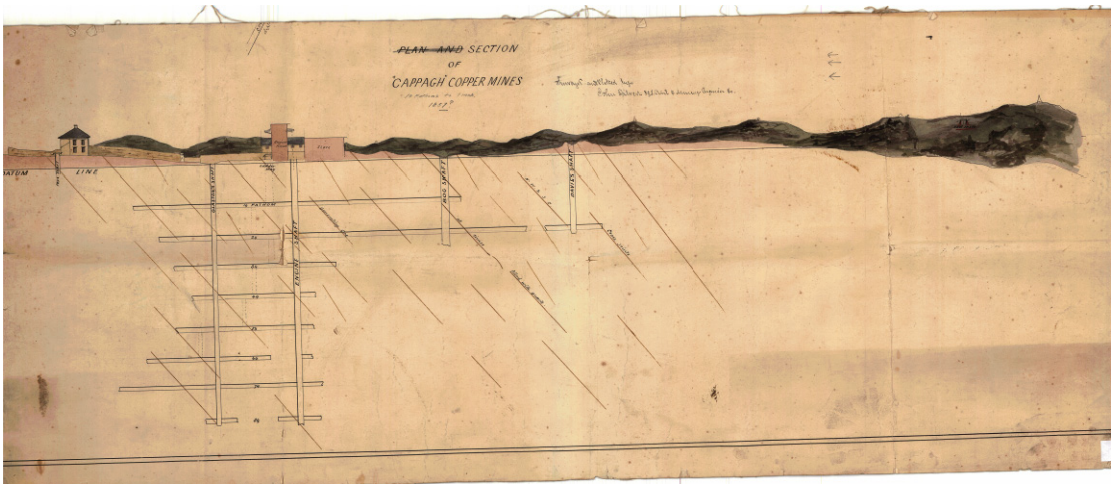
The EU makes the distinction between a site that is closed, meaning that mining has ceased but the person who operated the mine still exists and is known and a site that is abandoned, which means that mining has ceased and that the operator is no longer known. This latter case can easily be envisaged where mining took place in earlier times, for example the Bronze Age (usually dated at 2000BC to 500BC in Ireland).

This project is not a full risk assessment of the closed mine sites. Risk assessment is a process used to assess and manage risk associated with hazardous situations of any sort, not just in mining areas.

2. **Who carried out the project?**

The project was carried over a three year period from 2006 to 2008. It was led by the GSI (Geological Survey of Ireland) with assistance from the EPA (Environmental Protection Agency) and EMD (the Exploration and Mining Division of DCENR). GSI hired specialist geochemists, environmentalists and mining geologists to assist in the carrying out of the work.

GSI is the National Earth Science Agency and is responsible for providing geological advice and information. GSI is the location of records of ancient and modern mines in Ireland. These records are an important data source for information on mining. The EPA has responsibilities for a wide range of licensing, enforcement, monitoring and assessment activities associated with environmental protection. EMD formulates policy for the minerals sector and regulates exploration and mining in Ireland.



An historic mine drawing showing underground workings at Cappagh, Co. Cork.

3. What past mining activity took place in Ireland?

Mine waste at Glenmalure, Co. Wicklow

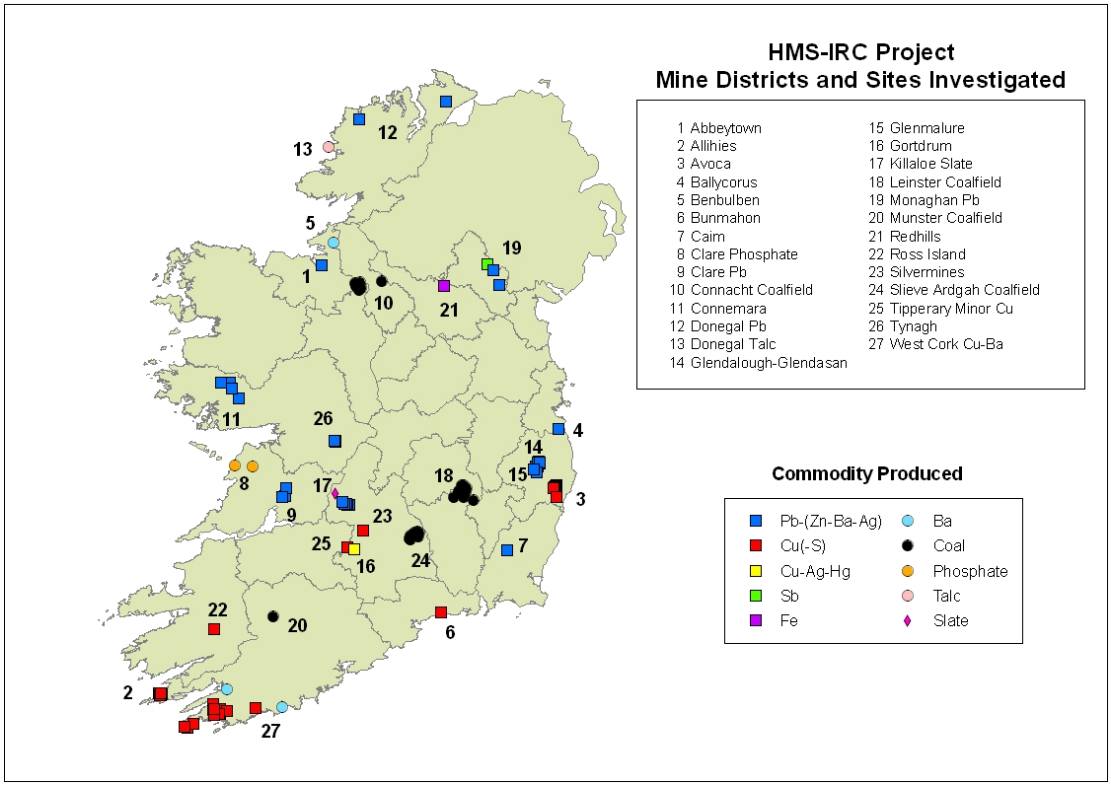
Ireland has a rich mining history dating back to the Bronze Age. GSI's minerals localities database, known as Minlocs, has over 5,000 entries which include both metallic and non-metallic commodities. Of these entries almost 1,500 are for metallic minerals and over 450 are described as mines.

There are numerous types of mineral deposits and Ireland has examples of many of them that have been worked over the years. Of the 450 mines listed in Minlocs some 220 had significant production of metals (for example lead (Pb) or copper (Cu)), non-metals (for example, gypsum used in the manufacture of plaster) and coal. Many of the deposits that are described as mines were often trials – an excavation into the ground exploring for minerals. A map showing the main mineral deposits in Ireland is shown on the next page.

The closed mines can be classified according to the mineral worked and the time in which they operated:

1. Underground and surface mining operations for coal since the 18th century.
2. Workings for non-metals prior to the 1920s.
3. Metal bearing veins worked for the most part prior to the 20th century – but some workings operated into the 1950s.
4. Modern workings for non-metals (latter half of 20th century).

5. Modern metal operations mainly from the latter half of the 20th century.



Map of Ireland showing various mineral deposits

Coal Mines

Coal deposits in Ireland date from the Upper Carboniferous (approximately 320 million years ago) and occur in four areas – the Leinster Coalfield straddling Counties, Kilkenny, Laois and Carlow; the Slieve Ardagh Coalfield on the border of Counties Kilkenny and Tipperary; the Kanturk Coalfield in northwest County Cork and the Connaught Coalfield straddling Counties Leitrim, Roscommon, Sligo and Cavan. Most coal mining operations in Ireland started during the 18th century and were worked intermittently into the 20th century, some up until the 1990s.

Vein Operations

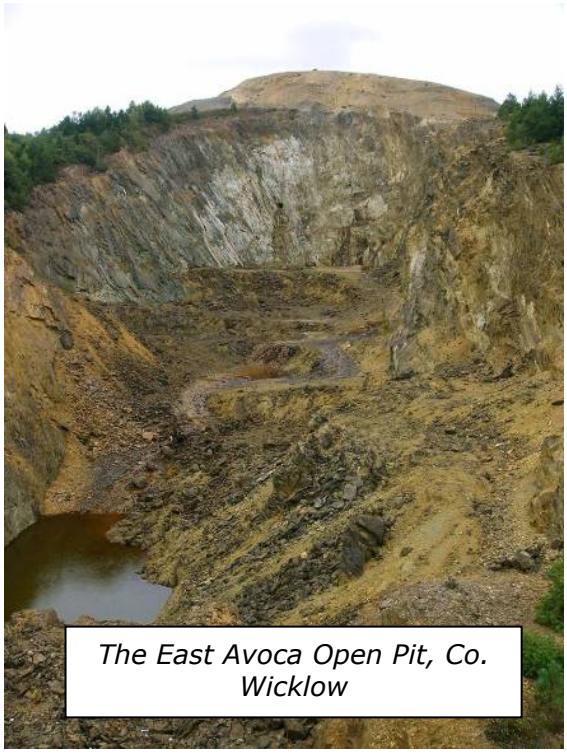
Up until the start of the 20th century most mining operations in Ireland worked veins of minerals containing metal. Most of these were for copper (Cu) or lead (Pb) while a smaller number were worked for either iron (Fe) or zinc (Zn). Silver

(Ag) was commonly recovered from the lead veins. The veins occurred in a number of settings:

1. Lead (and silver) veins associated with granites, e.g. Glendalough District, Co. Wicklow.
2. Copper veins within volcanic rocks, e.g. Bunmahon, Co. Waterford.
3. Copper veins within sandstones, e.g. Allihies, Co. Cork.
4. Lead (and silver) veins in limestones, e.g. Kilbricken, Co. Clare.
5. Iron veins associated with volcanic rocks, e.g. Kilbride, Co. Wicklow.

Modern Mining

Modern mining operations in Ireland commenced in the 1960s with the opening of the Tynagh mine in Co. Galway. Also at this time the historic mine at Avoca commenced large scale production using modern mining techniques. Mining activity at Avoca was intermittent from about 1720 until 1982. Extensive development had occurred at Avoca in the 18th and 19 Centuries using relatively primitive means that focussed on higher grade ore. Other examples of mechanised mining include Silvermines and Gortdrum, both in Co. Tipperary and three metal mines continue to operate today – Navan, Lisheen and Galmoy (although Galmoy is due to close in 2009).



The East Avoca Open Pit, Co. Wicklow

There were or are also a number of modern mining operations for industrial minerals, in particular for barytes and gypsum.

4. What is mine waste?

Mining, like any industry, produces waste. Mineral deposits occur within rock that, for the most part does not contain the valuable minerals. However, the extraction process requires the removal (or mining) of both the valuable mineral (known as ***ore*** in the mining industry) and the non-valuable rock that contains it (known as ***waste*** by the mining industry). It is necessary to separate the two and it is the non-valuable part or waste that is stored at the closed mining sites.

The mining industry produces two principal types of waste. The first has the consistency of a fine powder and in the mining industry is called ***tailings***. For this reason it is usually transported as slurry, that is, it is a mixture of the rock or mineral powder and water. This slurry is pumped, in pipes, to an area where it can not flow.

This photograph shows the two types of waste from the mining industry. In the foreground is a rehabilitated tailings facility. The background is an example of a waste heap. The photograph is from the closed Gortdrum mine in Co. Tipperary.

This is often referred to as a ***tailings management facility*** or ***tailings dam.*** A tailings dam structure is like a reservoir that contains water – only in the case of a tailings dam the contained material is tailings or mine waste. The second waste type from the mining industry consists of lumps of broken rock. The size of the lumps can vary from approximately 2mm to over 2m. Such materials are commonly heaped up forming mounds with shapes varying from pyramids to long berms. They are often referred to as ***spoil tips*** or ***heaps*** in the industry.

Above: Road Adit, West Avoca, Co. Wicklow

There is also waste water which comes from former mine sites. Water may flow from old entrances to mines (called ***adits***) or seeps from heaps. This water may then flow to streams or rivers, or to the sea in coastal areas and cause contamination to those streams or rivers or seas and affect any fish life or other habitat within them.

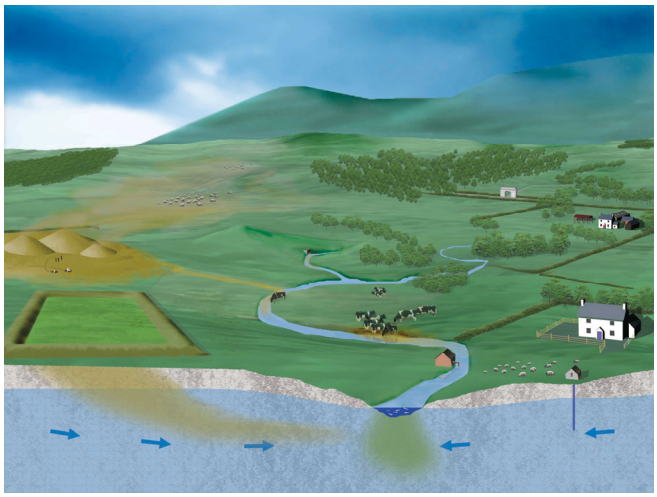
Right: Seep from Abbeytown Tailings, Co. Sligo

5. How was the project carried out?

This review involved an examination of mine records in the GSI, an examination of reported incidents from historic mine sites in Ireland, and a review of available documents on them. This formed the basis for planning the work at each of the sites. It was quickly realised that in order to carry out the field work that a systematic method was needed and the optimum approach would be to develop a **Conceptual Model**. This would guide the data collection in the field but would not be so rigid as to prevent the recording of features unique to any one site.

The Historic Mine Sites – Inventory and Risk Classification Project addresses the EU Directive on Wastes from the Extractive Industries requirement for an inventory of waste facilities and the national need for data at closed and/or abandoned mine sites. Both needs have been addressed on a risk basis. However, it is important to note that this is NOT a risk assessment of the sites. Rather the sites have been ranked so as to determine a relative ranking for future actions.

Conceptual Model

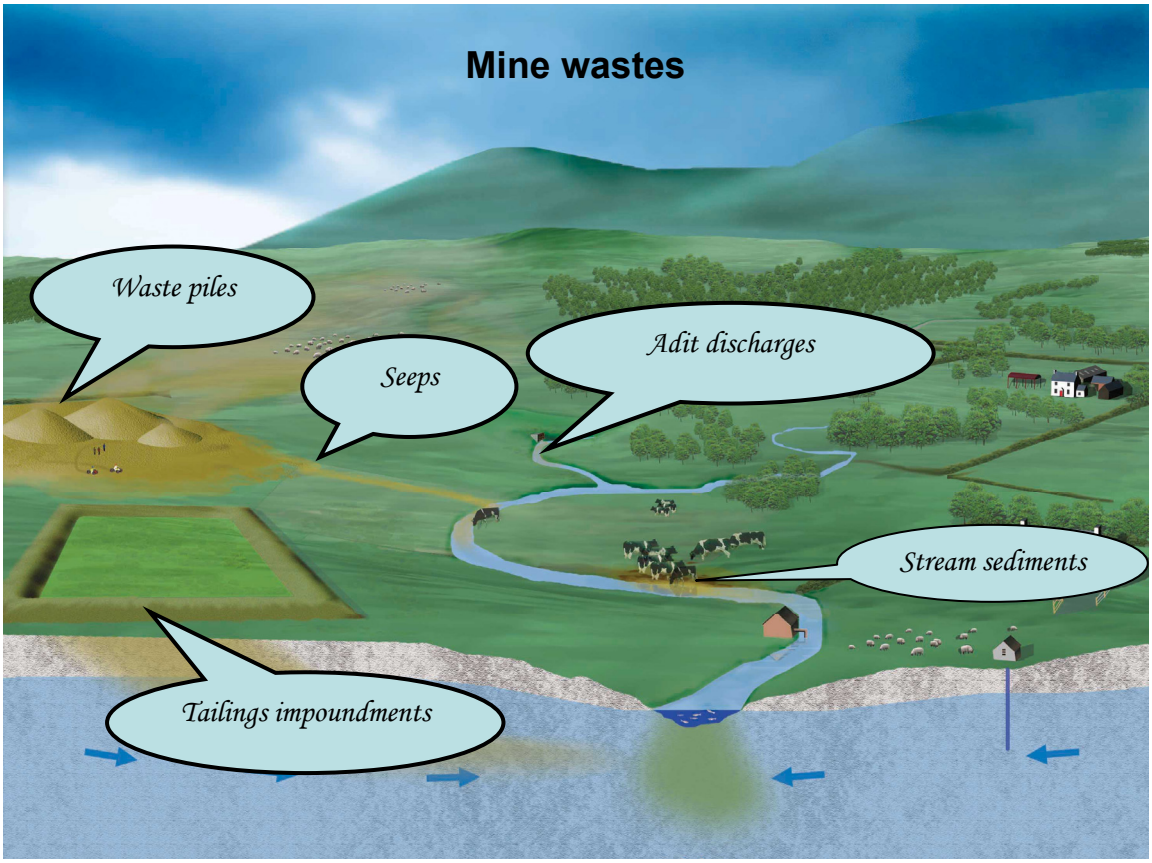


Contaminant risks come from waste facilities on the site. A common approach taken by environmental scientists in assessing hazard at a site is to use what is known as the Source – Pathway – Receptor Paradigm. The paradigm requires that each of the parameters within the model are documented, estimated, measured or recorded. The Conceptual Model to describe this is illustrated pictorially above.

The model identifies the source of any contamination; identifies who or what is affected (the receptor); and identifies how the source may reach the receptor (pathway). A contaminant linkage occurs when a source, pathway and receptor are demonstrated to occur together resulting in the receptor being connected to the source *via* a particular pathway. The conceptual model identifies all the sources, pathways and receptors. The collection of field data, observations and estimates confirms whether a linkage exists between the source and receptor and conclusions are drawn about the potential risks caused by the source of contamination.

Sources of contaminants

Sources are the origin of contaminants that may issue from an historic mine site. The cause or source of the contamination is identified as well as its location. The possible sources of contamination are listed on the next page and illustrated in the diagram below.



Liquid (water)

Adit discharges

Seeps from waste heaps

Solids

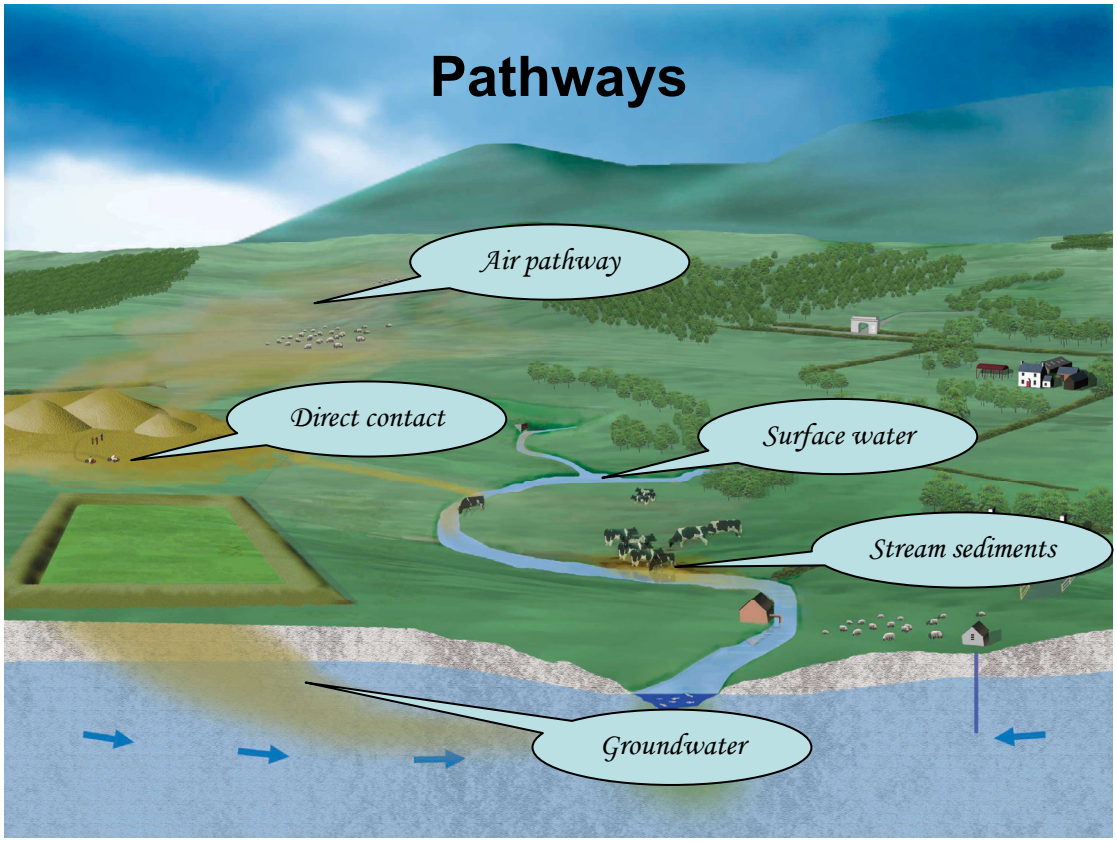
Waste piles

Tailings impoundments

Stream sediments

Pathways

The pathway is the route the source takes to reach the receptor. The five pathways for the Conceptual Model are illustrated in the diagram and listed below.



Groundwater

Surface water

Air pathway

Direct contact – solid waste piles

Direct contact – stream sediments

Receptors

Receptors are those elements of the paradigm that are affected by the potential contamination emanating from the various sources via the different pathways. If contamination is to cause harm, it must reach a receptor. A receptor is any person, animal, plant, eco-system, water system, protected site, or property. Receptors, in the context of the Historic Mine Site project include the following which are also illustrated on the diagram on the next page:

People

- Local inhabitants
- Workers
- Visitors to the site (authorised or otherwise)

Farm animals

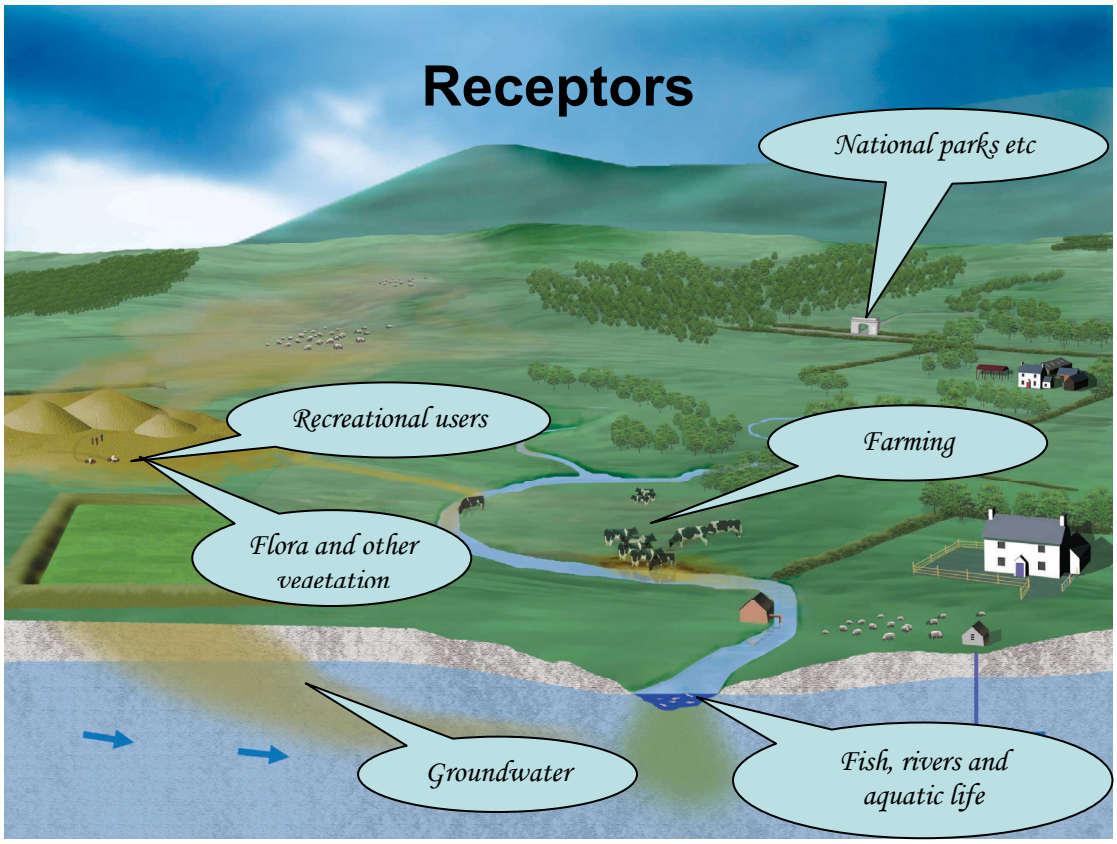
- Livestock

Ecosystem / Aquatic

- Rivers
- Estuaries
- Groundwater

Protected areas

- National parks
- National Heritage Areas (NHAs)
- Special Protection Areas (SPAs)
- Special Areas of Conservation (SACs)
- Nature Reserves



Historic Mine Sites – Inventory and Risk Classification Scoring System

Each of the parameters of the model (Source – Pathway – Receptor) is scored according to the observations made in the field and other information available to the project. The scores are added to give a final score which is then assigned a category according to the table below.

Class	Score	Description
I	>2,000	Sites which should have a full risk assessment carried out. Ongoing monitoring should be carried out.
II	1,000 – 2,000	Sites requiring general monitoring of most or all waste piles, discharges or stream sediments on an annual basis.
III	300 – 1,000	Sites requiring general monitoring of most or all waste piles, discharges or stream sediments on a biannual basis.
IV	100 – 300	Sites requiring specific monitoring on particular waste piles, discharges or stream sediments on a five yearly basis.
V	<100	Site not requiring any specific monitoring.

Cronebane Open Pit, Avoca, Co. Wicklow.

6. What sites were classified?

In all 82 sites were scored resulting in the classification of 27 individual sites or districts. Examples of individual sites include Ballycorus, Co. Dublin and Gortdrum, Co. Tipperary while examples of districts include the Leinster Coalfield and West Cork. The accompanying table provides a list of the sites and the minerals worked at them scored in this project.

Mine name	**County**	**Commodity(ies) extracted**
1. Abbeytown	Sligo	Pb, Zn, Ag
2. Allihies	Cork	Cu
3. Avoca	Wicklow	Cu, pyrite
4. Ballycorus	Dublin	Pb, Ag
5. Ballyhickey	Clare	Pb, Ag
6. Ballyvergin	Clare	Pb, Cu, Ag
7. Benbulben	Sligo	Barite
8. Bunmahon	Waterford	Cu
9. Caim	Wexford	Pb, Cu
10. Clements	Galway	Pb
11. Clontibret	Monaghan	Sb
12. Connacht Coalfield	Cavan, Leitrim, & Roscommon	Coal
13. Doolin	Clare	Phosphate
14. Glendalough/Glendasan	Wicklow	Pb
15. Glenmalure	Wicklow	Pb
16. Glentogher	Donegal	Pb
17. Gortdrum	Tipperary	Cu, Hg, Ag
18. Hollyford	Tipperary	Cu
19. Hope	Monaghan	Pb, Ag
20. Keeldrum	Donegal	Pb
21. Kilbricken	Clare	Pb
22. Leinster Coalfield	Carlow, Laois, & Kilkenny	Coal
23. Silvermines	Tipperary	Zn, Pb
24. Slieve Ardagh Coalfield	Kilkenny & Tipperary	Coal
25. Tassan	Monaghan	Pb, Ag
26. Tynagh	Galway	Zn, Pb, Ag, barite
27. West Cork	Cork	Cu, barite

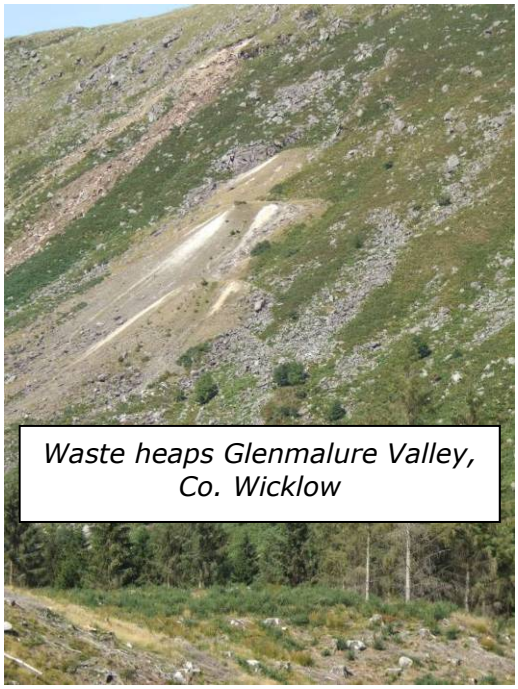
7. How do we know if a site has been impacted?

Mine waste can affect the environment and ultimately human and animal health by contaminating surface water, groundwater, the soil, and stream sediments. These media can become polluted by the release of contaminant elements from the mine waste. Such elements include the metal(s) for which the mining was carried out for in the first instance and minor elements associated with the ore minerals but which were not the goal to recover from the mining operation. Examples of the former would be lead (Pb), copper (Cu), zinc (Zn) and silver (Ag) while examples of the latter would be arsenic (As), cadmium (Cd), antimony (Sb) and mercury (Hg).

Ireland, the European Union and other countries have developed standards or guidelines for the different media that can be affected by these various contaminants. Where Irish standards or guidelines exist we have used these. Where such standards do not exist we have used any European values. We have also drawn upon standards and guidelines from the United Kingdom, Holland, the United States of America and Canada where there were no Irish or European values.

Allihies, Coom engine house.

8. What are the results?

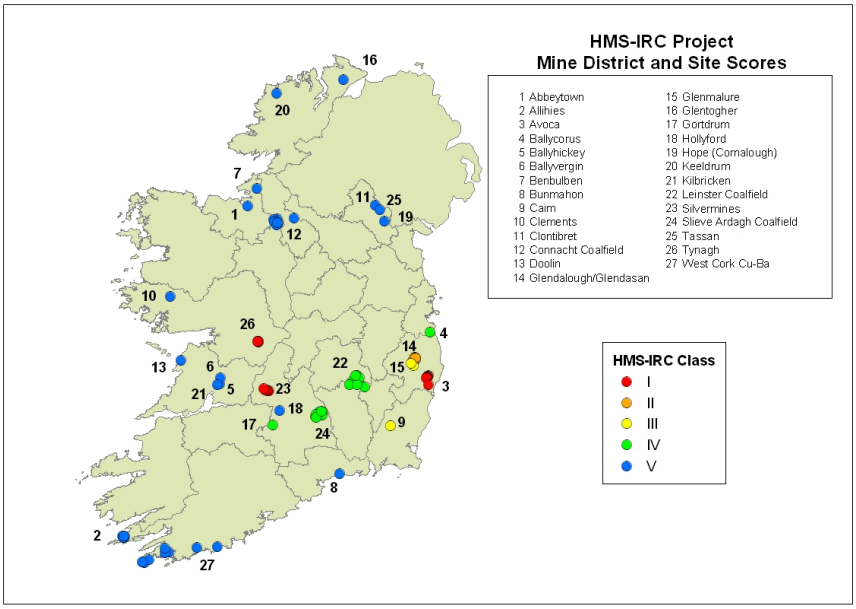


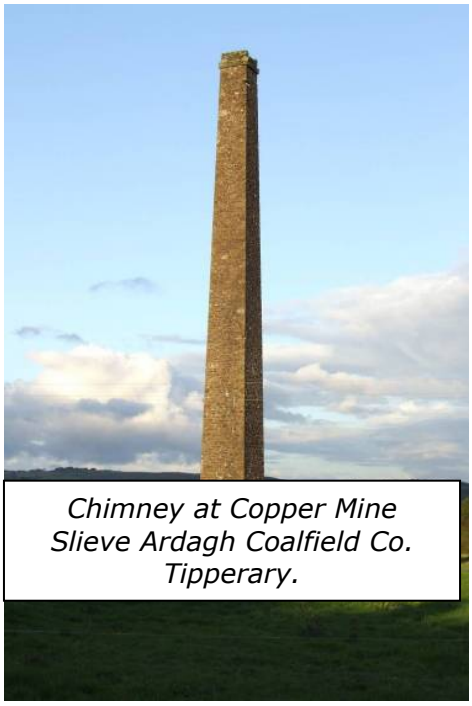
Waste heaps Glenmalure Valley, Co. Wicklow

Of the 27 individual districts/sites listed in the Table on the next page, three are classified in the highest Class I, one as Class II, two as Class III, four as Class IV the remaining 17 as Class V. The three Class A mine districts/sites are Silvermines, Tynagh and Avoca. All three districts were operated in the last century as modern, mechanized mines that produced large volumes of ore and waste. Volume and area of waste are important contributors to site scores in the HMS-IRC scoring system. However, large volume and area of waste are not sufficient in themselves to place a mine district or site in the highest category. The waste must also have significant concentration of contaminants with high relative toxicity. In the case of the three Class I sites, high Pb concentrations, in particular, contribute significantly to the total sites scores. In contrast, other mine districts and sites that were operated in the 20th century and that have very large volumes of waste, such as Gortdrum and the three coalfields, have relatively low rankings because none has significant concentrations of high-relative-toxicity contaminants.

Many of the 18th and 19th century sites produced much lower volumes of waste because mining was essentially manual and focused on relatively high-grade, low-volume ore. Thus, although their waste can have very high concentrations of high-relative-toxicity contaminants, especially Pb, these sites generally have relatively low ranking because of their small volumes of waste. The exception is the Glendalough-Glendasan district (Class II) which contains numerous sites spread over an extensive area.

Mine / District	No. of Sites	Hazard	Total Score	Class
Tynagh	4	9,772	2,712	I
Silvermines	6	6,565	2,545	I
Avoca	7	5,009	2,438	I
Glendalough/Glendasan	8	3,795	1,122	II
Caim	1	1,204	559	III
Glenmalure	2	1,944	335	III
Ballycorus	1	371	244	IV
Gortdrum	1	612	157	IV
Leinster Coalfield	7	389	133	IV
Slieve Ardagh Coalfield	10	451	118	IV
Clements (Connemara Pb)	1	292	97	V
Connacht Coalfield	7	342	91	V
Kilbricken (Clare Pb)	1	158	89	V
Allihies	6	245	76	V
Abbeytown	1	156	70	V
Tassan (Monaghan Pb)	1	199	44	V
Ballyvergin (Clare Pb)	1	115	43	V
Ballyhickey (Clare Pb)	1	80	19	V
Keeldrum (Donegal Pb)	1	74	17	V
West Cork Cu-Ba	8	154	17	V
Clare Phosphate (Doolin)	1	83	15	V
Bunmahon	1	48	14	V
Hope (Monaghan Pb)	1	43	13	V
Clontibret (Monaghan Pb)	1	60	12	V
Glentogher (Donegal Pb)	1	24	5	V
Benbulben	1	34	5	V
Hollyford (Tipperary Minor Cu)	1	11	4	V





Chimney at Copper Mine Slieve Ardagh Coalfield Co. Tipperary.

9. What are the conclusions and recommendations?

The main conclusions arising from this work are:

1. Ireland possesses an abundance of historic mine sites dating from the Bronze Age to the late 20th century.
2. The mineral deposits produced a wide range of commodities.
3. The Class I Sites are Silvermines, Tynagh and Avoca.
4. The Class II Sites is Glendalough-Glendasan
5. The Class III Sites are Caim and Glenmalure.
6. The Class IV Sites are Ballycorus, Gortdrum, the Leinster Coalfield and the Slieve Ardagh Coalfield.
7. The Class V Sites are Clements, the Connacht Coalfield, Kilbricken, Allihies, Abbeytown, Tassan, Ballyvergin, Ballyhickey, Keeldrum, West Cork Cu-Ba, Clare Phosphate (Doolin), Bunmahon, Hope, Clontibret, Glentogher, Benbulben and Hollyford.
8. The following sites have specific issues of concern which should be addressed:

   a. Abbeytown

   Pb- and As-rich leachate from the tailings pond enters the estuary at Ballysadare Bay.

   b. Avoca

   Measured Pb concentrations exceed 1% in solid waste at Connary, a site where sheep graze.

c. Ballycorus

Measured Pb concentrations exceed 1% in solid waste at Ballycorus in an area popular with walkers and horse riders.

d. Caim

Measured Pb concentrations exceed 5% in a solid waste heap at Caim, used by quad bikers and others.

e. Ballyvergin

Pb concentrations in excess of 20% were measured in fine-grained mine waste in an area used by cattle for feeding at Ballyvergin.

Old powder house (explosive store) at Earlshill, Slieve Ardagh Coalfield, Co. Tipperary

f. Glendalough - Glendasan

i. Measured Pb concentrations exceed 10% in solid waste at the Hero Processing site, at the head of the Glendasan valley. The site is very popular with tourists.

ii. Measured Pb concentrations exceed 10% in solid waste at Ballinafunshoge, Glenmalure, a site popular with quad bikers.

iii. High concentrations of Pb and Zn were measured in stream sediments in Glendasan and Glenealo Rivers downstream of the mines.

g. Gortdrum

Very high concentrations of Hg (>0.5%) and As (> 1%) were measured in solid waste at the site of former processing plant, now the site of an active business. The contaminated material is, however, contained on the site but may be a risk to on-site workers.

h. Silvermines

High concentrations of Pb (>2%) and As (>0.1%) were measured in solid waste at the site of the former processing plant in Garryard, now the site of an active business.

i. Tynagh

High concentrations of Pb (>2%) and As (>0.1%) were measured in solid waste at the site of the former processing plant, now the site of an active business. A Cd-rich discharge from a waste heap crosses grazing land and seeps underground, potentially affecting groundwater.

Discharge from Deep Adit, East Avoca, Co. Wicklow.

The principal recommendations are:

1. Local Authorities and other relevant agencies, such as the Health Services Executive, Health and Safety Authority and Teagasc should be advised of all issues falling within their specific areas of responsibility.
2. Sites classified as Class I, from a contaminant point of view should have a full environmental risk assessment carried out, if not already undertaken. A full study has been undertaken at the Avoca site and remediation work is currently underway at Silvermines. Ongoing monitoring should be carried out at these sites.

3. Sites classified as Class II, from a contaminant point of view, should have general monitoring of most or all waste piles, discharges or stream sediments carried out on an annual basis.
4. Sites classified as Class III, from a contaminant point of view should have specific monitoring on particular waste piles, discharges or stream sediments on a biennial basis.
5. Sites classified as Class IV, from a contaminant point of view should have specific monitoring on particular waste piles, discharges or stream sediments on a five yearly basis.
6. Sites classified as Class V do not requiring any specific monitoring.
7. A scientific based scheme of monitoring should be developed appropriate to each of the site classes incorporating relevant expertise from the EPA and GSI.
8. In order to comply fully with the Directive an inventory of closed aggregate and stone operations (quarries and pits) should be carried out.

Crookhaven, Co. Cork – magazine.

The Creevelea iron furnace, Creevelea, Co. Leitrim.