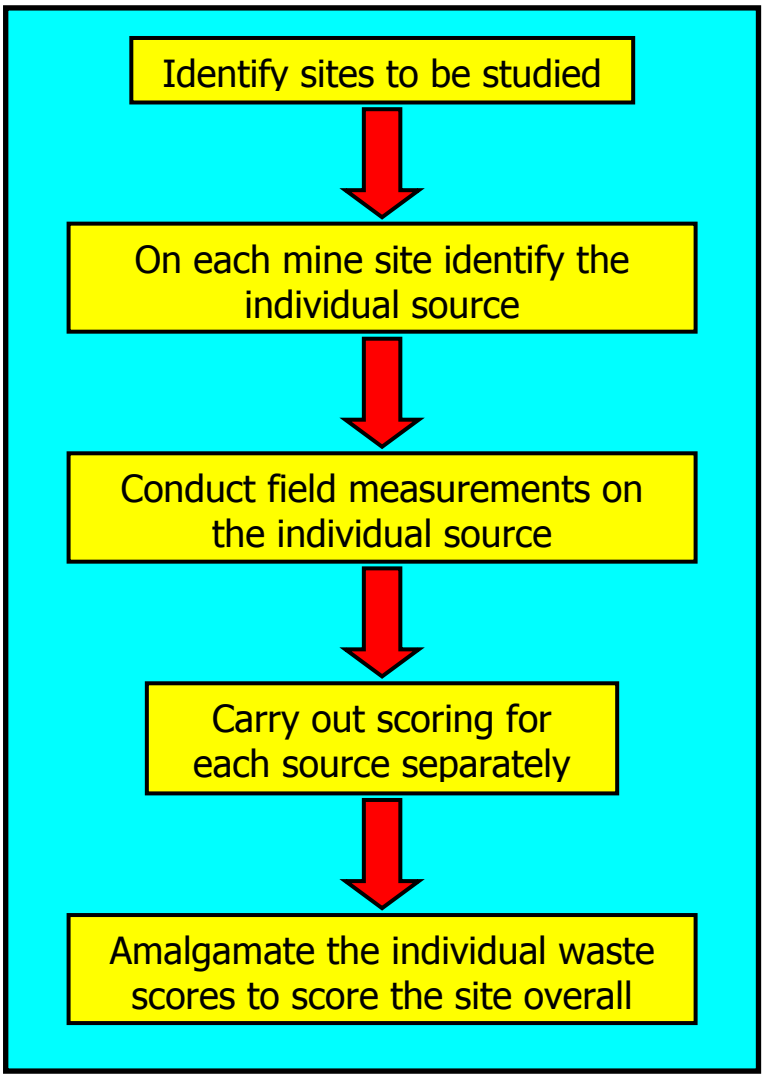
APPENDIX 1

HISTORIC MINE SITES

SCORING SYSTEM

(HMS – SS)

A project to categorize contamination sources from mine waste at Historic Mine Sites



GEOLOGICAL SURVEY OF IRELAND AND THE ENVIRONMENTAL PROTECTION AGENCY

FOREWORD

The Historic Mine Sites – Inventory and Risk Categorization Project addresses the EU Directive on Wastes from the Extractive Industries requirement for an inventory of waste facilities and the National need for data on physical hazards at closed and/or abandoned mine sites. In order to categorize and rank these relatively the Source – Pathway – Receptor Paradigm was utilized. Contaminant risks at mine sites come from potential contaminated mine waste source found on a site. The paradigm requires that each of the parameters within the model are documented, estimated, measured or recorded. 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. The collection of field data, observations and estimates confirms whether a linkage exists between the source and receptor.

The scheme developed to risk categorise the sites is described in this Appendix. The overall scheme seeks to score various parameters in order to develop an overall score for an individual waste pile, mine discharge or contaminated stream sediments. The individual waste scores are then added to develop an overall score for the site in question.

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1. INTRODUCTION

EU Directive 2006/21/EC, the Management of Waste from the Extractive Industries, requires each Member State to compile an inventory of closed waste facilities, including abandoned waste facilities, within their jurisdiction by 1st May 2012 and to update the inventory periodically thereafter (Article 20). Article 21 states that the inventory should be complied on a risk basis. The Geological Survey of Ireland, the Environmental protection Agency and the Exploration and Mining Division of the Department of Communications, Energy and Natural Resources (the partners) are conducting the inventory of closed waste facilities for Ireland.

This document describes the risk assessment method developed by the partners and known as the Historic Mine Sites Scoring System (HMS-SS). The system was developed to prioritise the historic mine sites from a human and animal health perspective as well as the general environment. The system is based on the Abandoned and Inactive Mines Scoring System (AIMSS) which was developed to carry out a similar exercise in the State of Montana, United States of America.

The system requires information from many sources including:

Geological Survey of Ireland data
Environmental Protection Agency data
Exploration and Mining Division data
Central Statistics Office data
Teagasc subsoils data
Local Authority data

Data from several sources needed to be compiled from documented sources in a GIS environment. This was then validated by field visits to each of the sites.

In addition, data has been collected in the field to be used in the scoring system. This included:

1. Surface water sampling and analysis (both summer and winter)
2. Stream sediment sampling and analysis
3. Tailings sampling and analysis
4. Waste pile sampling and analysis

Site safety and stability is assessed and described in a separate document associated with this project.

HMS-SS is not a detailed quantitative risk assessment. The scoring is designed to rank differing and disparate sites using existing or easily obtained new information on a common foundation on the basis of threats to human health, animal health and the environment.

2. OVERALL PHILOSOPHY

The overall approach to the scoring of the sites is illustrated in Figure 2.1.

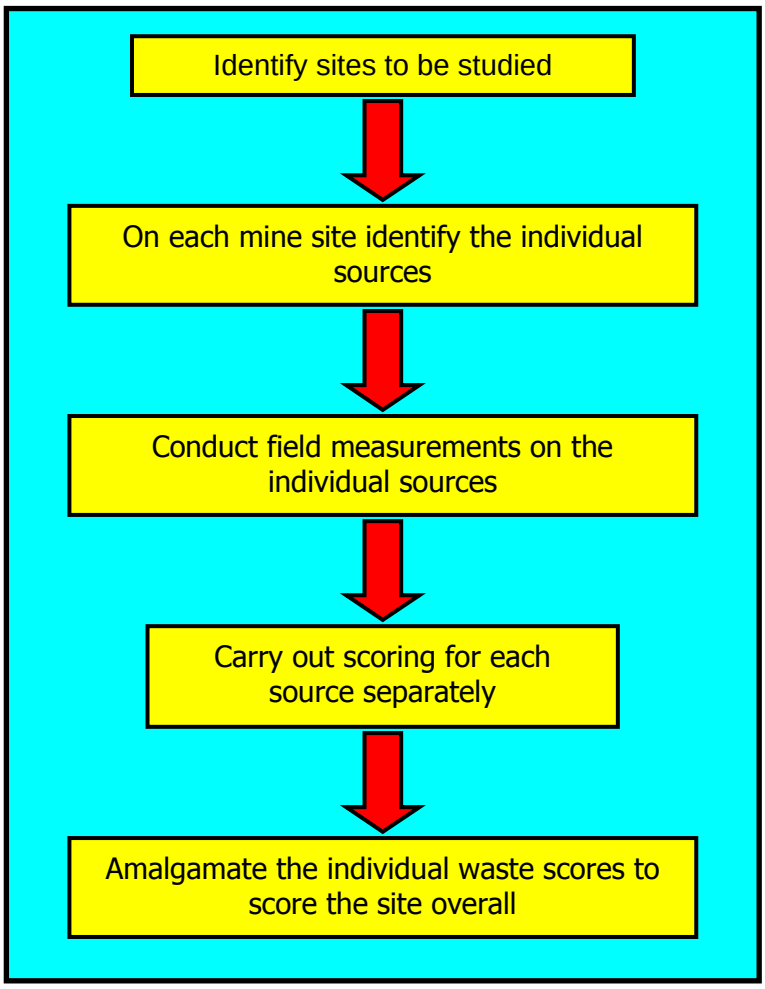


Figure 2.1. Overall approach to ranking contamination at mine sites.

First, the closed mine sites to be studied are identified, as described in Section 2.2 (Preliminary screening and site selection) of the Main Report. Next, within these sites individual contamination sources are identified. These sources are mapped and measurements and other data collected in and around each. The individual source types are characterised so that the hazard associated with each is known. In effect, the volume and chemical composition of each facility is determined and combined to produce a hazard score for each. The individual sources are assessed for the potential risk they pose to human health, animal health, and the environment. The scoring for human health, animal health and the environment within HMS-SS follows the source – pathway – receptor paradigm. Finally, the scores for the individual source types are combined to produce a site score whereby all the selected sites from around the country can be compared and a ranking categorization developed.

The sources, pathways and receptors that are considered in the HMS-SS system and pose a risk to human health, animal health and the wider environment are described in the following three sub-sections (Sections 2.1, 2.2 and 2.3 respectively).

The scoring process is automated with the use of an EXCEL workbook (HMS-SS_scoring.xls) for each source type. There are three workbooks with up to seven

different worksheets within each. The table below displays the different combinations of worksheets for each source type.

Solid Sources	Liquid Sources	Stream Sediments
1. Waste Hazard 2. Groundwater 3. Surface water 4. Air Pathway 5. Direct Contact (waste piles) 6. HMS-SS Score 7. Lookup Tables	1. Waste Hazard 2. Groundwater 3. Surface water 4. HMS-SS Score 5. Lookup Tables	1. Waste Hazard 2. Direct Contact (stream sediments) 3. HMS-SS Score 4. Lookup Tables

Table 2.1. The HMS-SS EXCEL workbooks.

The first worksheet (Waste Hazard) is common to all three workbooks. This sheet scores individual sources that have been investigated during this study. The next worksheets, the number depends on the source type, score the named and relevant pathways. Solid sources contain four of these pathways (Fig 2.2). Liquid sources have only two pathways sheets, groundwater and surface water. One pathway worksheet is present in the Stream Sediment workbook. The overall score for each source type is calculated on the HMS-SS worksheet. The final worksheet contains the lookup tables servicing the input to the other tables.

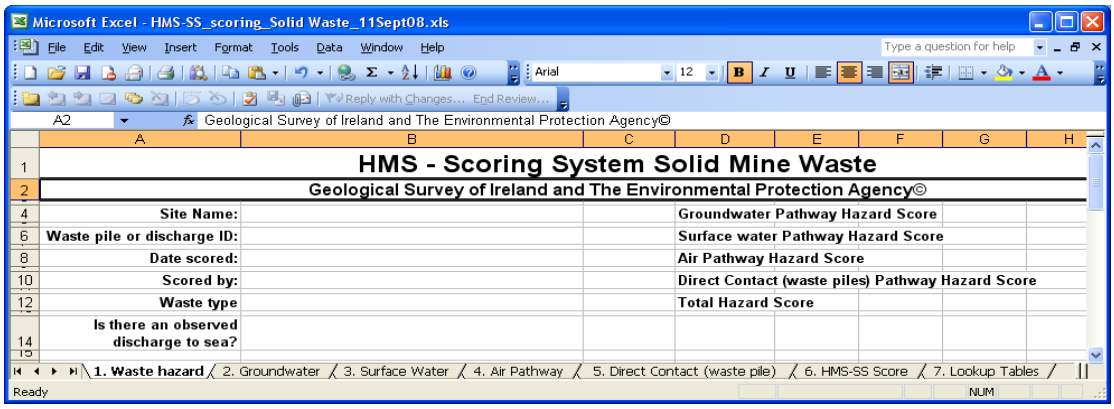


Figure 2.2. An example of a Solid Waste workbook.

2.1 Sources

The potential sources of contamination at mine sites include:

1. Tailings
2. Waste piles
3. In situ mineralization
4. Contaminated runoff
5. Adit and other discharges and seeps
6. Standing water on waste facilities and other ground within mine sites
7. Stream sediments

These can also be subdivided into solids sources, liquid sources and stream sediment contamination.

2.1.1 Solid sources

The solid mine waste scored using the HMS-SS system are:

1. Waste heaps or tips – natural rock extracted in the mining process but not processed for mineral extraction.
2. Tailings – the non-valuable end product of mineral processing having the consistency of fine to coarse flour.
3. Unprocessed ore – ore that has been taken out of the ground but has not been processed for any one of a number of reasons.
4. Processed or part processed waste – ore material which has been processed but is not tailings; often this is a waste from earlier more primitive processing methods.
5. A mixture of any of the above.

However, not all sources are equally a threat to humans, animals or the environment. The factors determining the threat posed for each source include:

1. Volume of waste material.
2. Surface area of the site.
3. Surface area of the particles (grain size).
4. Physical state of the source.
5. Chemical composition of the waste material.
6. Linkage to pathway and / or receptors.

2.1.2 Liquid sources

The liquid waste scored using the HMS-SS system are:

1. Contaminated surface water, streams, rivers and lakes.
2. Contaminated point source discharges to surface waters, for example, adit discharges and seeps.
3. Contaminated diffuse discharges to groundwater or surface waters.
4. Standing water in ponds.

However, not all sources are equally a threat to humans, animals or the environment. The factors determining the threat posed for each source include:

1. Volume of contaminated water.
2. Chemical composition of contaminated water.
3. Linkage to pathway and / or receptors.

2.1.3 Stream sediment contamination

Stream sediments are scored separately using the HMS-SS system.

However, not all sources are equally a threat to humans, animals or the environment.

The factors determining the threat posed for each source include:

1. Length of stream or river containing contaminated stream sediments.
2. Chemical composition of contaminated stream sediments.
3. Linkage to pathway and / or receptors.

2.2 Pathways

The potential pathways for contamination to reach receptors that are used in the HMS-SS are:

1. Groundwater
2. Surface water
3. Air
4. Direct contact involving waste piles
5. Direct contact involving stream sediments

2.3 Receptors

The potential receptors are:

1. Humans
2. Groundwater
3. Surface water
4. Fresh water ecosystems
5. Land based ecosystems
6. Marine (estuarine ecosystems)
7. Livestock

2.4 Scoring

The overall approach to the scoring system is to take for each source type, each relevant pathway in turn, groundwater, surface water, air and direct contact (with waste heaps or stream sediments). For each pathway three **primary factors** are evaluated:

- **Likelihood of release** of a contaminant to humans or the environment.
- Waste **hazard** characteristics, including chemical composition, quantity and relative toxicity.
- Potential **receptors** of exposure (human, animal and environmental)

There are several items within each factor and these are combined (either added or multiplied) to give an overall score. Once each factor within a pathway has been scored the total score is calculated and is the designated Site Score for the site under consideration.

For **Solid Waste**, the HMS Score is:

{[Groundwater Score (likelihood of release)*(hazard)*(receptors)] +
[Surface water Score (likelihood of release)*(hazard)*(receptors)] +
[Air pathway Score (likelihood of release)*(hazard)*(receptors)] +
[Direct contact (Waste piles) Score (likelihood of release)*
(hazard)*(receptors)]} ÷ 100,000

For **liquid Waste**, the HMS Score is:

{[Groundwater Score (likelihood of release)*(hazard)*(receptors)] +
[Surface water Score (likelihood of release)*(hazard)*(receptors)]} ÷
100,000

For **Stream Sediments**, the HMS Score is:

{[Direct contact (Stream Sediments) Score (likelihood of release)*
(hazard)*(receptors)]} ÷ 100,000

The three primary factors are multiplied together to derive each of the pathway scores. This equalises the relative effect of each primary factor. Hence, a greater likelihood of release, higher constituent concentrations, or more potential receptors all affect the pathway score similarly – as should be the case when assessing relative risk.

The associated pathways for each source type are summed and the result divided by 100,000 – simply to reduce the order of magnitude of the scores. Within the system the groundwater and surface water pathway are given greater relevance as they have the potential to affect more receptors than either the air or direct contact pathways.

There are inevitable uncertainties for some parameters. Those parameters which have the greatest uncertainties have been intervalised, i.e., ranges of values have been identified within which the score is the same. An examples of these parameters is population statistics.

Once each source type has been assessed, all the scores for each of the waste types for each mine site are added together to give an overall score for the mine site.

2.5 Some overarching topics

At the outset some of the overarching concepts, parameters and definitions need to be described.

2.5.1 Site boundary

The site boundary is often identified for a measure, for example the nearest residence. Where this is the case the site boundary is from the nearest waste feature – waste heap, tailings facility, adit discharge etc. see Figure 2.2.

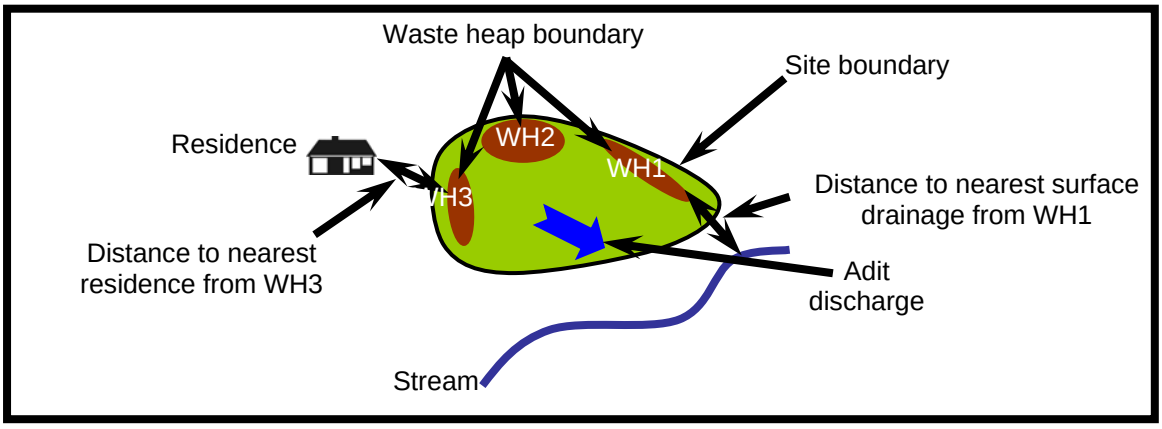


Figure 2.3. Illustration of nearest distances measurements from waste heaps to stream or residence. WH = waste heap.

2.5.2 Measure of central tendency of chemical composition for waste heaps

Large bodies of mine waste are typically heterogeneous and require up to several tens of samples to be collected and analysed to provide a realistic assessment of the likely overall composition of that facility. Different numbers of samples were taken at sites depending on its size and complexity. Also, smaller numbers of samples tend to provide a greater tendency for outliers (unusually small or large values) to occur. For this reason the decision was made to use the median value as a measure of

central tendency. The median value limits the influence of outliers and provides a more robust estimate value for average composition.

2.5.3 Measure of central tendency of chemical composition for stream sediments

Stream sediment sampling involved sampling a number of sub-sites downstream of each mine. Stream Sediments in a river are typically heterogeneous and require up to several tens of samples to obtain a realistic representation of the stream. For this reason the median statistic was used as a measure of central tendency. The median value limits the influence of outliers and provides a more robust estimate value for average composition.

2.5.4 Measure of chemical composition for water samples

Flow rates and concentrations of discharges and seepages vary seasonally. For this reason water samples were taken during both winter and summer seasons. The more conservative value was used when scoring these liquid wastes in the HMS-SS workbooks.

2.5.5 Relative toxicities

The relative toxicity of elements is taken into account in the scoring by modifying the hazard score throughout the system. This is achieved by multiplying the amount of the element by the relative toxicity number. However, the relative toxicities are different for different environments or habitats. For this study six relative toxicities categories are recognised:

Soil and sediment

- Human ingestion and inhalation
- Livestock

Surface water and groundwater

- Human ingestion
- Fresh water aquatic environment
- Marine water aquatic environment
- Livestock

The relative toxicities are given in Table 2.2.

Throughout the study the total quantity of the element is used. This is far simpler than having to carry out speciation studies, which are often complex and controversial, for elements in order to determine bio-availability. The approach of using total concentrations is also conservative.

In addition, not every pathway is relevant to each environmental situation or habitat. The relevant pathways for each environmental situation or habitat are illustrated in Table 2.3.

Relative Toxicity Values						
	Soil and sediment		Surface water and groundwater			
Metal	Human ingestion & inhalation	Livestock	Human ingestion	Eco Aquatic	Eco Salt - Aquatic	Livestock
Aluminium*	N/A	N/A	0	0.1	0.1	0.01
Antimony	10	0.1	10	0.1	0.1	0.1
Arsenic	10	0.1	10	0.01	0.1	0.01
Barium	0.01	0.01	0.01	0.001	0.001	0.1
Cadmium	10	10	10	10	1	10
Chromium	10	0.1	10	0.1	0.1	0.1
Copper	0	0.1	0	1	1	0.1
Iron	0.001	0.01	0.001	0.01	0.01	0.01
Lead	10	1	10	1	1	1
Manganese	0.1	0.001	0.1	0	0	0.001
Mercury	10	1	10	10	10	1
Nickel	10	0.1	10	0.1	1	0.1
Selenium	0.1	1	0.1	1	0.1	1
Silver	0.1	0.01	0.1	10	10	0.01
Thorium	10	0.01	10	0.01	0.01	0.01
Uranium	10	0.01	10	0.01	0.01	0.01
Vanadium	0.1	0.1	0.1	0	0	0.1
Zinc	0.01	0.01	0.01	0.01	0.1	0.01

Table 2.2. Relative toxicity values for different environmental and habitat situations.

***Aluminium is only measured in water samples.**

Receptors	Pathway				
	Groundwater	Surface water	Air	Direct contact	
				Waste pile	Stream sediment
Human					
ingestion	●	●		●	
inhalation			●		
Fresh water aquatic		●			
Marine water aquatic		●			
Livestock	●	●		●	●

Table 2.3. Cross tabulation of which pathway affects which environmental situation or habitat.

The table should be interpreted as follows. For each receptor the pathways indicated are the means by which the particular receptor is exposed to the hazard (mine waste). Therefore, human receptors are exposed to the hazard through coming into contact with groundwater (by drinking groundwater), by surface water (by drinking it), by the air pathway (by inhaling dust) and by direct contact (by walking over or being otherwise on a site). Fresh water aquatic ecosystems are

exposed to mine wastes via the surface water pathway (that is where they live). Marine water aquatic ecosystems are exposed to mine wastes via the surface water pathway (these water enter the marine environment and therefore pose a risk to marine organisms). Livestock are exposed to the hazard posed by mine wastes via the groundwater pathway (some livestock may get their drinking water from this source), via the surface water pathway (most livestock receive their water from surface water), via the direct contact pathway (livestock may enter onto mine waste facilities, either intentionally or by accident) and livestock my ingest mine waste by having access to contaminated stream sediments when drinking from surface drainages.

2.5.6 Constituents attributable to the site

In scoring the different pathways elements must be attributable to the site. For example, if a surface water sample is contaminated with lead but there is no lead at the site then the element is not attributable to the site. The source of the contamination must be other than the mine site. On the other hand, if the mine site does contain lead and there is lead contamination in the stream then the presumption is that the source of the lead is from the site is reasonable – even though there could be other sources.

3. APPLYING A HAZARD SCORE TO A MINE WASTE

As discussed above each waste facility is scored for the hazard that it presents to the environment separately. Once this score has been calculated the actual state of the facility and the receptors that are likely to be affected by the facility are then scored. Refer to Worksheet No. 1 Hazard Score in the workbook.

The hazard score is determined by two factors:

- the 'quantity' of waste, and
- the contamination hazard represented by the waste.

3.1 Quantity of waste

Waste can be either solid or liquid and each type is reported differently.

3.1.1 Solid waste quantity

In the case of a solid waste for the groundwater and surface water pathways the 'quantity' measure is a volume and is reported in cubic metres (m^3). In the case of a solid waste for the air and direct contact pathways the 'quantity' measure is an area and is reported in square metres (m^2).

Information requirements and sources:

The information required to score this sub-factor is:

- Solid wastes volumes – a measure of the volume of waste within each accumulation. This is obtained from field measurements, use of aerial photographs and the use of GIS software. The volume should be reported in m^3.
- Solid wastes areas – a measure of the area of waste within each accumulation. This is obtained from field measurements, use of aerial photographs and the use of GIS software. The area should be reported in m^2.

SCORING

Once the 'quantity' has been determined a score is applied as follows in Tables 3.1 and 3.2.:

For volumes:

Solid waste volume (m^3)	Score
<1,000	1
1,000 – 1,000,000	1 + Vol*/10,000
1,000,000	100

Table 3.1. Scores to be assigned for volumes of solid waste estimated for sites.

*Vol = volume of waste in m^3.

For areas:

Solid waste area (m^2)	Score
<100	0.001
100 – 1,000	0.01
1,000 – 10,000	0.1
10,000 – 100,000	1
100,000 – 1,000,000	10
1,000,000 – 10,000,000	100
>10,000,000	1,000

Table 3.2. Scores to be assigned for areas of solid waste estimated for sites.

3.1.2 Liquid waste quantity

For liquid wastes the measurement is in litres/day (l/d) for the groundwater and surface water pathways. In the HMS-SS system liquid wastes do not contribute to the air or direct contact pathways, so a 'quantity' measurement is not required for these pathways.

Information requirements and sources:

For liquid wastes – a measure of the flow of liquid waste in the field by use of the 'cut-throat' measuring device. The flow should be reported in l/day.

SCORING

Liquid waste volume (l/day)	Score
No seepage observed	0
Observed but not measureable	3
<10,000	10
10,000 – 100,000	30
100,000 – 1,000,000	100
>1,000,000	300

Table 3.3. Scores to be assigned for liquid wastes issuing from adits or other seeps at mine sites.

3.1.3 Contaminated Stream Sediments

For stream sediments the length of stream with contaminated stream sediments is the relevant 'quantity' and is reported in metres (m).

Information requirements and sources:

The information required to score this sub-factor is:

- A measure of the length of stream sediments contaminated by discharges from the mine site. This is obtained from identifying which parts of the stream sediment are contaminated through an examination of stream sediment analyses carried out and by measuring the distance along the stream or river, usually by using GIS software. The length should be reported in metres. The contaminating substance must be attributable to the mine site.

SCORING

Length of stream containing contaminated stream sediments (m)	Score
<10	0.001
10 – 50	0.01
50 – 100	0.1
100 – 150	1
150 – 250	10
250 – 500	100
>500	1,000

Table 3.4. Scores to be assigned for the length of contaminated stream sediments identified along drainages emanating from sites.

3.2 Contamination hazard

The contamination hazard of the waste is assessed by reference to:

- Chemical composition of the waste, and
- The relative toxicity of the particular element with reference to the receptor under consideration.

Therefore each receptor represents a different hazard to different receptors by virtue of the fact that different receptors are more or less sensitive to the same elements.

The chemical nature of each waste is assessed by carrying out a chemical analysis of the waste. Typically there will be a number of analyses. The median composition is calculated for both solid sources and stream sediments. A more conservative view is used with liquid sources, taking the higher values with the associated flow. These are described in Sections 2.5.2 – 2.5.4.

Each element (Cu, Pb, Zn etc) is assessed on its own. No account is made for 'original' background values as these are for the most part unknown or unknowable. The relative toxicity for each element is taken into account with the 'average' value (AV) of the element multiplied by the relative toxicity number (for the appropriate habitat under consideration). These numbers are given in Table 2.2 above. This is the '**hazard value'** for each site. Once the 'hazard value' for each element is calculated they are summed together to obtain the '**total hazard value'**.

SCORING

Because each receptor has a different relative toxicity number there are two potential hazard scores for each solid waste facility; four hazard scores for liquid waste sources and one additional one for stream sediments (Table 3.5).

Waste type	Receptor	Pathway(s)	Exposure mechanism
Solid	Human	Air	Inhalation
Solid	Human	Direct contact	Ingestion
Solid	Livestock	Direct contact	Ingestion
Liquid	Human	Groundwater OR surface water	Ingestion
Liquid	Fresh water ecosystem	Surface water	Ingestion
Liquid	Marine ecosystem	Surface water	Ingestion
Liquid	Livestock	Groundwater OR surface water	Ingestion
Contaminated stream sediment	Livestock	Direct contact	Ingestion

Table 3.5. The different hazard numbers generated when carrying out a full evaluation under HMS-SS.

Another way of looking at this is to consider each pathway and examine which receptors are affected (Table 3.6).

Pathway	Receptors affected
Groundwater	Human, livestock
Surface water	Human, fresh water ecosystems, marine ecosystems, livestock
Air	Human
Direct contact (waste pile)	Human, livestock
Direct contact (contaminated stream sediments)	Livestock

Table 3.6. Tabulation of receptors potentially at risk by the different pathways.

The same basic procedure is used to score each of the hazard scores for each receptor (Table 3.7).

Element no.	Average value (AV)	Relevant* toxicity no. (RT)	Hazard value (HV)
1	Element$_1$ conc (AV_1)	RT_1	$AV_1 * RT_1$
2	Element$_2$ conc (AV_2)	RT_2	$AV_2 * RT_2$
⋮	⋮	⋮	⋮
n	Element$_n$ conc (AV_n)	RT_n	$AV_n * RT_n$

TOTAL	$= \sum_{i=1}^{n} (AV_i * RT_i)$

Table 3.7. Computation of Hazard Scores

*** The relevant toxicity number could be the human toxicity by ingestion/inhalation due to either solid or liquid wastes, the fresh water aquatic environment due to liquid waste, the marine water aquatic environment due to liquid waste or livestock toxicity due to either solid or liquid waste – all values obtained from Table 2.2.**

Information requirements and sources:

The information required to score this sub-factor is:

- Concentrations of contaminants measured for each waste source, liquid or solid. Chemical analysis comes from field measurements with a field portable XRF in case of solids and from laboratory analysis for liquids.

TOTAL Hazard SCORE

The total score for HAZARD (waste characteristics) is obtained by calculating the product of the quantity of waste score and the total hazard score for each receptor for each pathway for each waste source and dividing the result by 10,000, i.e.,

$$\textbf{Total Score} = (\sum_{i=1}^{n} (AV_i * RT_i) * Q) / 10{,}000$$

4. SCORING THE GROUNDWATER PATHWAY

In this section both the information sources used for the scoring and the scoring for each of the 'Likelihood of Release' and 'Receptor' factors for the groundwater pathway are described. Refer to Worksheet No. 2 in both the solid source and liquid source workbooks.

4.1 Likelihood of Release

The likelihood of release score evaluates three sub-factors:

- Potential for observed releases to groundwater;
- Exceedances of water standards; and
- Potential to release.

4.1.1 Potential for observed releases to groundwater

An observed release is when the analytical results from a leach test (HMS-IRC Project Report, Appendix 2, *Geochemical Sampling protocols*) carried out on a sample of waste from the site for any constituent is THREE times the upgradient concentration of groundwater or surface water for that constituent that is attributable to the site. Surface water analysis is used as a substitute for groundwater analysis where no upgradient groundwater analysis exists. In the event that no groundwater or surface water was sampled during the project then the nearest analogous water sample, either surface water or groundwater, for which analytical results exist, may be used. Concentrations do not have to exceed any standards.

Wastes that could be sampled are:

- Waste rock heaps
- Tailings
- Ore concentrate
- Discharges

Scoring for Potential for observed release to groundwater is as per Table 4.1.

SCORING

Observed release	Score
YES	200
NO	0

Table 4.1. Scoring the 'Potential for observed releases to groundwater' sub-factor.

Information requirements and sources:

The information required to score this sub-factor is:

- Analytical results of groundwater or surface water upgradient of the site from work carried out during this project.

OR

- Analytical results for the nearest surface water or groundwater from work carried out previously and possibly for another organisation.

AND

- Analytical results for leach test carried out on waste from the site from work carried out during this project.
- Evidence that the element is attributable to the site.

4.1.2 Exceedances of water standards

For a solid waste source, an exceedance occurs when the analytical results from either a leach test carried out on a sample of solid waste from the site or an analysis of seepage from a solid waste heap for any constituent exceeds the **Surface water** or **Drinking Water Standard** for that constituent. For a liquid waste source, an exceedance occurs when an analysis of a mine water discharge for any constituent exceeds the **Surface water** or **Drinking Water Standard** for that constituent. The relevant standards are contained in the Draft European Communities Environmental Objectives (Surface Waters) Regulations, 2008 and the European Communities (Drinking Water) (No.2) Regulations 2007, **S.I. No. 278 of 2007.** The Drinking Water Standard came into operation in June 2007 (Appendix 1.1). The exceedance score applies whether a release has occurred or not. The score is applied for any one exceedance. Exceedances of water standards is scored as per Table 4.2.

SCORING

Exceedance	Score
YES	200
NO	0

Table 4.2. Scoring for the 'exceedances of water standards' sub-factor.

Information requirements and sources:

The information required to score this sub-factor is:

- Analytical results for leach test carried out on waste from the site. Work carried out during this project.
- Analytical results for a discharge at the site. Work carried out during this project.
- Current surface water and drinking water standards.

4.1.3 Potential to release

The potential to release is evaluated by:

- The extent to which waste at the site is contained; and
- The estimated depth to the water table.

Site containment

The extent to which a waste heap or discharge is contained by engineered structures designed to prevent releases is evaluated by reference to any as-built engineering drawings and by a visual inspection of the facility. Structures include berms, liners, covers and surface water run-on diversions. Any of these structures must be intact, functioning, and monitored / maintained regularly. Containment is scored as per Table 4.3.

SCORING

Containment	Score
No containment	20
Presence of ONE of the following: berm, liner, run-on diversions or vegetated cover	15
Presence of TWO of the following: berm, liner, run-on diversions or vegetated cover	10
Presence of THREE of the following: berm, liner, run-on diversions or vegetated cover	5
Completely contained - presence of ALL FOUR of the following: berm, liner, run-on diversions or vegetated cover	1

Table 4.3. Scoring the 'containment' element of the 'potential to release' sub-factor.

Depth to the water table

Virtually no bedrock in Ireland has primary porosity or permeability remaining; secondary porosity and permeability have been created through processes of fracturing, weathering and karstification. Although fractures/karst conduits within a bedrock unit may occupy only a small fraction of the total volume (typically 1-2%), the permeabilities of the individual fractures/conduits are typically high. Fractures and some conduits are typically sub-vertical.

In general, little attenuation of contaminants occurs in the bedrock. Because of the high permeability and orientation of the fractures, once any contaminated water comes in contact with bedrock it can pass rapidly to the water table, regardless of how far below the top of the bedrock the water table is. Therefore, in Ireland, depth to bedrock rather than depth to water table is used when assessing groundwater vulnerability to contamination, as it is the subsoils overlying the bedrock that are considered to be the single most important natural feature influencing groundwater vulnerability and groundwater contamination prevention. The exception is where the subsoil is itself an aquifer, i.e. sand and gravel deposits.

The depth to bedrock is estimated from existing boreholes and wells and subsoil maps that show where rock is at or close to the surface. As far as is known, there are no mine sites in Ireland underlain by sand and gravel aquifers but should this be the case then a detailed examination of depth to water table is warranted. In general, however, depth to bedrock is used instead of depth to water table. The depth to the water table is scored as per Table 4.4.

SCORING

Depth to the water table	Score
<10m	20
10 – 30m	10
>30m	2

Table 4.4. Scoring the 'depth to the water table' part of the 'potential to release' sub-factor.

Potential to Release Score

The total score for potential to release to obtained as the product of the Containment and Depth to the water table scores.

Containment score X Depth to the water table score

Information requirements and sources:

The information required to score this sub-factor is:

- Containment: visual inspection at the site into the presence, functioning and maintenance / monitoring of liners, covers and run-on diversions.
- Depth to water table: depth-to-bedrock maps (GSI Bedrock and Groundwater Section; Teagasc Subsoil map), borehole and well logs, field observations of depth to bedrock.

TOTAL Likelihood of Release SCORE

The total score for LIKELIHOOD TO RELEASE is obtained by summing the three sub-factors:

Observed releases to groundwater + Exceedances of water standards + Potential to release

The score will range from a low 2 of to a high of 800.

4.2 Receptors

The receptor sub-factor is evaluated by assessing the following:

- The aquifer category.
- No. of wells within certain radii of the site.
- Distance to nearest well.
- Groundwater vulnerability.

4.2.1 Aquifer category

Under the Water Framework Directive a national aquifer categorization has been developed. The classification recognizes the following two gravel aquifer categories plus nine bedrock aquifer categories as shown in Table 4.5.

	Regionally Important	Locally Important	Poor
Bedrock aquifers	**Rk** – Karstified	**Lm** – Generally moderately productive	**Pl** – Generally unproductive except for local zones
	Rkc – Karstified, dominated by conduit flow	**Ll** – Moderately productive only in local zones	**Pu** – Generally unproductive
	Rkd – Karstified, dominated by diffuse flow	**Lk** – Locally important karstified aquifer	
	Rf – Fissured bedrock		
Sand/gravel aquifers	**Rg** – Extensive sand/gravel	**Lg** – sand/gravel	

Table 4.5. Aquifer classification used in Ireland.

SCORING

Each aquifer category receives a score. Those aquifers that are more productive receive a greater score than the less productive aquifers (Table 4.6).

Aquifer Class	Score
Rk – Regionally Important Karstified	20
Rkc – Regionally Important Karstified, dominated by conduit flow	18
Rg – Regionally Important Extensive sand/gravel	15
Rkd – Regionally Important Karstified, dominated by diffuse flow	15
Rf – Regionally Important Fissured bedrock	10
Lm – Locally Important Generally moderately productive	8
Ll – Locally Important Moderately productive only in local zones	5
Lk – Locally important karstified aquifer	5
Lg – Locally Important sand/gravel	5
Pl – Generally unproductive except for local zones	2
Pu – Generally unproductive	1

Table 4.6. Scores for the different aquifer classes.

Information requirements and sources:

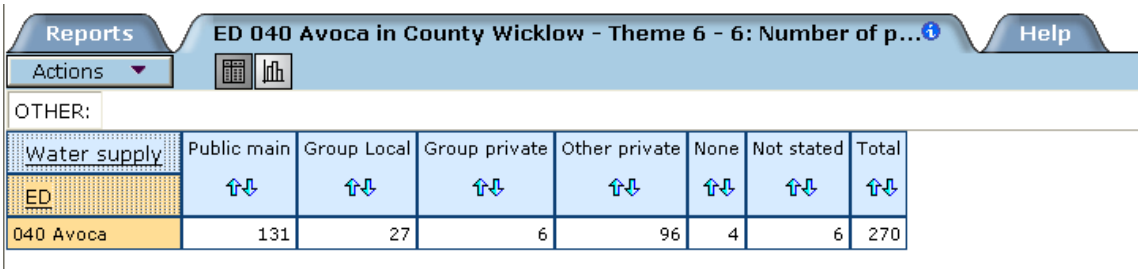
The aquifer category is obtained from the National Aquifer Map produced by the Groundwater Section of the Geological Survey of Ireland (Appendix 1.2). This is available in digital form.

4.2.2 Number of wells within 1km

The 2006 National Census is the basis for scoring under this heading published by the Central Statistics Office (CSO). The data is obtained from the CSO website (www.cso.ie).

The data from the National Census are categorized as follows:

- Public main
- Group local
- Group private
- Other private
- None
- Not stated
- Total



Water supply / ED	Public main	Group Local	Group private	Other private	None	Not stated	Total
040 Avoca	131	27	6	96	4	6	270

Figure 4.1. Screen dump from the CSO Small Area Population Statistics.

SCORING

The National Census reports information on an Electoral Division basis. There are 3409 Electoral Divisions in the country (Appendix 1.3). It is necessary to identify the Electoral Division or Electoral Divisions relevant to the site under consideration. This is achieved through GIS. Obviously a 1km buffer around a facility will not coincide with an Electoral Division. The area intersected by the 1km buffer should be expressed as a percentage of the total area of the Electoral Division (adjusted area) and this percentage is used to calculate the number of wells within 1km.

The adjusted number of wells is multiplied by 3 which is the national average of the number of persons per household (actually 2.81 but rounded up to 3).

Therefore, the score for the number of wells within 1km of the site boundary is the number of wells in the District Electoral Division(s) adjusted for area and population centres multiplied by 3:

(Group local$_{aa}$ + Group private$_{aa}$ + Other private$_{aa}$ + Not stated$_{aa}$) X 3

Where aa = adjusted area.

Information requirements and sources:

The number of wells is obtained from the CSO website (www.cso.ie).

4.2.3 Basic groundwater receptor score

The above two scores are added together.

Score for aquifer category + Score for no. of wells within 1km

GROUNDWATER receptor SCORE

The above takes no account of the vulnerability of the aquifer. Groundwater vulnerability maps have been prepared for the Water Framework Directive. The vulnerability map is reproduced in Appendix 1.4 and is available in ArcGIS digital format.

Seven vulnerability classes are recognized:

Extreme (rock near surface or karst)
Extreme
High
High to low
Moderate
Low
No data

The total score is adjusted by multiplying by a factor determined by the vulnerability classification. This takes into account the protection provided by the composition of the overlying materials, their thickness, etc. Those areas that are less vulnerable have their scores reduced while those areas that are vulnerable are not adjusted as much.

TOTAL Receptor SCORE

The Groundwater receptor score is determined by multiplying the Basic Groundwater Score by a factor (Table 4.8).

Description	Factor
Extreme (rock near surface or karst)	1.00
Extreme	1.00
High	0.80
High to low	0.50
Moderate	0.40
Low	0.25
No data	0.50

Table 4.8. Adjustment factors for receptor score.

(Score for aquifer category + Score for no. of wells within 1km)* X *vulnerability factor

4.3 Groundwater Pathway Score

TOTAL GROUNDWATER SCORE

The total Groundwater pathway score for the waste under consideration is obtained by multiplying the three main factors together:

[Likelihood of Release] X [Hazard (waste characteristics)] X [Receptors]

5. SCORING THE SURFACE WATER PATHWAY

In this section both the information sources used for the scoring and the scoring for each of the 'Likelihood of Release' and 'Receptor' factors for the surface water pathway are described. Refer to Worksheet No. 3 in both the Solid source and Liquid source workbooks.

5.1 Likelihood of Release

The likelihood of release score evaluates three sub-factors:

- Potential for observed releases to surface water;
- Exceedances of water standards; and
- Potential to release.

5.1.1 Potential for observed releases to surface water

An observed release is recorded when the analytical results of a water sampled down stream of a mining facility is THREE times the upgradient concentration of surface water for that constituent OR the analytical results of a stream sediment sampled down stream of a mining facility is THREE times the upgradient concentration of stream sediment for that constituent. The constituent must be one that is attributable to the mine site. A constituent is considered attributable to the site if that constituent exists in any waste material at the site at a concentration more than three times the background concentration of the constituent. The background concentrations are obtained from the National Soil Database, 2007 (Fay et al. 2007) (Appendix 1.5). Concentrations do not have to exceed any standards. In the absence of chemical data OR where there is a visible discharge to a local drainage (discolouration) without a chemical exceedance then the visible discharge should be scored.

SCORING

Observed release	Score
YES	200
Visible discharge	50
NO	0

Table 5.1. Scores to be assigned to the 'potential for observed releases to surface water' sub-factor.

Information requirements and sources:

The information required to score this sub-factor is:

- Analytical results for surface water upstream AND downstream of the site from work carried out during this project.

OR

- Analytical results for stream sediments upstream AND downstream of the site from work carried out during this project.
- Evidence that the element is attributable to the site.
- National Soil Database.

5.1.2 Exceedances of water standards

An exceedance occurs when the analytical results from a downstream surface water for any constituent exceeds the **Draft Surface Water Standards** or the **Drinking Water Standard** for that constituent, which can be attributed to the site. The relevant standards are contained in the Draft European Communities Environmental Objectives (Surface Waters) Regulations, 2008 and the Drinking Water Standard **S.I.**

No. 278 of 2007. The Drinking Water Standard came into operation in June 2007 (Appendix 1.1). The standard applied will be the more stringent of the standards in either legislation in the case where there is a difference between the two standards. The exceedance score applies whether a release has occurred or not. The score is applied for any one exceedance.

SCORING

Exceedance	Score
YES	200
NO	0

Table 5.2. Scores assigned to the 'exceedances of water standards' sub-factor.

Information requirements and sources:

The information required to score this sub-factor is:

- Analytical results for surface water upstream AND downstream of the site from work carried out during this project.
- Evidence that the element is attributable to the site.

5.1.3 Potential to release

The potential to release is evaluated by:

- The extent to which waste at the site are contained; and
- The distance from waste to surface water.

Site containment

Containment of the waste pile is assessed by reference to any as-built engineering drawings and by a visual inspection of the facility. Surface water from a waste pile may be contained by engineered features designed to mitigate releases to surface waters. Engineered features include dams, diversions and sediment basins or traps. Surface water run-off can also be contained by bodies of standing water, such as open-pit lakes. Any of these structures must be intact, functioning, and monitored / maintained regularly.

SCORING

Containment	Score
No containment	40
Presence of ONE of the following: dams, diversions, pit lakes and sediment basins or traps	20
Presence of TWO of the following: dams, diversions, pit lakes and sediment basins or traps	10
Presence of all THREE of the following: dams, pit lakes, diversions and sediment basins or traps	1

Table 5.3. Scores assigned to the 'containment' of the waste pile under consideration.

Distance to nearest surface water drainage

The distance to the nearest surface water drainage, including intermittent drainages, is measured during the field work at the site, in metres.

SCORING

Distance to nearest surface drainage	Score
<10m	10
10 – 30m	5
>30m	1

Table 5.4. Scores assigned to the 'distance to the nearest surface water drainage' from the waste pile under consideration.

Potential to Release Score

The total score for potential to release to obtained as the product of ***Containment*** and ***Distance to the nearest surface water drainage***.

Containment score X Distance to the nearest surface water drainage score

Information requirements and sources:

The information required to score this sub-factor is:

- Containment: visual inspection at the site into the presence, functioning and maintenance / monitoring of dams, diversions, pit lakes and sediment basins or traps.
- Distances of waste pile(s) to nearest surface water drainage: measured either in the field or within the GIS program.

TOTAL Likelihood of Release SCORE

The total score for LIKELIHOOD TO RELEASE is obtained by summing the three sub-factors:

Observed releases to surface water score + Exceedances of water standards score + Potential to release score

The score will range from a low 1 of to a high of 800.

5.2 Receptors

The receptor sub-factor is evaluated by assessing the following:

- The number of persons using surface water for drinking.
- Impacted drainages.
- Other water users.

5.2.1 The number of persons using surface water for drinking

The number of persons using surface water for drinking is obtained from the compilation of Abstractions of Ground and Surface Water in Ireland prepared for the Water framework Directive and published in 2007 within 10km downstream of the site. Each and every abstraction is counted and the sum calculated.

SCORING

Abstraction no.	Score
1	No. of people serviced by abstraction no. 1
2	No. of people serviced by abstraction no. 2
⋮	⋮
n	No. of people serviced by abstraction no. n

TOTAL	$\sum_{n=1}^{n}(no.\_of\_people\_served\_by\_abstraction\_n)$

Table 5.5. Scoring the 'number of persons using surface water for drinking' sub-factor.

Information requirements and sources:
The information for this sub-factor is obtained from Abstractions of Ground and Surface Water in Ireland prepared for the Water Framework Directive and published in 2007. The 10km radius is obtained from the GIS project.

5.2.2 Impacted drainage
Impacted drainage is approached differently for both Solid and Liquid sources.

5.2.2.1 Solid Waste
An impacted drainage score is applied to solid waste heaps if the waste heap is within 100m of a drainage system. The presence of a drain within 100m of the waste heap that links the heap with a drainage system also results in an impacted drainage score for the waste heap. Drainage refers to small streams, rivers or constructed channels that can facilitate the transfer of any surface water to the local river network.

SCORING

Presence	Score
YES	200
NO	0

Table 5.6. Scoring the 'drainage system' sub-factor.

Information requirements and sources:
The information required for this sub-factor is:

- The presence of a drainage system gathered during field work at the site.
- The distance within 100m is measured using the ArcGIS system.

5.2.2.2 Liquid Waste
This is the cumulative total length of a river or stream impacted downstream by discharges issuing from the mine. The length of an impacted river or stream is estimated from the chemical composition of water or stream sediment samples. A stream is impacted if the analytical results of water sampled or stream sediments sampled down stream of a mining facility is THREE times the upgradient concentration of surface water for that constituent. The stream length, in metres, is the figure used in scoring. This value is divided by 100 to obtain the score.

SCORING

= Measured impacted drainage length (m) / 100

Information requirements and sources:

The information required to score this sub-factor is:

- Analytical results for surface water upstream AND downstream of the site from work carried out during this project.

OR

- Analytical results for stream sediments upstream AND downstream of the site from work carried out during this project.

AND

- Evidence that the element is attributable to the site.
- The length is measured using the GIS system.

5.2.3 Other users

Other uses are:

- Fishery class.
- Recreational use.
- Protected area status (SACs, SPA, NHA, and National Parks).
- Livestock watering.

These are assessed within a 10km radius downstream of the site. They are assessed from observations on the site visit and data available from other agencies.

SCORING

Use	Class or Category	Score
Fishery class	Salmonid	20
	No classification	0
Recreational use	Observed	5
	Not observed	0
Protected area status	YES	20
	NO	0
Livestock watering	YES	20
	Unknown	10

Information requirements and sources:

- Fishery classification data are obtained from the Central Fisheries Board and the EPA.
- Recreational use is observed while in the field.
- Protected areas designations are obtained from the classifications prepared by the National Parks and Wildlife Service and are available online at www.npws.ie
- Livestock watering is observed while in the field.

TOTAL Receptor SCORE

The Total Receptor Score is the sum of the above six sub-factors.

(No. of persons using surface water for drinking) + ***(Impacted drainage)*** + (***Fishery class***) + (***Recreational use***) + (***Protected area status***) + (***Livestock watering***)

TOTAL SURFACE WATER SCORE

The total Surface Water pathway score is obtained by multiplying the three main factors together:

[Likelihood of Release] X [Hazard (waste characteristics)] X [Receptors]

6. SCORING THE AIR PATHWAY

In this section both the information sources used for the scoring and the scoring for each of the 'Likelihood of Release' and 'Receptor' factors for the air pathway are described. Refer to Worksheet No. 4 in the Solid source workbook.

6.1 Likelihood of Release

The likelihood of release score evaluates two sub-factors:

- Observed release to the air pathway.
- Potential to release.

6.1.1 Observed release to the air pathway

An observed release to the air pathway is defined in three ways:

- Material (dust) observed blowing off the site during any site visit.
- Evidence of wind deposited waste away from the waste source.
- Anecdotal evidence from other investigators, local residences or other reliable sources attributable to the site.

One or more of the constituents in the source must be more than THREE times the background concentration of that constituent.

SCORING

Observed release	Score
YES	300
NO	0

Table 6.1. Scores assigned to the 'observed release to the air pathway' sub-factor.

Information requirements and sources:

The information required for this sub-factor is derived by:

- Observation while on the site visit;
- Discussions with local residents;
- Research carried out by others and recorded in reports and documents;
- Concentrations of constituents in soils in and around the site; and
- The National Soils Database.

6.1.2 Potential to release

The potential to release to the air pathway is evaluated by the criterion:

- Containment of the waste at the site.

The containment of waste with respect to the air pathway is facilitated by the presence of topsoil, vegetative cover or perennially wet cover. The percentage of any of these three is estimated and used as the basis for scoring.

SCORING

Description	% cover	Score
High dust potential	<50% or screening	300
Moderate dust potential	50 – 75%	200
Low dust potential	75 – 95%	100
No dust potential	>95%	10

Table 6.2. Scores assigned to the 'potential to release' sub-factor.

Information requirements and sources:
The information required for this sub-factor is obtained by observation during the site visit.

Potential to Release Score
The potential to release score is given by the ***Containment of the waste at the site*** score.

TOTAL Likelihood of release SCORE

The total score for LIKELIHOOD TO RELEASE is obtained by summing the two sub-factors:

Observed release score + Potential to release score

The score will range from a low 10 of to a high of 600.

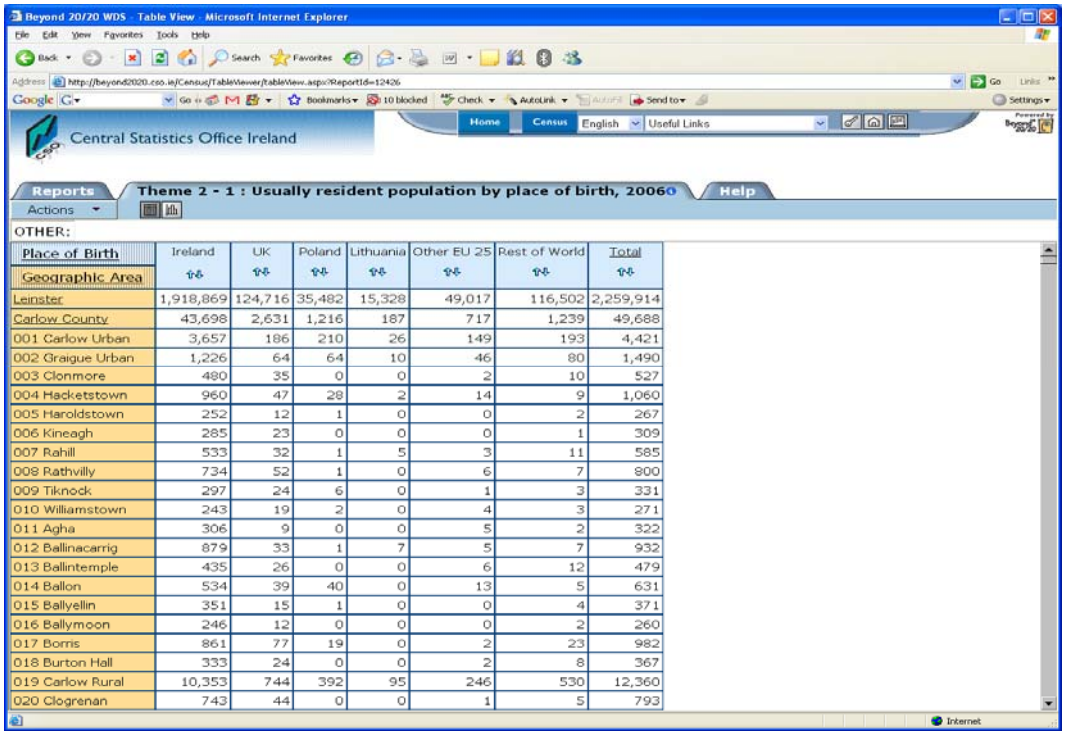
6.2 Receptors

The air pathway receptor sub-factor is evaluated by assessing the following:

- Population within 1km of a waste pile at the site.
- Distance to the nearest residence.
- Sensitive environments.

6.2.1 Population within 1km of the site.

The number of persons within 1km of the site is obtained from the 2006 National Census. The data is obtained from the CSO website (www.cso.ie). The statistics are broken down by nationality and include a total population figure for each Electoral Division area (Figure 6.1).



Place of Birth / Geographic Area	Ireland	UK	Poland	Lithuania	Other EU 25	Rest of World	Total
Leinster	1,918,869	124,716	35,482	15,328	49,017	116,502	2,259,914
Carlow County	43,698	2,631	1,216	187	717	1,239	49,688
001 Carlow Urban	3,657	186	210	26	149	193	4,421
002 Graigue Urban	1,226	64	64	10	46	80	1,490
003 Clonmore	480	35	0	0	2	10	527
004 Hacketstown	960	47	28	2	14	9	1,060
005 Haroldstown	252	12	1	0	0	2	267
006 Kineagh	285	23	0	0	0	1	309
007 Rahill	533	32	1	5	3	11	585
008 Rathvilly	734	52	1	0	6	7	800
009 Tiknock	297	24	6	0	1	3	331
010 Williamstown	243	19	2	0	4	3	271
011 Agha	306	9	0	0	5	2	322
012 Ballinacarrig	879	33	1	7	5	7	932
013 Ballintemple	435	26	0	0	6	12	479
014 Ballon	534	39	40	0	13	5	631
015 Ballyellin	351	15	1	0	0	4	371
016 Ballymoon	246	12	0	0	0	2	260
017 Borris	861	77	19	0	2	23	982
018 Burton Hall	333	24	0	0	2	8	367
019 Carlow Rural	10,353	744	392	95	246	530	12,360
020 Clogrenan	743	44	0	0	1	5	793

Figure 6.1. Screen dump from the CSO website showing the figures used in the 'population within 1km of the site sub-factor'.

SCORING

The National Census reports information on an Electoral Division basis. There are 3409 Electoral Divisions in the country (Appendix 1.3). It is necessary to identify the Electoral Division or Electoral Divisions relevant to the site under consideration. This is achieved through GIS. Obviously a buffer of 1km around a facility will not coincide with an Electoral Division. The area intersected by the 1km buffer should be expressed as a percentage of the total area of the Electoral Division (adjusted area) and this percentage is used to calculate the population within 1km of the site.

Once the population within 1km of the site has been determined the following Table is used to assign the score.

Population range	Score
0	0
1 – 10	1
10 – 30	10
30 – 100	30
100 – 300	100
300 – 1,000	300
1,000 – 3,000	1,000
3,000 – 10,000	3,000
>10,000	10,000

Table 6.3. Scores assigned to the 'population within 1km of the site' sub-factor.

Information requirements and sources:
The population statistics is obtained from the CSO website (www.cso.ie).

6.2.2 Distance to nearest residence
The distance to the nearest residence is measured in metres. It is obtained from the site survey or by assuming the nearest building to the site is a residence on air photographs.

SCORING

Distance (m)	Score
<100	20
100 – 200	15
200 – 300	10
>300 or unknown	5

Table 6.4. Scores assigned to the 'distance to the nearest residence' sub-factor.

Information requirements and sources:
The distance to the nearest residence is obtained during the field survey or from air photographs.

6.2.2 Sensitive environments
Sensitive environments are designated sites, such as:

- Natural Heritage Area (NHA)
- Special Protection Area (SPA)
- Special Area of Conservation (SAC)
- Statutory Nature Reserve
- National Park

SCORING

If any of **Natural Heritage Area** (NHA), **Special Protection Area** (SPA), **Special Area of Conservation** (SAC), **Statutory Nature Reserve** or **National Park** are within 1km of a mine waste site then the following scores should be applied. If more than one area is within the 1km radius then the presence score is multiplied by the number of designated areas present.

Designated area	Score
Present	20
Absent	0

Table 6.5. Scores assigned to the 'sensitive environment' sub-factor.

Information requirements and sources:

These sites are published on the National Parks and Wildlife Service website in GIS format. This is imported to our GIS project and the presence or absence within 1km of a mine waste site of these special areas determined. The NPWS website is www.npws.ie (see Figure 6.2 for a view of the home page).

Figure 6.2. Screen dump of the NPWS home page.

TOTAL Receptor SCORE

The total score for the Air pathway is the sum of the above three:

Population score + ***Distance to nearest residence score*** + ***Sensitive environments score***

TOTAL AIR PATHWAY SCORE

The total Air pathway score is obtained by multiplying the three main factors together:

[Likelihood of Release] X [Hazard (waste characteristics)] X [Receptors]

7. SCORING THE DIRECT CONTACT (WASTE PILES) PATHWAY

In this section both the information sources used for the scoring and the scoring for each of the 'Likelihood of Release' and 'Receptor' factors for the direct contact (waste piles) are described. Refer to Worksheet No. 5 in the Solid sources workbook.

In this section both the information sources used for the scoring and the scoring for each primary factor for the direct contact pathway are described.

7.1 Likelihood of Release

The likelihood of release score evaluates two sub-factors:

- Observed exposure.
- Potential exposure.

7.1.1 Observed exposure

An observed exposure is defined in two ways:

- Residence within 250m of the mine waste.
- Used for recreational purposes – either permitted or not permitted. Examples of recreational activity include quad biking, pony trekking, clay pigeon shooting. These may be direct observation or evidence of such activities taking place, e.g., quad bike tracks.

One or more of the constituents in the source must be more than THREE times the background concentration of that constituent and attributable to the site.

Residence within 250m of a mine waste

Information requirements and sources:

Residences can be observed either on the site visit or through the examination of air photographs.

SCORING

The score for the direct contact pathway is allocated as follows:

Criterion	Score
Residence within 250m of the site	200
No residence within 250m of the site	0

Table 7.1. Score assigned to 'residence within 250m of the site' sub-factor.

Used for recreational purposes

Information requirements and sources:

Whether the site is used for recreational use or not may be observed while on the site or through the observation of on-site evidence for such activities.

Criterion	Score
Used for recreational use	200
Not used for recreational use	0

Table 7.2. Score assigned to 'used for recreational use' sub-factor.

Observed Exposure Score

The Observed Exposure score is the sum of Residence within 250m of a mine waste and Used for recreational purposes sub-factors.

Residence within 250m of a mine waste score + Used for recreational purposes

7.1.2 Potential exposure

This is assessed by determining the accessibility of the mine waste site and the distance to the nearest residence.

Accessibility is evaluated with respect to fencing, signs and other physical barriers or deterrents present at the site which restrict access to the site. These access restrictions must be intact and partially effective at limiting access to people.

Site accessibility is scored by evaluating both, the type of access restrictions employed and the condition /maintenance of the access restrictions.

Access restrictions

The type of access restrictions are scored as in Table 7.3.

SCORING

Access restrictions	Score
Easily accessible (no fences, gates or signs)	20
Moderately accessible (barbed wire fences, road gated, signage)	10
Difficult access (chain link fence, road gated and locked)	5
Not accessible (site completely fenced, access road gated and locked, on site security within 250m of the waste pile)	1

Table 7.3. Scores assigned to the type of access restrictions employed at a site.

Information requirements and sources:

Site observation is required to evaluate this accessibility.

Maintenance of the site restrictions

The condition of the fencing and other restriction are scored according to Table 7.4.

SCORING

Condition of restrictions	Score
Well maintained, no breaches	0.1
Small animals can access with ease. Humans and animals can access with difficulty. Vehicles cannot gain entry. Less than three breaches.	0.7
Small animals, human and livestock can access with ease. Vehicles* can enter. Less than five breaches.	1.0
Small animals, human and livestock can access with ease. Vehicles* can enter. More than five breaches.	2.0

Table 7.4. Scores assigned to the 'condition of restrictions' sub-factor.
*** A vehicle can be a motor cycle, quad bike or car.**

Information requirements and sources:
Site observation is required to evaluate maintenance of the site restrictions.

Distance to the nearest residence
The distance to the nearest residence is measured in metres. It is obtained from the site survey or by assuming the nearest building to the site is a residence on air photographs.

SCORING

Distance (m)	Score
<500	20
500 – 1,000	10
>1,000	5

Table 7.5. Scores assigned to the 'distance to the nearest residence' sub-factor.

Information requirements and sources:
The distance to the nearest residence is obtained during the field survey or from air photographs.

Potential Exposure Score

The score for the Potential Exposure factor is the product of the site restrictions score, the condition of the site restrictions score and the distance to the nearest residence score.

Site restrictions score* X *condition of the site restrictions score* X *distance to the nearest residence score.

TOTAL Likelihood of release SCORE

The total score for LIKELIHOOD TO RELEASE is obtained by summing the two sub-factors Observed exposure + Potential Exposure:

Observed exposure* + *Potential Exposure

The score will range from a low of 0.5 to a high of 1,200.

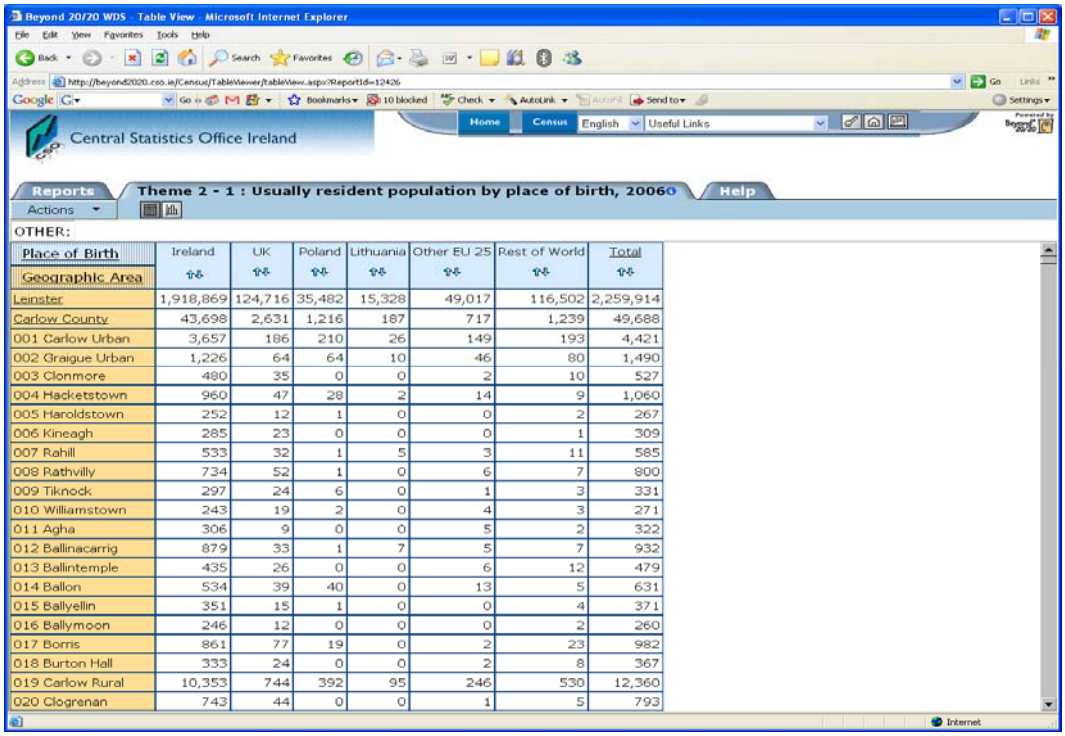
7.2 Receptors

The direct contact pathway receptor sub-factor is evaluated by assessing the following:

- Population within 2km of a waste pile at the site.
- Distance to the nearest residence.
- On site workers.
- Attractiveness of the site for recreational use.

7.2.1 Population within 2km

The number of persons within 2km of the site is obtained from the 2006 National Census. The data is obtained from the CSO website (www.cso.ie). The statistics are broken down by nationality and include a total population figure for each Electoral Division area (Figure 7.1).



Place of Birth / Geographic Area	Ireland	UK	Poland	Lithuania	Other EU 25	Rest of World	Total
Leinster	1,918,869	124,716	35,482	15,328	49,017	116,502	2,259,914
Carlow County	43,698	2,631	1,216	187	717	1,239	49,688
001 Carlow Urban	3,657	186	210	26	149	193	4,421
002 Graigue Urban	1,226	64	64	10	46	80	1,490
003 Clonmore	480	35	0	0	2	10	527
004 Hacketstown	960	47	28	2	14	9	1,060
005 Haroldstown	252	12	1	0	0	2	267
006 Kineagh	285	23	0	0	0	1	309
007 Rahill	533	32	1	5	3	11	585
008 Rathvilly	734	52	1	0	6	7	800
009 Tiknock	297	24	6	0	1	3	331
010 Williamstown	243	19	2	0	4	3	271
011 Agha	306	9	0	0	5	2	322
012 Ballinacarrig	879	33	1	7	5	7	932
013 Ballintemple	435	26	0	0	6	12	479
014 Ballon	534	39	40	0	13	5	631
015 Ballyellin	351	15	1	0	0	4	371
016 Ballymoon	246	12	0	0	0	2	260
017 Borris	861	77	19	0	2	23	982
018 Burton Hall	333	24	0	0	2	8	367
019 Carlow Rural	10,353	744	392	95	246	530	12,360
020 Clogrenan	743	44	0	0	1	5	793

Figure 7.1. Screen dump of page from the CSO website showing population statistics.

SCORING

The National Census reports information on an Electoral Division basis. There are 3409 Electoral Divisions in the country (Appendix 1.3). It is necessary to identify the Electoral Division or Electoral Divisions relevant to the site under consideration. This is achieved through GIS. Obviously a buffer of 2km around a facility will not coincide with an Electoral Division. The area intersected by the 2km buffer should be expressed as a percentage of the total area of the Electoral Division (adjusted area) and this percentage is used to calculate the population within 2km of the site

Population range	Score
0	0
1 – 10	1
10 – 30	10
30 – 100	30
100 – 300	100
300 – 1,000	300
1,000 – 3,000	1,000
3,000 – 10,000	3,000
>10,000	10,000

Table 7.6. Scores assigned for the 'population within 2km of the site' sub-factor.

Information requirements and sources:
The number of wells is obtained from the CSO website (www.cso.ie).

7.2.2 Distance to nearest residence
The distance to the nearest residence is measured in metres. It is obtained from the site survey or by assuming the nearest building to the site is a residence as displayed on air photographs.

SCORING

Distance (m)	Score
<500	10
500 – 1,000	5
>1,000 or unknown	0

Table 7.7. Scores assigned to the 'distance to the nearest residence' sub-factor.

Information requirements and sources:
The distance to the nearest residence is obtained during the field survey or from air photographs.

7.2.3 On-site workers
At a number of sites post mining activities were taking place. This involved workers being in contact with the waste piles to a greater or lesser extent depending on the nature of the post mining activity.

SCORING

On-site workers	Score
Predominantly working outside	200
Farmers	100
Predominantly working inside	50
No workers	0

Table 7.8. Scores assigned to the 'on-site workers' sub-factor.

Information requirements and sources:
The information required to score on-site workers is made by direct observation during the site visit.

7.2.4 Attractiveness of the site for recreational use

Recreational use is evaluated to take into account those people who live outside the 2km radius. Some sites may be more attractive than others for such use and may be influenced by criteria such as:

- Proximity to heavily populated areas.
- Proximity to roads.
- Uncommon feature attracting visitors to the site.
- Proximity to other attractions.
- Evidence of the use of the site for recreational use.
- Mining heritage.

SCORING

The attractiveness of the site for recreational use is scored as in Table 7.9.

Observation	Score
Highly attractive for recreational use	100
Moderately attractive for recreational use	50
Low attractiveness for recreational use	25
Not attractive for recreational use	0

Table 7.9. Scores assigned to the 'attractiveness of the site for recreational use' sub-factor.

TOTAL Receptor SCORE

The total score for RECEPTOR is the sum of the four sub-factors – Population score, Distance to the nearest residence score, On-site workers score and Attractiveness of the site for recreational use score.

Population score + ***Distance to the nearest residence score*** + ***On-site workers score*** + ***Attractiveness of the site for recreational use score***

TOTAL DIRECT CONTACT PATHWAY (waste piles) SCORE

The total **DIRECT CONTACT** (Waste Pile) pathway score is obtained by multiplying the three main factors together:

[Likelihood of Release] X [Hazard (waste characteristics)] X [Receptors]

8. SCORING THE DIRECT CONTACT (STREAM SEDIMENTS) PATHWAY

In this section both the information sources used for the scoring and the scoring for each of the 'Likelihood of Release' and 'Receptor' factors for the direct contact (stream sediments) are described. Refer to Worksheet No. 2 in the Stream Sediments score workbook.

8.1 Likelihood of Release

The likelihood of release score evaluates a single sub-factor:

- Observed exposure.

8.1.1 Observed exposure

One or more of the constituents in the stream sediments must be at a concentration level that is more than THREE times the upstream concentration levels and that the constituent is attributable to the site. It is assumed that livestock will have access to any length of stream section.

An observed exposure is defined as:

- A farm within 250m of the stream or drainage section.

Information requirements and sources:

Farms can be observed either on the site visit or through the examination of air photographs.

SCORING

Criterion	Score
Farm within 250m of the stream or drainage	200
No farm within 250m of the stream or drainage	0

Table 8.1. Score assigned to 'residence within 250m of the site' sub-factor.

TOTAL Likelihood of release SCORE

The total score for LIKELIHOOD TO RELEASE is obtained from the Observed Exposure score.

Observed exposure score

The score will range from a low 0 of to a high of 200.

8.2 Receptors

The direct contact (stream sediments) pathway receptor sub-factor is evaluated by assessing:

- Livestock accessing the stream.

When livestock access a stream for watering they will, more than likely ingest some of the bottom sediment. Evidence therefore for cattle using any particular stream can be by direct observation or through indirect evidence such as hoof prints in the stream.

SCORING

Livestock using stream for watering	Score
Livestock observed in stream or other signs, e.g., hoof marks	200
Unknown	100

Table 8.2. Scores assigned to the 'livestock using stream for watering' sub-factor.

Information requirements and sources:
Evidence for assessing whether livestock use a stream for watering is obtained during the field survey or from air photographs.

TOTAL Receptor SCORE

The total score for RECEPTOR is the Livestock using stream for watering score.

Livestock using stream for watering score

TOTAL DIRECT CONTACT PATHWAY (stream sediments) SCORE

The total **DIRECT CONTACT** (Stream Sediments) pathway score is obtained by multiplying the three main factors together:

[Likelihood of Release] X [Hazard (waste characteristics)] X [Receptors]

9. TOTAL SITE SCORE FOR HUMAN AND ANIMAL HEALTH

9.1 Total Waste Score

The total waste score for each waste or contamination type (solid waste, liquid waste and stream sediment contamination) is determined as described in the following sub-sections.

9.1.1 Solid Waste

The total score for solid waste is obtained by summing the total for each of the relevant pathways – Groundwater, Surface water, Air and Direct Contact (waste piles) pathways and dividing by 100,000. The subscript **sw** indicates a solid waste score.

(**GROUNDWATER**$_{sw}$ Score + **SURFACE WATER**$_{sw}$ Score + **AIR PATHWAY**$_{sw}$ Score + **DIRECT CONTACT (Waste Piles)**$_{sw}$ Score) / 100,000

9.1.2 Liquid Waste

The total score for liquid waste is the summation of the Groundwater pathway score and Surface water pathway score. This total is then divided by 100,000 to give the total Liquid waste score. The subscript **lw** indicates a liquid waste score.

(**GROUNDWATER**$_{lw}$ Score + **SURFACE WATER**$_{lw}$ Score) / 100,000

9.1.3 Stream Sediments

The total stream sediments score is the total of Direct Contact (Stream sediment) pathway divided by 100,000. The subscript **ss** indicates stream sediment contamination.

(**DIRECT CONTACT (Stream Sediments)**$_{ss}$ Score) / 100,000

9.2 Final Mine Site Score

The final score for a mine site is the sum of all the individual waste scores, i.e., for all waste piles, mine discharges and stream sediments.

FINAL Mine Site Score

Total **Solid** Waste score + Total **Liquid** Waste score + Total **Stream Sediments** score

9.3 Classification

All sites are then classified as follows:

Class	Score	Description	Response
I	>2,000	Relates to large complex sites which have a number of issues, the sites contain large volumes of metal-rich waste that potentially pose risks to human and animal health and safety as well as the environment.	These sites should have a full risk assessment carried out. These sites should be monitored on an ongoing basis.
II	1,000 – 2,000	A district consisting of several sites, containing numerous small spoil piles with high concentrations of metals and are visited regularly by the public. Accordingly these sites potentially pose risks to human and animal health and safety as well as the environment.	These sites require general monitoring of most or all waste piles, discharges or stream sediments on an annual basis.
III	300 – 1,000	Sites containing fewer and smaller spoil piles which have high concentrations of metals. The sites are used by the public and potentially pose risks to human and animal health and safety as well as to the environment.	These sites require general monitoring of most or all waste piles, discharges or stream sediments on a biennial basis.
IV	100 – 300	Sites which generally have large volumes of waste with low concentrations of those metals that potentially pose risks to human and animal health and safety as well as to the environment. Any high metal spoil piles are very small in volume.	These sites require specific monitoring of particular waste piles, discharges or stream sediments on a five-yearly basis.
V	<100	These sites pose little threat to humans, animals or the environment**,** although there may be minor site specific issues which need to be addressed	These site generally do not require monitoring except where there are minor specific issues.

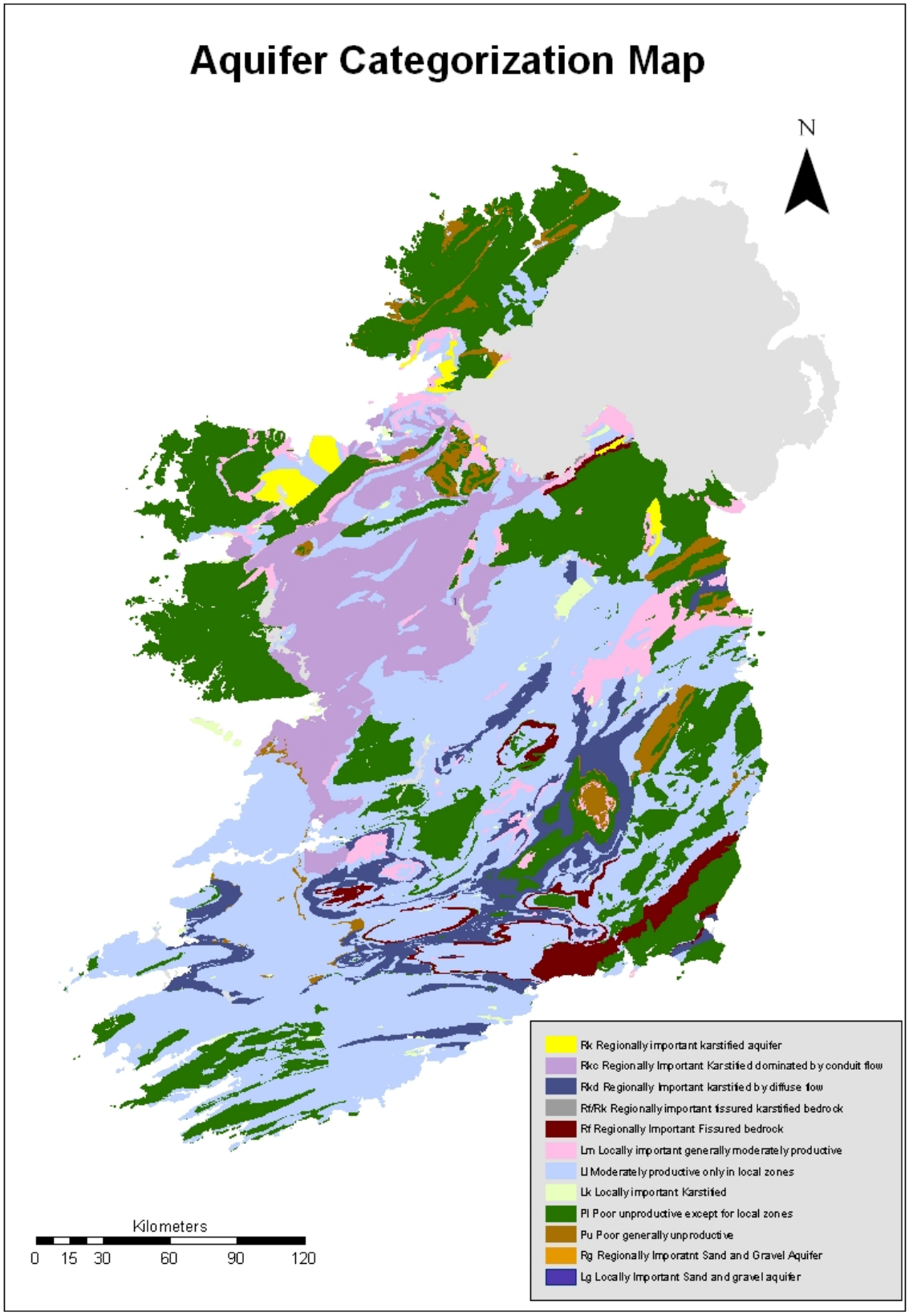
APPENDIX 1.1

Water standards used for the HMS-IRC project.

Parameter	Unit	Standard	Source
pH		≥ 6.5–≤ 9.5	SI 278 (2007)
EC	mS/cm	≤ 2.5	SI 278 (2007)
Al	µg/l	200	SI 278 (2007)
As	µg/l	25	Draft EC (2008)
Cd	µg/l	0.25	Draft EC (2008)
Cr	µg/l	50	SI 278 (2007)
Cr III	µg/l	4.7	Draft EC (2008)
Cr IV	µg/l	3.4	Draft EC (2008)
Cu [hardness < 100 mg/l $CaCO_3$]	µg/l	5	Draft EC (2008)
Cu [hardness > 100 mg/l $CaCO_3$]	µg/l	30	Draft EC (2008)
Hg	µg/l	0.05	Draft EC (2008)
Fe	µg/l	200	SI 278 (2007)
Mn	µg/l	50	SI 278 (2007)
Na	µg/l	200,000	SI 278 (2007)
Ni	µg/l	20	Draft EC (2008)
Pb	µg/l	7.2	Draft EC (2008)
Sb	µg/l	5	SI 278 (2007)
Se	µg/l	10	SI 278 (2007)
SO_4	µg/l	250,000	SI 278 (2007)
Zn [hardness < 10 mg/l $CaCO_3$]	µg/l	8	Draft EC (2008)
Zn [hardness 10-100 mg/l $CaCO_3$]	µg/l	50	Draft EC (2008)
Zn [hardness > 100 mg/l $CaCO_3$]	µg/l	100	Draft EC (2008)

APPENDIX 1.2

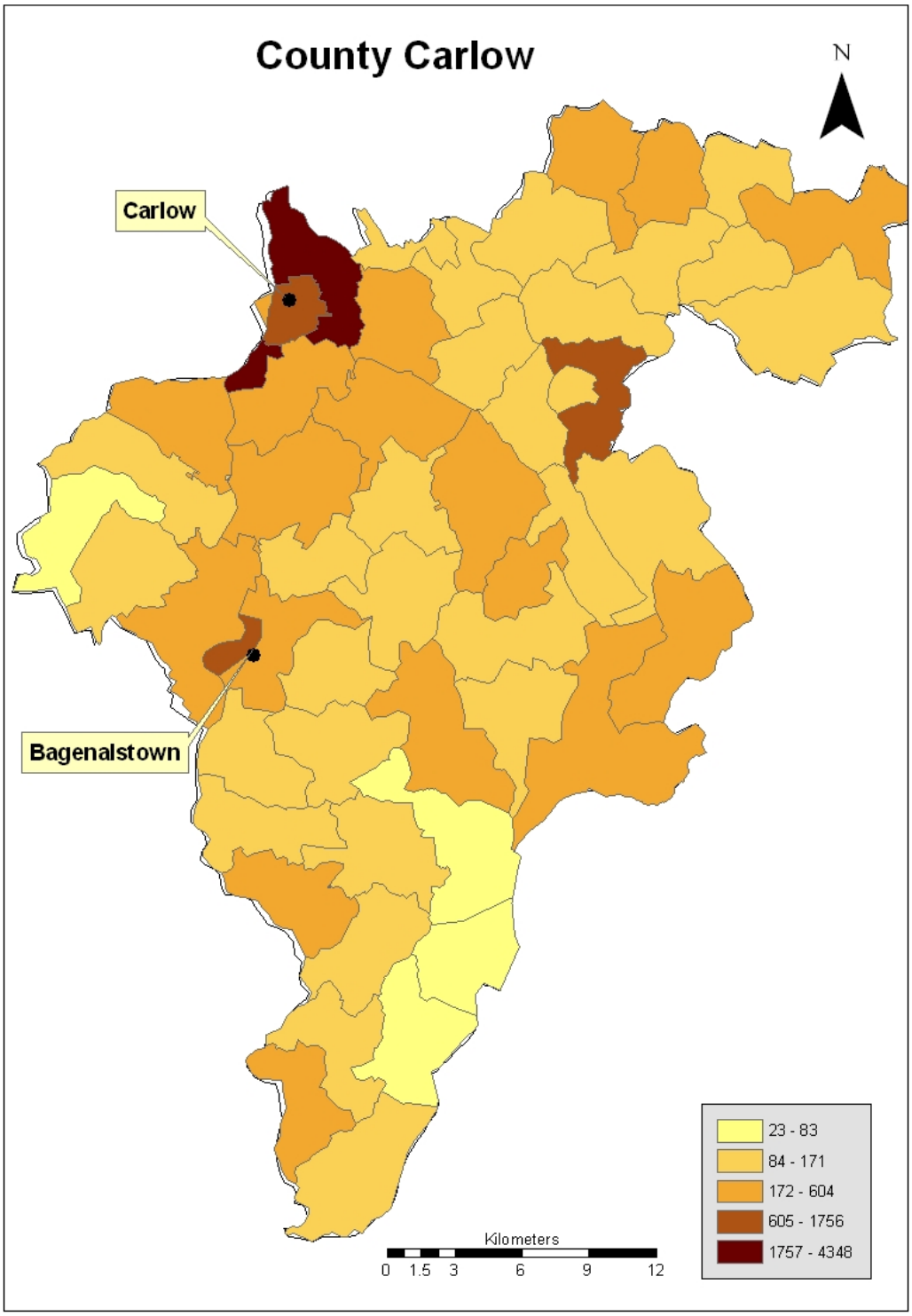
Aquifer Categorization
(Water Framework Directive)



APPENDIX 1.3

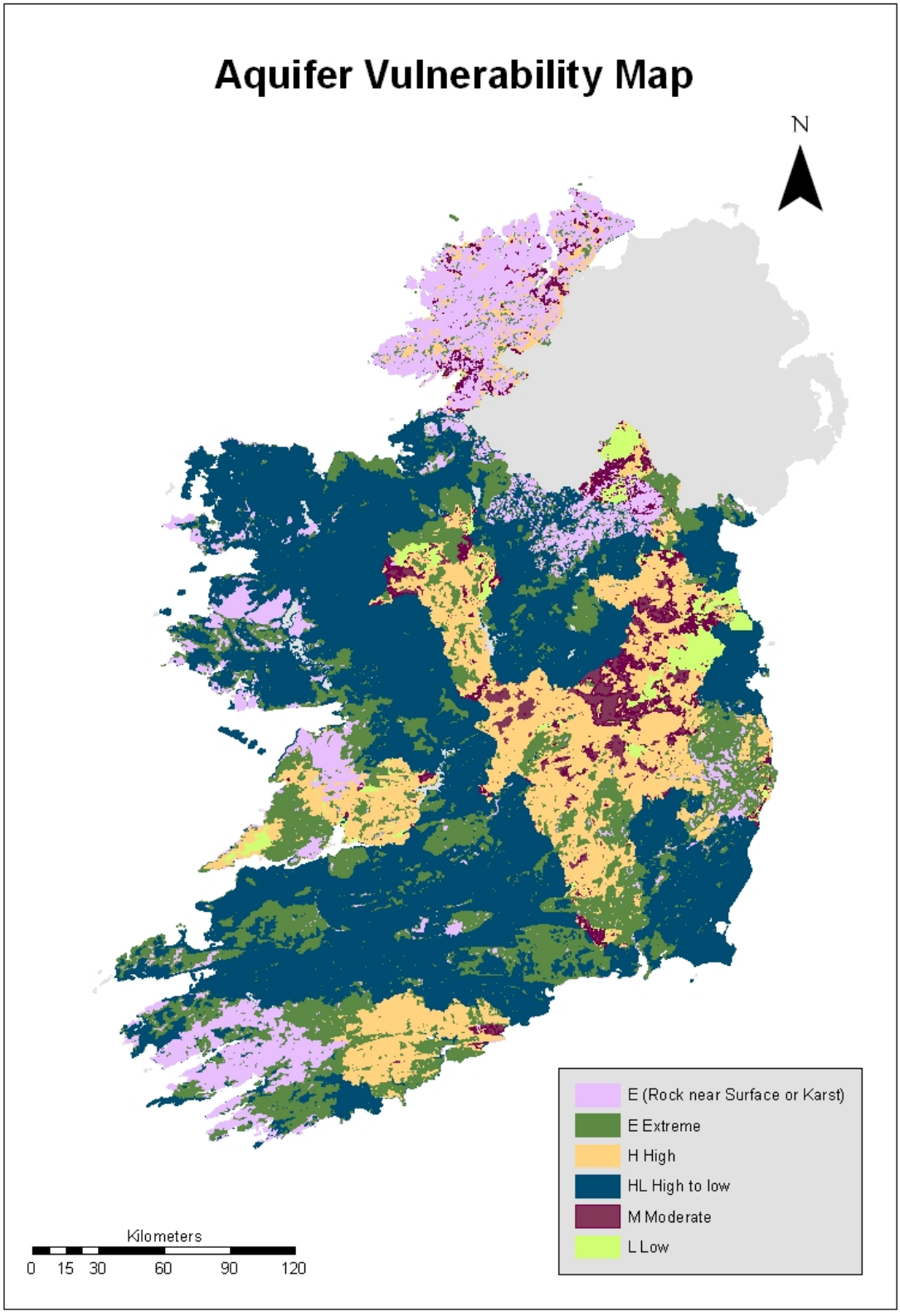
District Electoral Divisions

There are 3409 DED in the 26 counties in Ireland. The map below displays County Carlow. This contains 54 different DED within its area of 90,018ha.



APPENDIX 1.4

Groundwater vulnerability map
(Water Framework Directive)



APPENDIX 1.5

Soils Geochemical Atlas of Ireland

The National Soils Database was used as a guideline to natural background levels present in soils in Ireland. **The Soils Geochemical Atlas of Ireland**, Fay *et al.*, (**2007**) provided a baseline of soil geochemistry. It was used as a point of reference for both stream sediments and direct contact (waste piles). Mine waste, obviously does contain higher and more localised concentrations of elements attributed to the specific mine conditions. The atlas is good statistical indication of the distribution of elements around Ireland. The atlas is available from the EPA website (http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=105). Below is an example of krigged Cu data. Krigging is an interpolation technique used to estimate value at regular intervals from originally more widely spaced data.