Information on Land Quality in Scotland:

Sources of Information (including background contaminants)

R&D Technical Report P293

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Publishing Organisation:
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BRISTOL, BS32 4UD.

Tel : 01454 624400 Fax : 01454 624409
Website: www.environment-agency.gov.uk

ISBN: 1 85705 125 4

Dissemination Status:
Internal: Released to Regions
External: Released to public domain

Statement of Use:
This report identifies and summarises sources of information relating to land contamination in Scotland. The report is intended for use by regulators and other practitioners involved in the assessment and management of land quality issues.

Key Words
Information, land quality, background concentrations, natural contamination, anthropogenic, Scotland.

Research Contractors:
This document was produced under R&D project P5-019 by:

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Environment Agency R&D Dissemination Centre, c/o
WRc, Frankland Road, Swindon, Wilts SN5 8YF

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OVERVIEW

This report is the outcome of Environment Agency Research Project P5-019, 'Information on Land Quality in the UK'. The report has been produced in four volumes which collectively cover i) sources of information on land contamination and ii) data that may be used to interpret background contaminant concentrations in the UK - see Table i.

Table i List of report numbers for project P5-019

Title	Number
Information on Land Quality in England including background levels of Organic and Inorganic Contaminants	P291
Information on Land Quality in Wales including background levels of Organic and Inorganic Contaminants	P292
Information on Land Quality in Scotland including background levels of Organic and Inorganic Contaminants	**P293**
Information on Land Quality in Northern Ireland including background levels of Organic and Inorganic Contaminants	P294

The work was carried out by BGS and LGC. The principal contributors to the study were Dr Barry Smith, Dr Barry Rawlins, Mr Alex Ferguson, Dr Michael Hutchins, Ms Fiona Fordyce (BGS), Mr Jim Finnamore and Mr David Barr (LGC).

We are grateful for the help, information and support provided by the individuals and organisations who have contributed information for incorporation into this report.

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GLOSSARY

Background concentrations / levels	*'the concentration (or level) of a substance characteristic of a soil type in an area or region arising from both natural sources and non-natural diffuse sources such as atmospheric deposition*. (after ISO 11074-1:1996)
Brownfield sites	'*any land that has previously been developed'*
Contaminated land	*'land that contains substances that when present in sufficient quantities or concentrations are likely to cause harm directly or indirectly, to man, to the environment, or on occasions to other targets'* (NATO CCMS). Note this definition differs from that used in Part IIA of the Environmental Protection Act, 1990 which defines contaminated land as *"any land which appears to the local authority in whose area it is situated to be in such condition, by reason of substances in, on or under the land that: significant harm is being caused or there is a significant possibility of such harm being caused, or pollution of controlled waters is being, or is likely to be, caused."* (section 78A(2) Part IIA Environmental Protection Act 1990).
Derelict land	*'land so damaged by industrial or other development that it is incapable of beneficial use without treatment'* (Wickens et al., 1993)
Harm	*harm to health of living organisms or other interfaces with ecological systems of which they form part. In the case of humans includes harm to property:* Note harm is not just a matter of exceeding action or trigger levels, but is that determined by a structured source-pathway-receptor analysis and the effects on a given receptor (i.e. not just exposure)
ICRCL	*Interdepartmental Committee for the Redevelopment of Contaminated Land*
Land	*'any ground, soil or earth, houses or other buildings,.....'* (House of Commons, 1990).
Land contamination	*'the presence of a substance or component that is not present naturally that does not necessarily cause harm'* (ISO 11074-1:1996) Note, virtually all substances occur naturally occasionally at concentrations far exceeding those encountered at point sources of anthropogenic pollution such as land fills. This implies that the concept of contamination is dependent upon both the concentration and physio-chemical form of a given substance. Due to this duality Land Contamination in the context of this report has been taken to include both naturally occurring and anthropogenicaly derived contaminants.

Natural background concentrations / level	*'the concentration or level of a substance that is derived solely from natural sources (i.e. of geogenic origin)'* (after ISO 11074-1:1996)
Pollutant	*'a substance or agent present in the soil which due to its properties, amount or concentration causes adverse impacts on (i.e. harm to) soil functions or soil use'* (ISO 11074-1:1996)
Regolith	*'Layer of unconsolidated, weathered material, mineral grains and all other superficial deposits, that rests on unaltered, solid bedrock'*
Risk quotient	*Factor linking exposure to a potentially negative outcome or event*
Soil	*'the upper layer of the earth's crust composed of mineral parts, organic substance, water, air and living matter'* (ISO11074-1:1996)
Soil functions	*'soil functions describe the significance of soils to man and the environment* (ISO 11074-1:1996*).* *Important soil functions include:* • *control of substance and energy cycles as compartment of ecosystems* • *basis for the life of plants, animals and man* • *carrier of genetic reservoir* • *basis for the stability of buildings* • *basis for the production of agricultural products* • *buffer inhibiting movement of water, contaminants or other agents into groundwater* • *reservoir of archaeological remains* • *reservoir of paleoecological remains'*
Soil quality	*'all current positive or negative properties with regard to soil utilization and soil functions'* (ISO11074-1:1996)

ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
BNFL	Formerly British Nuclear Fuels Ltd.
Bsi	British Standards Institute
DEFRA	Department of the Environment, Food, and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DoE	Department of the Environment (now incorporated into DETR)
DoE (NI)	Department of the Environment (Northern Ireland)
EA	Environment Agency
GC/HRMS	Gas Chromatography / High Resolution Mass Spectrometry
GCMS	Gas Chromatography Mass Spectrometry
GIS	Geographical Information System
HMIP	Her Majesty's Inspectorate of Pollution (now incorporated into the Environment Agency)
HpCDD	Heptachlorodibenzo-p-dioxin
ICP-AES	Inductively Coupled Plasma- Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma – Mass Spectrometry
ICRCL	Interdepartmental Committee on the Redevelopment of Contaminated Land
ISO	International Standards Organisation
ITE	Institute of Terrestrial Ecology
MAFF	Ministry of Agriculture Fisheries and Food
NAB	National Average Background
NERC	Natural Environment Research Council
OS	Ordnance Survey
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenol
PCDD	Polychlorinated-p-dibenzodioxin
PCDF	Polychlorinated dibenzofuran
PeCDD	Pentachlorodibenzo-p-dioxin
PHES	Potentially Harmful Elements and Species
QA	Quality Assurance
QC	Quality Control
SEPA	Scottish Environment Protection Agency
SSSI	Site of Special Scientific Interest
TCDD	Tetrachlorodibenzo-p-dioxin
TEQ	Toxic Equivalent
WWW	World-Wide Web
XRF	X-Ray Fluorescence

Throughout this report, chemical elements are referred to using standard one or two letter abbreviations e.g. S Sulphur, and Cd Cadmium.

EXECUTIVE SUMMARY

This report presents an overview of information on land quality in Scotland, carried out for the Environment Agency who are required, together with the Scottish Environment Protection Agency, under the Environment Act (1995), to form an opinion on the state of pollution of the environment. The main objective of the study was to review existing knowledge on background levels of contaminants in Scottish soils (Environment Agency R&D reports P291, P292 & P294 review levels of contaminants in England, Wales and Northern Ireland respectively). This involved prior consideration of concepts and definitions regarding background levels. The various factors that control the variability in background levels at a range of scales from site-specific studies to national surveys were reviewed. The research was undertaken by extensive literature review and through consultation with Agency staff and external organisations, in order to identify a wide range of land quality information, including soil survey data, environmental monitoring data, research studies, and land use information. Particular emphasis was placed on identifying data sets representative of land quality at regional to national scales, rather than collating site-specific and local scale information.

A wide range of indicators may be used to provide a measure of land quality, reflecting its ability to sustain both natural and economic functions. A direct index of land quality may be obtained by measuring the physical, chemical and biological properties of soil, including the presence of contaminants. There is no assumption that harm will occur as a result of the presence of any contaminants, simply that they may affect the quality of the land. The range of media considered in this study was necessarily broad, and included soils of human and natural origin, river, stream, and estuarine sediments, as well as all forms of made or infilled ground.

From the findings of the study, it is apparent that the principal reasons for monitoring background levels land quality are (i) legislative pressures including future moves towards risk assessment and the impact of pollution on human and ecological health; and (ii) the requirement for sustainable practices in terms of urban development, mineral exploration, agricultural performance and waste disposal. The study identified the spatial extent of coverage on land quality data, identifying key organisations holding data sets of a substantial nature. Data indicating temporal trends were also identified. During the course of the study, data were categorised depending on whether they provided direct information on land quality (e.g. soil data for potentially harmful substances such as heavy metals or polyaromatic hydrocarbons) or indirect evidence (e.g. major element soil chemistry, stream sediment chemistry). The spatial resolution of direct land quality information on a national scale was given particular attention, the study illustrating that soils information is at a lower spatial resolution than many indirect indicators of land quality. It has been revealed through the study that a variety of methods have been employed to estimate background levels and the upper limit of background concentrations. Individual studies have typically used criteria such as “2.5 times the mean value” or identified breaks in cumulative frequency curves to define such thresholds. The study also identified the nature of data availability from individual data holders together with costing information.

In the review, specific attention was focused on urban land, which has often been characterised at a higher resolution than elsewhere. The potential for use of contextual descriptive information in defining land quality and the variation in background levels is particularly high in urban environments. Contextual descriptive data, for example in the form of land classification, provides valuable additional information in both urban and rural

environments and has been identified on a nationwide basis in the study. Historically, much reliance has been placed on land classifications, which provide a qualitative measure of the potential for beneficial use of the land. It should be stressed that in this study, land classification information has been used primarily to provide corroborative information in the context of data sets that give actual levels of contaminants.

Results indicate a number of knowledge gaps in our current understanding and assessment of background levels and land quality information, which need to be addressed in order to prioritise research needs and formulate national policies. In general, existing data sets for inorganic substances (including radionuclides) are much more extensive and of a higher resolution that those for potential organic contaminants and contextual soil properties affecting the mobility and toxicity of contaminants. Data indicating the presence of pathogens in soils is extremely limited. Despite the scarcity of data in some important areas of land quality, the major factors limiting the integration and full exploitation of existing data relating to the derivation of land quality are (i) the development and accessibility of integrated GIS data sets, and (ii) the inter-comparability of existing data sets.

1 INTRODUCTION

1.1 Background

Land is an important resource which fulfils a number of essential functions including: providing a reserve of potable water and raw materials; acting as a support medium for plant growth and a protective filter for groundwater resources; providing a structural base on which to build; and maintaining habitats and biodiversity. Land quality reflects the capacity to maintain these functions, which in turn depends on the complex chemical, biological and physical properties and interactions of the key constituents of land i.e. soil, water, air and biota.

Unlike air and water, the importance of soil quality has often been overlooked, possibly because indicators of poor soil quality are not as visually obvious. Similarly, deterioration in soil quality often occurs gradually, creating difficulty in detecting changes even over long periods of time.

Soil quality and the causes of reduction in quality may be considered under three broad headings, Pierzynski et al. (1994).

- Reduction in soil quality owing to unacceptable concentrations of contaminants.
- Reduction in soil quality that limits its function.
- Soil as a source of contaminants leading to, for example, leaching of solute.

Contaminants may be chemical, biological, radiological or physical. Natural contaminant concentrations vary widely across many geological units and formations, due to the presence of both primary and secondary mineralisation. Industrial and agricultural activities, particularly over the past 150 years, have added an increasingly diverse range of anthropogenic contaminants to the environment. This has resulted the elevation of background concentrations above natural background concentrations. The extent of land contamination may be relatively localised in the case of point sources, or more widespread where diffuse contaminant releases, such as application of pesticides, have occurred. Human activities have also dispersed contaminants at national and global scale through atmospheric deposition. Therefore, many background measurements are not necessarily truly representative of natural background conditions.

Pressures on soil, as a constituent of land, have intensified, not only from contamination, but also from a variety of land use practices, such as urban expansion, mineral extraction, waste disposal and intensification of agricultural production. It is now widely recognised that soil is a limited resource, which is readily damaged. This has led to concerns about sustainable use of the land, and the potential impacts of contamination on soil functions and soil biodiversity.

The 19th report of the Royal Commission on Environmental Pollution entitled 'Sustainable Use of Soil' (Royal Commission on Environmental Pollution, 1996) recommended the design and implementation of a soil protection strategy. The Government responded by indicating their intention to formulate a national strategy for soil protection (DoE, 1997). A key step in designing such a strategy will be to establish indicators of land quality, and to monitor the changes in these indicators at local, regional and national scales.

1.2 Purpose

This research project P5-019 is designed to identify and summarise potential sources of land quality information and sources of information that may be used to define background levels of substances of contaminants.

The specific objectives of the project are:

- to review existing knowledge on the nature and extent of land contamination in a wide range of urban and rural environments in England, Wales, Scotland and Northern Ireland; and
- to review existing knowledge on background contaminant concentrations in England, Wales, Scotland and Northern Ireland.

The purpose of this volume of the report is to provide a summary of information on land contamination in Scotland. The nature of contamination considered in this review comprises:

- Background levels of chemical and radiological contaminants derived naturally or via atmospheric deposition from anthropogenic sources;
- Enhanced levels of chemical and radiological contaminants present as a result of natural or anthropogenic processes;
- Pathogens and munitions;
- Saline soils resulting from natural and anthropogenic processes;
- Made ground and mine shafts; and
- Closed or active landfill sites.

Certain chemical parameters, such as pH, organic matter and phosphorous content, which may influence the hazardous properties of soil or soil function, are also considered in the study.

2 APPROACH AND METHODOLOGY

2.1 Rationale

2.1.1 Sources of Information

The determination of natural background levels forms an integral component of contaminated site investigation protocols. However, such data is site specific, and it is, therefore, difficult to consider their relevance at a regional and national scale, as is required in support of many national and international policies structured to ensure environmental sustainability. Land quality information is relevant to a wide range of organisations, affecting policy decisions, strategic planning issues as well as research and business programmes. In order to identify published and unpublished information which may be available to the Agency, a large number of organisations and individuals were, consulted during this project, including officers within SEPA, the Environment Agency and DoE (NI), local and central government departments, research institutions, professional bodies, consultants and landowners.

An important aspect of this research has been to indicate those data sets that may be available for further assessment. In order to facilitate access to the information, contact details were compiled, where available, of those individuals responsible for the maintenance of each data set.

Many land quality data sets include information considered to be commercially sensitive, and maybe confidential. The extent of information available may, therefore, be limited to some degree. Access restrictions were assessed along with indicative costs of obtaining the information.

2.1.2 Information Criteria

Determinands

Land contamination manifests itself in a wide range of physical, chemical or biological forms. There is no assumption that harm results from the presence of a contaminant, simply that it may affect the quality of the land. Therefore, in order to provide a comprehensive assessment of land quality, a wide range of hazardous and non-hazardous contaminants were included in the review, including those listed below:

- Chemical contaminants;
  - organics
  - inorganics
  - munitions
  - salinity
- Pathogens;
- Radiochemicals; and
- Physical contaminants, including made ground and mine workings

Certain soil chemical parameters, such as pH, organic matter and phosphorous content, are of prime importance in controlling the mobility of contaminants, which in turn may influence the hazardous properties of soil. Information on the distribution of these parameters was also

included in the review to provide an indication of the relative mobility of contaminants at regional and national scales.

Within the context of this study, background contamination relates to the presence of naturally occurring substances, as well as those derived from human activities via atmospheric deposition. The following chemical contaminants were included in this review.

- organics
- inorganics, including radiochemicals.

Media

As discussed in Section 1, the physical, chemical and biological properties of soil may be measured to provide a direct index of land quality. The chemical composition of soil may be measured to provide a direct estimate of background concentrations of a given contaminant and the physiochemical environment that controls contaminant mobility and toxicity. The regolith is also a dynamic system, with a continuous flux of soil matrix and pore fluid occurring both within and between each identifiable unit. Measurements made down hydraulic gradient, or in translocated sediments, may provide an indirect estimate of soil quality. Therefore, the nature of media considered in this review included soils of human and natural origin, river, stream, and estuarine sediments, as well as all forms of made or infilled ground.

Information relating solely to groundwater or surface water quality was not considered within this review, unless it could be specifically correlated to land quality.

Land quality is reported in terms of its ability to sustain both natural and economic beneficial uses. It is commonly reported in terms of land classifications, such as 'brownfield land' and 'derelict land', which provide a qualitative assessment of the condition of the land, and an indication of its ability to support beneficial uses. Certain land use data sets were, therefore, included in the review.

An important function of soil is to provide a basis for the production of crops and livestock. The quality of agricultural land is often reported as a grade, which reflects its crop yield potential. Although the classifications are ultimately determined by the physical, biological and chemical properties of the soil, they indicate only the potential impact of soil quality, rather than the actual nature of any contamination. Information on agricultural land classification schemes was, therefore, not included in this review.

Spatial and temporal information

The spatial extent, resolution, and temporal aspects of land quality data are important features of each data holding. At a simple level, spatial information defines the location and geographical extent of land quality data. Depending on the objectives of a study, spatial extents and resolutions may range from high resolution, site-specific studies to regional and national surveys, typically conducted at lower resolutions. Increasing the sample density may provide a more accurate representation of the spatial variation of background levels or contaminant concentrations in the environment. Land quality information from different surveys may, therefore, be compared using information on the spatial resolution of sampling densities used to determine contaminant concentrations.

Concerns over sustainable land use and the potential impacts of global climate change have led to the development of temporal monitoring research programmes, which include land quality parameters. The availability of temporal data enables distinctions to be made between short-term fluctuations and long-term trends, and where possible, enables the prediction of future changes.

Quality control (QC) and quality assurance (QA)(including analytical methods)

QC and QA are essential components in the study of land quality as they represent the only means by which the accuracy and precision of a given study may be transparently demonstrated and assured to the user community and public alike. In addition, adequately documented QC and QA procedures are essential if data from a wide range of individual studies is to be compared at local, regional and national scales.

Within the context of land quality, QC may be achieved through inter-comparison studies and, in the case of chemical analysis, through the determination of elements and compounds in internationally recognised and certified standard reference materials. The need for QA in the assessment of land quality is often confused with the participation in a number of accreditation schemes. It should be noted that participation in such schemes does not necessarily guarantee data reliability, and that for many involved in land quality issues, particularly in the academic environment, an appropriately documented and adhered to methodology may suffice. This is particularly so where such methodology makes reference to nationally and internationally recognised standard procedures, such as those published by the British Standards Institute, the International Standards Organisation (ISO) or the United States Environmental Protection Agency (USEPA). The use of such standardised methods not only assist in the selection of an appropriate methodology, but also improves the repeatability of the test and inter-comparability of derived data.

Whilst the majority of contract laboratories undertaking the characterisation of samples derived from investigations of land quality operate well documented QA and QC programmes, far less attention has been devoted to documenting the collection and pre-treatment of samples prior to analysis. Such documentation is particularly important in the context of land quality due to the high level of heterogeneity often apparent in natural systems. Additionally, the reported concentration of a particular analyte can vary depending on the method of collection, type of sample analysed and analytical method. For example, concentrations of contaminants in soils and sediments will vary depending on the size fraction analysed. Samples sieved to a fine size-fraction (< 100 μm) often tend to have higher contaminant levels because many substances in natural soils, subject to long-term chemical weathering, concentrate in the fine, clay mineral particles. A coarser fraction (< 2mm) generally contains more quartz and feldspar grains, which have lower contaminant concentrations. Conversely, higher concentrations of contaminants may be found in the courser size fractions of ‘soils’ derived predominantly from man-made sources such as slags and ash from smelting and refining processes.

Many analytical measurements of contaminants are quoted as ‘total’ concentrations. In the case of inorganic contaminants, analytical methods capable of determining true total concentrations usually involve the bombardment of the sample with X-rays (XRF) or neutrons (NAA). An alternative approach involves digesting the samples in an acid solution. A combination of hydrofluoric-nitric-perchloric acid is a strong reagent that yields pseudo-total

results. Other less vigorous reagents, such as *aqua regia*, have been developed to assess the more readily available concentration of contaminants in soils and sediments. The readily available concentration will be lower than the total. It should be noted that even these less vigorous reagents used in the leaching process are poor indicators of the mobile or bio-available fraction of a given contaminant as leaching conditions are still far removed from physiological conditions associated with natural receptors.

Therefore, it is important when assessing contaminant concentrations that the methods of sample collection, sample preparation and analysis are defined for both the guideline and the samples in question. Furthermore, it is often difficult to compare data sets generated by different organisations, unless standard reference materials have been analysed to guarantee the accuracy of the data. For these reasons, information on data quality control procedures was included in the review.

2.2 Methodology

After identifying information sources and data holdings, land quality information was collated using two mechanisms: literature review and consultation with information providers.

Literature reviews were undertaken to determine the nature and amount of published information available in the form of articles, books, academic theses, maps, reports or scientific papers. In addition to this, a broad range of organisations were consulted to corroborate sources of published information and identify unpublished information such as databases and report archives.

The review strategy concentrated on identifying the most comprehensive data sets representative of national and regional coverage, rather than considering in detail localised or site specific survey information. However, where regional land quality information was either absent, or was present only at a limited resolution or of questionable quality, information from studies conducted at local scales was included, as illustrated in Figure 2.1.

In addition to the spatial distribution of land quality, a number of monitoring networks and programmes were also assessed in order to provide information on the temporal trends in land quality and background data.

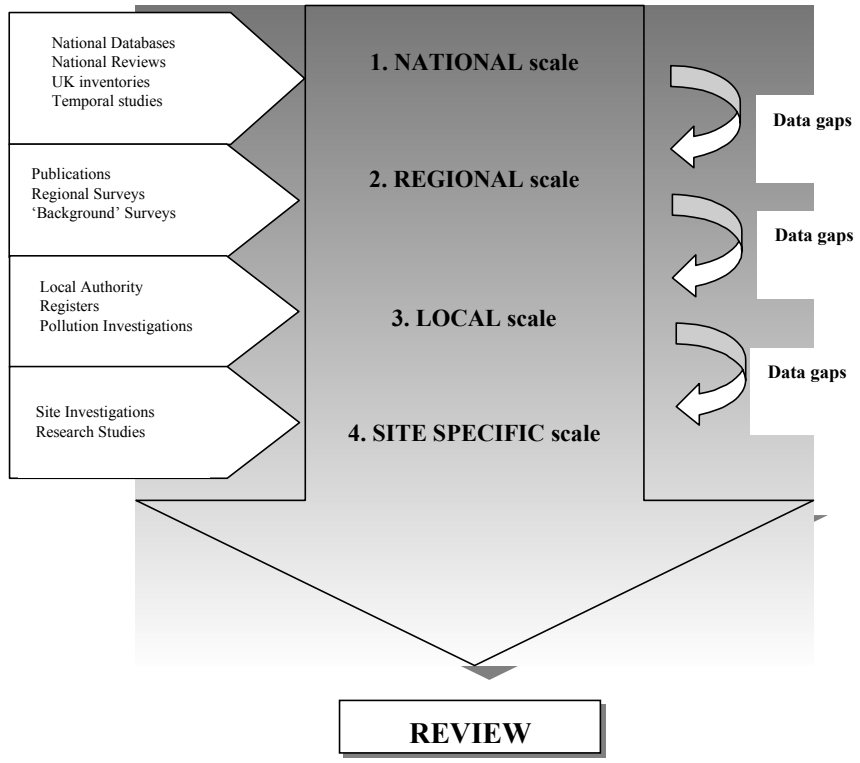

Figure 2.1 Data collection strategy

2.3 Literature Review

Published information was gathered by conducting keyword searches on the following bibliographic databases:

- AGRICOLA (1970-March 1999)
- APILIT® (1965-March 1999)
- BIDS (Bath Information and Data Services; 1981-March 1999)
- CAB Abstracts (1972-February 1999)
- Enviroline® (1975-January 1999)
- GEOBASE ™ (1980-February 1999)
- GeoRef (1985-March 1999),
- GEOSEARCH
- Inside Conferences (1993-March 1999)
- Pascal (1973-January 1999)
- Pollution Abstracts (1970-April 1999)
- SciSearch® (1990-March 1999)
- WASTEINFO Pollution Abstracts

The searches were conducted in two phases. Initially, a general search for articles relating to land quality surveys within the UK was performed, using the following keywords:

SOIL or LAND or SEDIMENT
AND
CONTAMINAT* or QUALITY or POLLUT*

AND
ENGLAND or SCOTLAND or WALES or IRELAND or UNITED KINGDOM or UK

(* Indicates any text allowed at end of keyword)

Details of bibliographic materials (published and non-published) held by organisations were also requested for inclusion in the review.

Initially, titles and abstracts of articles were assessed for relevance to the objectives of the review. A selection of key references were then obtained in order to enable further assessment. A database of relevant articles was compiled using Microsoft Access™, detailing the following information:

- Rationale for the survey
- Year of survey
- Media to which the data relates
- Source of contamination- natural or anthropogenic contamination
- Spatial resolution of the data set
- Temporal resolution of the data set
- Range of contaminants included
- Analytical methods used
- Quality control/ quality assurance protocols
- Data format- eg paper, digital, database, GIS
- Level of interpretation- eg. statistical analysis, modelling
- Status of survey- ongoing or complete
- Data availability
- Costs

For those references which were considered to be of less importance, for example localised studies where data was already available in a national dataset, only limited reference details were recorded. Key references are discussed in greater detail in the data review sections of this report.

2.4 Questionnaire Survey

2.4.1 Aim of the Survey

A questionnaire was prepared for use in consultations, in order to gather information on the nature, extent, quality and availability of land quality information held by consultees (see Appendix A). The design of the questionnaire was intended to enable efficient collation of such information to a consistent level of detail. The questions were intended to provide sufficient detail to identify the nature and extent of national, regional and local data sets held by each organisation, and prioritize data sets for further research. The questionnaire was used as a basis for collating information during telephone interviews and meetings, and was sent to consultees for completion. A copy of the questionnaire template is included in Appendix A.

2.4.2 Consultees

Consultation focused on approximately 250 organisations which were considered to hold a range of land quality information, including survey records, research data, monitoring

network data and land use information. A list of the key organisations consulted during the research is summarised below.

Agencies

SEPA officers, responsible for the collation and storage of land quality information within each Region and Head Office, were consulted during the research, in order to establish the extent of information already held internally.

Government Offices

The assessment of land quality is an important function of a number of government offices, affecting policy formulation, strategic planning decisions, and scientific research priorities. A selection of central government departments were, therefore, consulted in order to identify major data sets which may not be in the public domain, as well as any ongoing programmes of land quality data collation.

Local Authorities

Land quality information is held by the majority of local authorities, usually within planning or environmental health departments. This is generally in the form of site investigation reports and land use assessments which have been commissioned for the purposes of satisfying planning conditions, investigating statutory nuisances, and developing structure plans. The nature, format and quality of land quality information varies according to factors such as geological conditions, the extent of previous industrial and mining activities, and variation in pressure to redevelop brownfield land. A representative range of local authorities were consulted, including:

- Unitary Authorities in whose areas previous industrial activities may have resulted in extensive land contamination (e.g. Glasgow City and Edinburgh City Councils) ;
- Local authorities situated in rural areas; and
- Local authority officers attending conferences on contaminated land.

Other Organisations

Land quality information may be held internally by a wide range of organisations, rather than being published or released in the public domain. Therefore, a selection of key research institutions, professional bodies, landowners and consultants were contacted in order to identify any such data sets. In the context of this report other organisations consulted included: the Scottish and Northern Ireland Forum for Environmental Research (SNIFFER), the Environmental Research Forum, the Edinburgh Center for Rural Research and the Contaminated Land Research and Remediation Center (CLARRC).

3 INFORMATION IN THE PUBLIC DOMAIN

3.1 Inorganic Contaminants

3.1.1 National Data Sets

Natural Contamination Review of Great Britain

This study (Appleton, 1995) reviews the relevance to planning and development of natural contaminants from geological sources throughout Great Britain. The review was based on literature and data from readily accessible library and archive sources. It presents a map at a scale of 1:625:000 highlighting areas of above average national background concentrations of a range of PHEs, including Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb) and Zinc (Zn). The National Soil Inventory datasets for England, Wales and Scotland were of insufficient resolution to define natural contamination for planning purposes. For this reason, the map was generated using the stream sediment geochemical datasets of the Wolfson geochemical atlas of England and Wales and Geochemical Baseline Survey of the Environment programme of the British Geological Survey.

A statistical procedure, involving the interpretation of cumulative frequency curves, was used to distinguish natural background concentrations in stream sediments from higher concentrations derived from weathering in areas of metalliferous mineralisation or mine spoil. Although the range of natural background concentrations varies in different geological settings, a NAB (national average background) concentration was derived for each of the PHEs. For each PHE, the stream sediment data were subsequently classified into those below NAB, between NAB and 2 x NAB, 2 to 4 x NAB and greater than 4 times NAB. An interpolation procedure was used to grid the data. The five element datasets were superimposed and the highest value selected for each grid square. Data presented in the map are of variable resolution based on the stream sediment sampling density (1 sample per 1.6 to 2.5 km^2).

The map indicates that small areas of the land surface of Scotland are characterized by above NAB concentrations of the five PHEs, (significantly smaller areas in comparison to England and Wales). The most extensive areas exhibiting elevated concentrations of PHEs occurred in Dumfries and Galloway. The influence of anthropogenic contamination was also evident around the urban centres of Glasgow and Edinburgh.

On the basis of a comparison between stream-sediment and soil data, it was concluded that areas with greater than four times the background concentration of PHEs in stream sediment are likely to contain soil concentrations that require further investigation on the basis of the ICRCL guideline values which applied at that time (ICRCL, 1987).

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WWW: http://www.bgs.ac.uk/bgs/w3/argg/argg

National Soil Inventory of Scotland (Macaulay Land Use Research Institute)

The Macaulay Land Use Research Institute holds data on the geochemistry of Scottish topsoils at a 10 km grid square resolution. Top soils were sampled between 1978 and 1982. The samples were sieved to 2 mm and were subjected to an *aqua regia* digest. They were analysed by ICP-AES for the total concentration of the following determinands: Aluminium (Al), Barium (Ba), Calcium (Ca), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Potassium (K), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Sodium (Na), Nickel (Ni), Phosphorous (P), Lead (Pb), Strontium (Sr), Titanium (Ti) and Zinc (Zn). The organic carbon content of samples were determined by a catalytic oxidation. The extractable concentration of Ca, K, Mg, and Na were also determined. Data is held in GIS (ARC-INFO) and database (Oracle) formats. It is geo-referenced to the British National Grid. QA and QC has been undertaken through use of an internationally recognised standardised procedure and the use of internal procedure consistent with that of a NAMAS accredited laboratory. The data set include both natural and anthropogenic sources and does not differentiate between either source as being responsible for a given contaminant level. In some cases estimates of bioavailability of potentially toxic elements have been made from the data set using microbial bioassays.

In addition to the main data set Macaulay also holds similar data for four SW/NE transects of Scotland (30 samples in total). These samples were collected at the same time as samples for PCB analysis (Bracewell et al., 1993).

Data from the National Soil Inventory of Scotland has not been published and it has therefore been impossible to review derived background levels.

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Environmental Change Network (ECN) of the Institute of Terrestrial Ecology (ITE)

The ECN was established to monitor the temporal variation in a range of variables, including major ions and heavy metals, identified as being of major environmental importance by ITE and the user community and sponsors (including SEPA, Scottish National Heritage and the Scottish Office). Following integration and statistical analysis, these data will be used to: i) identify natural and man-induced changes and improve understanding of the causes of change; ii) distinguish short-term fluctuations from long-term trends, and iii) predict future changes in environmental quality (including land quality).

ECN Objectives:

- to establish and maintain a selected network of sites within the UK from which to obtain comparable long-term datasets through the monitoring of a range of variables identified as being of major environmental importance;
- to provide for the integration and analysis of these data, so as to identify natural and man-induced environmental changes and improve understanding of the causes of change;
- to distinguish short-term fluctuations from long-term trends, and predict future changes; and

- to provide, for research purposes, a range of representative sites with good instrumentation and reliable environmental information.

Starting in 1993, data has been collected from the terrestrial sites (there are both freshwater on the following aspects: meteorology; atmospheric chemistry; precipitation chemistry; surface water discharge (chemistry and quality); soil solution chemistry and soil properties. Parameters are monitored on a five-yearly basis from soil cores for major ions, and every 20 years from soil pits for major ions, physical properties and heavy metals, including total (acid leachable), extractable and exchangeable major and trace ions. Heavy metals determined include Pb, Zn, Cd, Cu, Hg, Co, Mo, As, Cr, and Ni. The data are stored on an ORACLE database - a GIS is currently being developed. The data are categorized using the ITE land classification. A standardized monitoring protocol is employed at the terrestrial sites as a means of quality assurance (The United Kingdom Environmental Change Network: Protocols for Standard Measurements at Terrestrial Sites (1996), Edited by J M Sykes and A M J Lane, Published by The Stationery Office, (ISBN 0 11 702197 0))

Raw data are available through the ECN management programme in digital and hard copy (maps etc) format. Information is spatially referenced using national grid coordinates (GB and Irish Grid) and, additionally, may be made available in a number of GIS formats (ArcView and ArcInfo).

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WWW: http://mwnta.nmw.ac.uk/ecn/

Critical Load Maps of Soil Acidification

The database comprises estimates of the vulnerability of the land surface of the United Kingdom to the effects of atmospheric pollution (particularly acid deposition). Vulnerability is assessed on the basis of air quality, and the sensitivity of receptor soils, geology, freshwaters and vegetation (trees, semi-natural vegetation and crops). The Critical Loads Database was developed by the amalgamation of data sets from the Institute of Terrestrial Ecology, the Soil Survey and Land Research Centre (SSLRC), Macaulay Land Use Research Institute (MLURI) and the University of Aberdeen. The database is managed by the Critical Loads Mapping and Data Centre (MADC) at Monks Wood, and this acts as the UK National Focal Centre for the Critical Loads Advisory Group (CLAG), which was set up in 1991 by the Department of the Environment to develop a national critical loads and levels programme.

Data within the basic database correspond to each of the 250,000 x 1km squares of the British National Grid. Data are held in digital forms within Laserscan Horizon and Arc/Info GIS, and within an Oracle database. The MADC uses the database to map particular receptor pollutant combinations, which are then combined with current deposition loads or exposure levels for that pollutant to produce critical load or level exceedance maps. Areas of potential damage can be quantified from these maps and these form a basis for relating policy on pollutant emission abatements to environmental benefits.

Critical load maps of acidity for soils indicate their sensitivity to acidification following atmospheric deposition of acidifying compounds, principally those of nitrogen and sulphur. Increased acidification of soils below a threshold pH may be viewed as a reduction in land

quality, as it may limit future land-use or lead to ecosystem damage. Sensitivity to acidification in mineral soils is determined largely by the rate of mineral weathering (i.e. mineralogy). In peat soils, local hydrogeology and the type of peat deposit are more important factors.

A critical load map of soil acidity for soils in the UK has been generated by this programme at a resolution of 1 km^2. Critical loads were calculated on the basis of dominant soil mineralogy in soil map units, and for peat soils on the basis of regression equations from experimental work on the acidification of peats and the distribution of annual runoff. In addition to regional maps, thematic maps are being produced for a number of sensitive ecosystems.

Data is available through the Critical Loads Mapping and Data Centre (MADC) at Monks Wood either as paper maps or in digital form. Raw data is held in an Oracle database and is spatially referenced using GB national grid coordinates (Ordnance Survey) and is available in a number of GIS formats, including Arc Info.

Contact: Dr J. Hall, Institute of Terrestrial Ecology,
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WWW: http://mwnta.nmw.ac.uk/ite/edn2.html.

UK Sewage Sludge Survey

The UK Sewage sludge survey was undertaken on behalf of the Agency by the WRc at Medmenham. The report describes a survey of sewage sludge production, treatment, recycling and disposal in the United Kingdom for the financial year 1996/97. It forms an extension of a previous survey performed for DETR in 1991 and in addition to fulfilling similar objectives has provided data which is held by the Agency on an accessible computer database. Data in the report was collated from information provided by all major producers of sludge in England, Wales, Northern Ireland and Scotland.

The data reports an increase in total sludge production of only 1% (based on 1991 estimates) which is much less than was previously estimated. Approximately 47% of this sludge was applied to 80,000 ha of land (0.5 % of the total area of agricultural land in the whole of the United Kingdom). Concentrations of potentially toxic trace elements observed in sewage sludge were similar to those observed in the 1991 survey with the exception of zinc which was reduced by 14%. Elements reported in the data set included: Zn, Cu, Ni, Cd, Pb, Hg, Cr, Mo, Se, As and F. Concentrations of these elements were reported in both the applied sludge and land unit to which the sludge was applied. Analytical data QA and QC was carried out according to each individual laboratories formalized QA programmes. In addition to chemical data, data was also collated for spreading method, application rates, pH of soil (in the land unit) etc. National grid coordinates were recorded where available (note % of data returned ungeocoded was not recorded).

Contact: Mr Neil Veitch, Environment Agency, National Centre for Environmental Data and Surveillance, Rivers House, Lower Bristol Road, Bath, BA2 9ES. Tel: 01225 444 066. Fax: 01225 469 393

Geochemical Baseline Survey of the Environment (G-BASE), British Geological Survey (BGS)

The G-BASE programme began in 1968 and is currently surveying the whole of the UK from north to south. The survey is scheduled for completion by 2012. Geochemical mapping is based on stream sediment, stream water and soil sampling at an average density of 1 sample site per 1.5 sq km. The data are presented in the form of Geochemical Atlases, which describe sampling and analytical methodologies and present element distribution maps accompanied by interpretative text. Atlases currently published cover the whole of Scotland. The data for Scotland are part of a continuous data set, which also encompasses England, Wales and Northern Ireland. The G-BASE programme is ongoing and is scheduled to provide complete coverage of the UK by 2012. In addition to the published format, all data are available digitally, and representative splits of all solid sample media are archived at the BGS in the National Geosciences Data Centre (NGDC).

G-BASE is a continuing programme and, as developments have been made in analytical techniques, it has become possible to carry out simultaneous analyses for an increasing suite of parameters and a wider range of sample media. For this reason, as the programme has progressed throughout the UK, successive atlas publications have reflected these developing methodologies. Recent publications contain a wider range of elements for sediment, soil and water, with determinations having been made to lower detection limits than were possible in the early stages of the programme. For an accurate description of the coverage of the programme and associated changes, the description has been split into the atlas areas published by the BGS and presented in a tabular form in Appendix B.

Data quality control is consistent throughout the programme and is carried out on the data in several ways. Samples are collected in a random order, predefined by random number lists for batches of one hundred. These are then analyzed in numerical order to allow systematic errors to be attributed to either the sampling or the analytical stages. Internal standards are included in each batch of one hundred. In the case of water samples, blank water is included instead of a standard. International standards are also included for each analytical technique, in accordance with standard laboratory procedures. In addition, duplicate samples are taken at one site per hundred samples, before being sub-sampled and analysed. Duplicate analyses allow the determination of intra-site and inter-site variance, and enable the calculation of practical detection limits and precision.

During its initial phases, the programme concentrated on the collection of stream sediment and stream water samples from first and second order streams in rural areas. As the programme moved into lowland areas of the country, where the drainage network was less well developed, rural soil samples were also collected. The stream sediment and rural soil data provide valuable information on the background concentrations of inorganic contaminants in the surface environment. These data sets also include information on naturally elevated levels of contaminants associated with certain rock types, and elevated concentrations of contaminants occurring naturally but enhanced by anthropogenic activities such as mining.

As described above data is presented in a series of ten atlases and has not yet been collated into one atlas covering the whole of Scotland. Nevertheless throughout the ten separate atlases similar general trends occur. These relate to the presence or absence of potentially toxic trace elements in minerlisation associated with geological strata underlying each catchment (from which stream sediments were collected) and the presence or absence of the

urban environment. The latter, particularly, influencing the distribution of Lead (Pb) and Copper (Cu) around the major conurbations of Glasgow and Edinburgh.
Mg kg^{-1}

Data indicating the concentration of Arsenic (As) in stream sediments is available for the area south of Inverness. In this region the concentration varies between 1 and 2,400 mg kg^{-1} with a median concentration of 6 mg kg^{-1}. Highest values are associated with SW-NE trending bands of minerlisation from Strathclyde to Aberdeen in the north and from Stranraer to Berwick upon Tweed in the south. Concentrations of Nickel (Ni) (<1, 44, 3762 [minimum, median, maximum] mg kg^{-1}), Cu (<1, 18, 1042 mg kg^{-1}), and Zinc (Zn) (<1, 140, 8745 mg kg^{-1}) follow broadly similar patterns to As except that all are strongly enriched over the igneous rocks found throughout the Western Isles, Skye and western cost of the Highlands. Although this enrichment is less marked for Zn. All three of these elements show clear urban haloes around the conurbations of Glasgow and Edinburgh.

Concentrations of Pb are low (typically < 36 mg kg^{-1}) throughout the Highlands except over the Grampian mountains, Island of Arran, the granites of Dumfries and Galloway and the lead mineralisation of Leadhills (maximum concentration 15,000 mg kg^{-1}). Again clear urban haloes (>200 mg kg^{-1}) exist in stream sediments associated with the conurbations of Glasgow and Edinburgh. Cadmium (Cd) levels reach a maximum concentration of 30 mg kg^{-1} with a median of <0.3 mg kg^{-1}. Whilst the highest concentrations of Chromium (Cr) (>12,000 mg kg^{-1}) are present over the igneous rocks of the Western Isles, Skye and western cost of the Highlands significantly enriched levels of Cr stretch in a broad band from Glenrothes to Carlisle (typical range >100 and <700 mg kg^{-1}).

Data are available through the G-BASE data officer at BGS, Keyworth, either as paper maps or in digital form. Raw data are held in an Oracle database and are spatially referenced using GB national grid co-ordinates (Ordnance Survey). Data are also available in a number of GIS formats (including Map Info, Arc Info and Arc View).
Individual Atlases are sold through the Sales Desk, British Geological Survey, Keyworth, Nottingham, NG4 5GG at a cost of between £50 and £100 depending upon region.
Tel: 0115 9363241; Fax: 0115 9363488

Contact: Mr B Smith, Analytical and Regional Geochemistry Group, British Geological Survey, Keyworth, Nottingham.
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WWW: http://www.bgs.ac.uk/bgs/w3/argg/argg

Countryside 2000 Module 6. Soils and Pollution: Monitoring & Assessing Soil Quality

A total of 1255 soil samples have been collected at sites throughout England, Wales and Scotland as part of the CS2000 project. Five samples were taken from 251 individual (1 km) squares of the 256 (1km) original squares sampled in the Countryside Survey (1978).

In Scotland, 530 samples were collected from 106 km squares. Following *aqua regia* extraction, the samples will be analysed for a range of major ions and trace metals using ICP-AES. The sites represent the main types of landscape, land cover and soil types in Great Britain (and are only a proportion of the CS2000 1 km squares). In 1978, an annotated soil description was recorded for each site, as well as details of slope, aspect and vegetation.

Climatic and altitude data are available for the sites from the main countryside survey databases.

No specific data have been returned on QA protocols to be employed. A standard reference material (LGC: coal carbonisation site soil) will be used for QC purposes.

The main objectives of CS2000 are i) to provide good quality data on soil chemical and biological properties for the development of national databases, and ii) to improve the understanding of links between soil biology, chemistry and the wider environment to support the development of suitable, effective strategies and policies relating to soil quality.

The specific objectives are:

- to provide a national overview of chemical and biological soil properties, and a baseline against which specific sites can be compared;

- to measure pH and soil carbon content, and carry out a range of chemical analyses and a laboratory evaluation of faunal diversity and microbiological status to provide a baseline for the monitoring and assessment of soil quality in England and Wales; and

- to integrate information on chemical and biological properties, and to look at it in terms of soil quality assessment and the wider terrestrial environment.

It is intended that data will be made available through the CS2000 officer at ITE, Merlewood. Data are due to be available in either paper or digital form (spatially referenced using GB national grid co-ordinates) in a number of GIS formats (including Map Info, Arc Info and Arc View).

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Regional Distribution of Sulfate in Rocks and Soils of Great Britain

Sulfate salts in soils can have damaging effects on concrete structures buried below the water-table in sulfate-bearing soils. Little information has been published on the regional distribution of sulfates in soils throughout the UK. One such study (Forster et al., 1995) compiled this information from geotechnical databases, in which one of the parameters recorded was sulfate content. Areas for which databases have been assembled include some parts of southern Scotland. These records have been derived from commercial site investigations, geotechnical consultants and records at the British Geological Survey. The British Standard Procedure for assessing sulfate content was used, as described in the Buildings Research Establishment Digest 250. Sulphate content is separated into five classes, and each region is assigned to a class on the basis of its median sulfate content. The authors also describe five classes of potential hazard to construction presented by soils developed from different geological formations.

The potential for sulfate effects on road structures was highlighted recently by investigations on the M5, where a road bridge structure was shown to have been subject to thaumasite attack. This led to a joint study by the Highways Agency and the British Geological Survey to

produce a 1:625,000 scale map of the principal sulphate bearing formations of England, Wales and part of Southern Scotland.

The map is available in digital format from the British Geological Survey
Contact: Dr. J. Hallam (Tel: 0115 9363376)

Scottish Environment Protection Agency (SEPA)

The Scottish Environment Protection Agency state that they do not currently collate information on land quality and that research is currently being directed at issues related to contaminated land sites rather than at trends in soil quality.

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3.1.2 Local Data Sets

Local Authority Information

Both of the major city councils (Glasgow and Dundee) hold data on the concentrations of a range of inorganic contaminants from site-specific studies.

3.1.3 Literature Review

Table 3.1 Summary of published information on background levels of inorganic substances throughout Scotland

Region / Area	Summary	References
Scotland	Several studies describing the trace element content of Scottish soils	(Berrow and Reaves, 1981; Berrow and Reaves, 1985; Berrow and Reaves, 1986; Berrow et al., 1987; Berrow and Ure, 1985; Berrow and Ure, 1986) (Reaves and Berrow, 1984a; Reaves and Berrow, 1984b; Reaves and Berrow, 1984c) (Ure et al., 1979)
Shetland	Preliminary report on the mineral resources of Shetland and results of a pilot geochemical survey	(Buchanan and Dunton, 1991)
SE Scotland	Regional variation of extractable copper and cobalt in the topsoils of south-east Scotland	(McBrateny et al., 1982)

Table 3.2 Summary of published information on land contamination by inorganic substances throughout Scotland

Contaminant Location	Source of Contamination	Summary	References
Trace metals Heavy metals Cr	Urban/ Industrial	Contaminated ground and contaminated estuary sediment illustrated by two case histories	(Bell et al., 1997)
	Urban/ Industrial	A survey of trace metal contamination in Glasgow urban soils	(Gibson, 1983)
Glasgow and Forth Estuary		Chromium contamination in Glasgow, Scotland	(Jeffries, 1995)
Heavy metals	Sewage Sludge	Effect of heavy metal contamination on the rate of decomposition of sewage sludge and microbial activity	(Cheshire et al., 1996)
Aberdeen	Road traffic	Urban Soils as Pollutant Sinks - A Case study from Aberdeen, Scotland	(Paterson et al., 1996)
Cd, Pb Baldovie	Waste incinerator	An investigation of environmental levels of cadmium and lead in airborne matter and surface soils within the locality of a municipal waste incinerator	(Collett et al., 1998)
Pb, Zn Heavy netals Central Scotland	Atmospheric Pollution	Grass and surface soils as monitors of atmospheric metal pollution in central Scotland	(Gailey and Lloyd, 1985)
Acid deposition	Atmospheric Pollution	Highlights variation in susceptibility of Scottish Soils to acid deposition	(Langan and Wilson, 1994)
Scotland	Atmospheric Pollution	Peat acidification in Scotland	(Skiba et al., 1989)

3.2 Organic Contaminants

3.2.1 National Data Sets

Natural Contamination Review of Great Britain

This study (Appleton, 1995) reviews the relevance to planning and development of natural contaminants from geological sources throughout Great Britain. The review was based on literature and data from readily accessible library and archive sources. It presents a map at a scale of 1:625:000 highlighting areas likely to exhibit elevated concentrations of methane, carbon dioxide and hydrocarbons.

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E:mail: D.Appleton@bgs.ac.uk. WWW: http://www.bgs.ac.uk/bgs/w3/argg/argg

Prior to the mid-1980s, practically no data had been published on the distribution of dioxins and furans in UK soils. Various levels of PCDDs and PCDFs were reported in samples of soil collected in the vicinity of potential emission sources such as chemical waste incinerators and other combustion sources. However, a lack of reliable published information on the normal

concentrations of these compounds meant that it was virtually impossible to interpret such data. In addition, no standard methodology had been developed for the analysis of PCDDs and PCDFs at low levels.

A number of surveys have since been undertaken to establish concentrations of these potentially toxic contaminants, although the data are dominated by localised surveys undertaken in the vicinity of suspected sources of contamination, with relatively few surveys undertaken at a regional to national scale. No information is available indicating concentrations of PCDDs and PCDFs within different habitats.

Low levels of PCDDs and PCDFs have been reported in Scottish soils, although the limit of detection used proved insufficient to confirm the presence of these compounds at trace levels (Scottish Office, 1987).

Determination of Polychlorinated Biphenyls, Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans in UK Soils: 1st Technical Report, 1989

This report was prepared by Her Majesty's Inspectorate of Pollution (HMIP), partly in response to public concern over potential emissions of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) from chemical waste incinerators and other combustion sources. Various levels of PCDDs and PCDFs were reported in samples of soil collected in the vicinity of such plants. However, it was virtually impossible to interpret such data, as there was no reliable published information indicating the normal concentrations of these compounds in the environment, and no standard methodology had been developed for the analysis of PCDDs and PCDFs at low levels.

In order to address these concerns, HMIP commissioned the University of East Anglia to develop an analytical method for the analysis of trace quantities of PCDDs and PCDFs, and to undertake a survey to establish background concentrations of these compounds in UK soils. Samples were collected during 1986 and 1987. Samples were collected from urban sites located on the intersects of a regular 50km grid across England, Wales and lowland Scotland, offset by 1000m from the Greenwich Meridian. Eleven of the sites were located within Scotland. At each sampling site, between six and eight core samples of 5.5cm diameter were collected. Core samples were obtained to 5cm depth, based on a strategy published by the United States Environmental Protection Agency and the Canadian Environmental Survey of incinerator sites.

Local variations in concentrations were investigated at four of the grid intersects selected at random, by collecting three samples at sites 1km radially distant from each intersect. In order to investigate the combined effect of heterogeneity of sampling and analytical precision, two replicate pairs of samples were also collected from controlled plots of cereal crop and grass pasture at the Rothamsted Experimental Station, Harpenden, Hertfordshire.

Quality control procedures followed the criteria published in the UK by the Steering Group on Food Surveillance, including the use of reference solutions, blank samples, duplicate samples, and the checking of standards.

Sample preparation and analysis procedures were identical for all samples collected. Samples were air dried to constant weight, ground and seived using 2mm mesh. Approximately 250g of dry soil was spiked with carbon-13 labelled internal standards $^{13}C_{12}$-2,3,7,8-TCDD and

$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD. Extraction was undertaken using a hexane/acetone mixture, followed by clean up via high performance liquid chromatography to remove any interference from other chlorinated aromatic substances. Analysis was performed by gas chromatography-mass spectrometry, applying strict criteria for the positive identification of PCDDs and PCDFs. Results are reported as total concentrations of congeners.

For proper definition of typical background levels, samples containing PCDD or PCDF concentrations in excess of 2.5 standard deviations above the mean were rejected as outliners. Within this reduced data set, concentrations of PCDD congeners were in the range 6.6ng kg^{-1} to 191ng kg^{-1} and PCDF concentrations from 23ng kg^{-1} to 41ng kg^{-1}. Survey results indicate the ubiquity of PCDDs and PCDFs in soils throughout the UK, while the mean concentrations of PCB are similar to levels reported for surveys of English (Creaser and Fernandes, 1989) and Welsh soils (Eduljee et al., 1987). Total concentrations were found to be higher in rural locations than urban areas, with concentrations of the lower congener groups showing the greatest elevation above background levels. Trends indicated that major contributions of PCDDs and PCDFs in urban areas arise from localised sources and short range transport mechanisms.

Table 3.3 PCDD/F concentrations in soil samples collected in Scotland (after HMIP, 1989)

Grid Ref.	TCDD	PeCDD	HxCDD	HpCDD	OCDD	TCDF	PeCDF	HxCDF	HpCDF	OCDF
NT 0301	18	21	57	140	330	44	83	150	190	310
NT5100	8.9	6.5	25	32	150	20	40	17	14	33
NT 5150	1.5	1	35	62	180	6.8	4.7	29	15	20
NS 5050	5.4	6.7	25	35	130	23	35	24	11	19
NS 9950	6.1	9	59	77	170	24	31	70	60	8
NS 4905	14	3.9	21	43	110	28	10	19	13	15

Temporal trends in PCDD and PCDF soil loading have been studied by comparing archived samples collected since the 1840s from a semi-rural location in Hertfordshire with contemporary samples from the same location. Concentrations are seen to increase around the turn of the century, with total concentrations of PCDD/Fs rising from 31 to 92 ng kg^{-1} between 1893 and 1986, due primarily to increases in atmospheric transport and deposition of these compounds. Although regional differences are likely to exist between Scottish soils at those present at the test site, it is suggested that the increases in soil and herbage PCDD/Fs observed are likely to be representative agricultural systems in many industrialised countries. The results may therefore be broadly representative of trends in Scottish soils.

Contact Details:
Authors: HMIP, C.S.Creaser, A.R. Fernandes, S.Harrad, PW Skett, School of Chemical Sciences, University of East Anglia. Note: C.S.Creaser is now at Nottingham Trent, University (see below). ISBN: 011 7522686
Publishers: Stationery Office

2nd Technical Report, 1995

The initial survey described in the 1st Technical Report concentrated on defining the range of concentrations of PCDDs and PCDFs that may be found throughout the UK. A further study commenced in 1988, with the aim of better defining the degree of contamination present in soils within urban areas and in the vicinity of various types of incinerators and other potential

sources of PCDD and PCDF emission. Urban samples were collected from seven towns and cities within England, Scotland and Wales. Two sets of samples were collected broadly up and down wind at set distances of between 150m and 1200m of potential point emission sources, providing up to 12 samples per site.

To maintain consistency of results with the initial survey, identical sampling, analytical and quality control protocols were applied, using the original research team. Quality control was further enhanced by participation in an interlaboratory collaboration exercise. Limited data on toxic equivalence factors (TEQ) for PCDD and PCDF isomers are presented for samples collected from urban locations. Congener-specific analysis of PCBs was also undertaken for samples collected on the regular 56km grid during the initial survey.

Soil samples analysed showed a range of PCDD and PCDF homologues similar to those reported in the initial survey, although the observed concentrations were generally higher than those for rural and semi-urban soils. Elevated levels of lower homologues were recorded in urban samples, suggesting that major contributions of PCDD and PCDF levels in urban samples must arise from localised sources and short-range transport mechanisms.

Contact Details:
Authors: E.A.Cox, HM Principal Inspector of Pollution, C.S.Creaser, Department of Chemistry and Physics, Nottingham Trent University.
Publisher: Stationery Office

3.2.2 Polychlorinated Biphenyls (PCBs)

PCBs are ubiquitous in the environment, due to their prolonged stability, extensive previous use, and short atmospheric lifetimes. Background levels of PCBs in soils have been reported for industrialised countries, and range from low $\mu g\ kg^{-1}$ levels to a few tens of $\mu g\ kg^{-1}$. In the UK, a number of surveys have identified generally PCB concentrations at low $\mu g\ kg^{-1}$ levels in rural areas, with higher levels for urban and semi-urban areas. No information is available indicating PCB concentrations to be expected in different habitats.

The 1986 HMIP survey included the analysis of total PCB concentrations in all samples (HMIP, 1989). As for PCDD/Fs, background levels of PCBs in soils remote from urban and industrial locations were determined by excluding samples with concentrations in excess of 2.5 standard deviations above the mean. Elevated concentrations were detected in samples collected from industrialised areas, while small number of high concentrations were attributed to local sources, including open-ended usage or spills. (Creaser et. al. 1989).

A number of regional surveys have been undertaken to establish background levels of PCBs in England and Wales. However, the mineral soils which dominate is such areas may not be representative of the highly organic soils and peat in upland areas of Scotland. A survey by Bracewell et el. (1993) investigated the influence of localised effects of heavy industry on PCB concentrations in Scottish soils, by collecting samples from four transects across the country.

Summary results are presented in Table 3.4. Results indicated a marked increase in PCB concentrations from the north to the south, with the Northern Scotland and central Highlands transects possibly representing general background levels, unaffected by direct industrial or

population densities. The area of Central Valley transect crossed the heavily industrialised areas, and showed approximately twice these background levels. However, the highest concentrations occurred in samples collected from the comparatively rural Southern Uplands, probably derived from sources within the Central Valley.

Table 3.4 Total PCB concentrations in Scottish soils

Survey	Mean (μg kg^{-1})	Median (μg kg^{-1})	Range (μg kg^{-1})	Reference
N.Scotland transect	62	48	29 – 124	Bracewell et al., 1993
Central Highlands transect	66	61	21 – 103	Bracewell et al., 1993
Central Valley transect	119	127	53 – 174	Bracewell et al., 1993
Southern Uplands transect	196	176	112 – 362	Bracewell et al., 1993
UK survey, Scottish sites	10.2*	not available	1.9 – 32*	HMIP. 1989
UK 'rural' sites*	9.5	6.1	1.7 – 3.2	HMIP, 1989
UK (46 sites)**	4.0	not available	0.3 – 8.7	Lead et al., 1997

* Calculated from data set presented

** Total data set- includes samples collected outside Scotland

A survey of PCB concentrations in soils collected at 46 sites throughout England, Scotland and Wales reported spatial variations which could not be assigned solely to land use differences (Lead et. al, 1997). Statistical analysis of congener-specific data indicated that the composition of woodland soil samples were not significantly different from samples representative of pasture and grassland soils. However, no correlation was found between PCB concentrations and other possible controlling factors, such as organic matter content, soil type or sample region. Summary PCB results of selected samples are presented in Table 3.5.

Table 3.5 Summary PCB results at selected sites (locations unknown) (after Lead et. al., 1997)

Soil type	Land use	Organic matter (%)	Total PCB (μg kg^{-1})
Clay	Scrub	9.0	2.9
Sandy loam	Pasture	16.2	3.3
Loam	Pasture	7.9	1.1
Clay	Pasture	12.2	0.33
Loam	Pasture	12.3	3.1
Loam	Pasture	9.6	2.6
Clay loam	Grassland	18.0	3.4
Sandy loam	Grassland	12.0	1.6
Loam	Grassland	5.1	1.2
Peat	Woodland	61.2	8.7

A study by Alcock et al (1993) included an assessment of PCB trends in archived soil samples collected at five long-term agricultural experimental sites in southern England. Samples were found to exhibit a sharp rise in PCB concentrations between about 1940 and the early 1960s, reaching a maximum during the late 1960s/ early 1970s. Concentrations have since decreased markedly, so that contemporary concentrations are now close to those found in the early 1940s soils. A summary of this data is presented in Table 3.6. Although regional differences are likely to exist, the results may be broadly representative of trends in Scottish soils.

Table 3.6 Total PCB concentrations (μg kg^{-1}) in samples from long-term experiments (after Alcock et. al. 1993)

Site	Approximate Year					
	mid 1940s	mid 1950s	mid 1960s	mid 1970s	mid 1980s	early 1990s
Rothamsted	8.8	14.9	341	-	10.5	-
Hoosfield	27.2	-	382	-	54.4	-
Woburn	60.4	123	394	555	58.8	12.8
Luddington	-	-	132	54.5	48.7	31.2
Lee Valley	-	-	298	181	47.9	-

Polychlorinated Biphenyls in UK and Norwegian Soils: Spatial and Temporal Trends

This paper presents the results of research into the transport and fate processes of semi-volatile organic compounds. 104 soil samples were collected from 46 sites across England, Scotland and Wales, as well as 12 sites in Norway. Approximately 20 samples were taken from each site at depths of 0-2.5cm and 0-25cm, covering a total area of $100m^2$.

Samples were analysed for a range of PCB congeners. Results showed spatial variation in the concentration and congener profile between Norwegian and UK samples, with higher concentrations detected in Norwegian samples. However, no correlation was found between PCB concentrations and possible controlling factors, such as land use, organic matter content, soil type or sample region. Concentrations of contemporary UK soil samples were found to be approximately five times lower, than in archive soils collected between 1951 and 1974. It was concluded that this was largely due to volatilization and biodegradation of these compounds.

Contact Details:
Authors: Wendy Lead, Eilive Steinnes, Jeffrey Bacon, Kevin Jones
Organisations: Institute of Environmental and Biological Sciences, Lancaster University, MLURI, Craigibuckler, Aberdeen.
Publication: The Science of the Total Environment, v193, 1997, pages 229-236
Publisher: Elsevier Science

3.2.3 Polynuclear aromatic hydrocarbons (PAH)

Natural background levels of PAH compounds in the environment are derived from the burning of vegetation. However, anthropogenic sources such as the combustion of fossil fuels, waste incineration and stubble burning have resulted in a substantial increase in levels of these compounds in the environment. Apart from data obtained at severely contaminated sites, there is very little information on contemporary levels of PAH in soils.

A survey of PAH concentrations in soils by Cousins et al. (1997) included a number of samples collected in Scotland. Sampling locations were identical to those used for a study of PCB levels (Lead et. al., 1997). Archived soils collected from these locations were also analysed, and PAH concentrations compared to contemporary soil data. Sample locations were characterised as either remote, rural or semi-rural, and all were located away from potential point sources. A wide range of 'total' PAH concentrations were found, (approximately 20μg kg^{-1} to 7400μg kg^{-1}), indicating that the quantity of deposition falling

and/or the storage capacity of the soils at each site varies significantly. Concentrations of individual PAH compounds exhibited a fairly constant relationship with total PAH.

Temporal trends in PAH concentrations have been studied at the Rothamsted Experimental Station in Hertfordshire (Jones et. al., 1989). Archived soils collected since 1843 from a 'control' plot at the site which has not received any soil fertilizers or amendments, were analysed to assess the significance of atmospheric inputs. Results indicate an overall increase in the soil burden of approximately 4 to 5 times since the 1890s, with contemporary total PAH content considered to be representative of the semirural character of the site. Although regional differences in PAH concentrations are likely to exist, the results may be representative of general trends occurring in Scottish soils. The degree of increase varies markedly between individual PAH compounds, with the most abundant compounds such as certain fluoranthene, pyrene and anthracene compounds exhibiting the greatest increase.

Table 3.7 Summary of PAH concentrations (μg kg^{-1} dry weight)

Year	Total PAH
1846	350
1881	300
1893	150
1914	370
1944	530
1956	1130
1966	590
1980	1770
1986	750

Local Authority Information

Both of the major city councils (Glasgow and Dundee) hold data on the concentrations of a range of organic contaminants from site-specific studies.

3.2.4 Literature Review

Table 3.8 Summary of published information on land contamination by organic substances throughout Scotland

Location	Contaminants	Title	Comments(1)	Reference
PCDD, PCDF	UK-wide	Exploring the balance between sources, deposition, and the environmental burden of PCDD/Fs in the UK terrestrial environment: and aid to identifying uncertainties and research needs	Review of the relationship between primary and potential secondary emissions of PCDD/Fs, the balance between atmospheric emissions and deposition, and the contemporary environmental burden of PCDD/Fs and possible historical input profiles.	(Duarte-Davidson et al., 1997)
Pentachloro phenol	UK wide	Pentachlorophenol in the UK environment. 1: A budget and source inventory.	A budget approach is adopted to predict the total pentachlorophenol load of different environmental compartments.	(Wild et al., 1992)

Location	Contaminants	Title	Comments(1)	Reference
PAH	UK wide	PAHs in soils: contemporary UK data and evidence for potential contamination problems caused by exposure of samples to air	Archived (1951-1974) and contemporary surface soils collected from 46 locations over the UK were analysed for 12 PAH compounds. No significant trends detected in compounds heavier than benzanthracene. Lower concentrations of lighter compounds found in modern soils.	(Cousins et al., 1997)
PAH	UK wide	Polynuclear aromatic hydrocarbons in the United Kingdom environment: an assessment of sources and sinks	Paper presents an attempt to quantify the production, cycling, storage and loss of PAHs in the UK environment. Uncertainties in data are highlighted.	
PAH	UK wide	Polynuclear aromatic hydrocarbons in the United Kingdom environment: A preliminary source inventory and budget	Paper presents first attempt to quantify the production, cycling, storage and loss of PAHs in the UK environment. Includes a review of papers.	(Wild and Jones, 1990)
PCDD, PCDF	UK wide	Dioxins in the Environment: A Review of Trend Data	Review of available PCDD/PCDF trend data in industrialised countries, particularly Germany, US, Sweden & UK. Trend data suggest that PCDD/F emissions have increased after 1940, peaked in 1960s & 70s, and subsequently declined.	UK wide
PCBs	UK wide	Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. Second Technical Report to Her Majesty's Inspectorate of Pollution	Samples collected from urban locations and at regular distances from potential dioxin sources. Data shows that concentrations of dioxins are higher in urban soils than rural, and show local variations in the vicinity of potential emission sources.	(Cox and Creaser, 1995)
PCDD, PCDF	UK wide	Survey of background levels of PCDDs & PCDFs in UK soils	Soil samples collected on 50km grid covering England, Wales and lowland Scotland, providing an indication of background levels of PCDDs and PCDF and PCBs in British soils.	(Creaser et al., 1989a)
PCBs	Scotland	Levels and distribution of polychlorinated biphenyls on the Scottish land mass	Surface horizons of selected peat horizons were sampled at 30 locations along 4 NE-Sw transects across Scotland. Results show an increase in total PCB concentration from north to south.	Bracewell et al., 1993
PCDD, PCDF	England, Wales, southern Scotland	Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. Second Technical Report to Her Majesty's Inspectorate of Pollution	Samples collected from urban locations and at regular distances from potential dioxin sources. Data shows that concentrations of dioxins are higher in urban soils than rural, and show local variations in the vicinity of potential emission sources.	(Cox and Creaser, 1995)

Location	Contaminants	Title	Comments(1)	Reference
PCDD, PCDF	England, Wales, southern Scotland	Determination of PCBs, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. First Technical Report to Her Majesty's Inspectorate of Pollution	Total of 78 soil samples collected on a regular 50km grid across England, Wales and Scotland. In addition, a further 13 samples were collected in central urban areas in London and Birmingham. Urban concentrations generally above background levels.	(HMIP, 1989)
PCDD, PCDF	England, Wales, Scotland, NI	Environmental Levels of Dioxins in the UK	Report prepared by AEA Technology for DETR and DGXI of the European Commission. Includes literature review of publications indicating PCDD/F concentrations, with summary table of I-TEQ values.	AEA, 1999 (in prep)
PCB	England, Wales, Scotland	Background levels of polychlorinated biphenyls in British soils- II	Analysis of rural and urban soils from a 50km grid covering England, Wales and lowland Scotland indicate mean PCB concentration of 9.5microgram/kg. Study forms part of HMIP survey (HMIP, 1989).	(Creaser et al., 1989b)
PCBs	England, Wales, Scotland	Polychlorinated biphenyls in UK and Norwegian soils: spatial and temporal trends	Contemporary soil samples from 46 sites across the UK were analysed for range of PCB congeners. Results showed spatial differences in concentrations and congener profile. Archive soils from same sites showed increasing concentrations up to the late 1960s.	(Lead et al., 1997)
PCB	England, Wales, Scotland	Survey of background levels of PCDDs & PCDFs in UK soils	Soil samples collected on 50km grid covering England, Wales and lowland Scotland, providing an indication of background levels of PCDDs and PCDFs and PCBs in British soils.	(Creaser et al., 1989a)
PCB	England, Wales, lowland Scotland	Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. First Technical Report to Her Majesty's Inspectorate of Pollution	Total of 78 soil samples collected on a regular 50km grid across England, Wales and Scotland. In addition, a further 13 samples were collected in central urban areas in London and Birmingham. Urban concentrations generally above background levels.	(HMIP, 1989)

3.3 Salinity

3.3.1 Regional Data / Literature Review

There were no records concerning problems of salinity in Scottish soils.

3.4 Radionuclides

3.4.1 National Data Sets

Natural Contamination Review of Great Britain

This study (Appleton, 1995) reviews the relevance to planning and development of natural contaminants from geological sources throughout Great Britain. The review was based on literature and data from readily accessible library and archive sources. It presents a map at a scale of 1:625:000 highlighting areas likely to exhibit elevated levels of radon.

Geologic units are classified according to the level of potential radon emissions from the ground, based on the interpretation of one or more of the following: (i) geological and geochemical information including uranium concentrations; (ii) gamma spectrometric data; (iii) rock and soil permeability; and, (iv) measurement of concentrations of radon in soil gas and (v) dwellings. Geological units are assigned a Radon Potential Class, ranging from Low to Very High, and results presented as a Radon Potential Map of England, Scotland and Wales.

Contact details: Dr. D. Appleton, Analytical and Regional Geochemistry Group, British Geological Survey, Keyworth. Tel: 0115 9363100. Fax: 0115 9363200.
E:mail: D.Appleton@bgs.ac.uk. WWW: http://www.bgs.ac.uk/bgs/w3/argg/argg

Radon Affected Areas: Scotland

Results of radon measurements in homes in the districts of Kincardine and Deeside and Gordon in Grampian Region and Caithness and Sutherland in Highland Region are mapped and used to delineate Affected Areas, defined as areas in which 1% or more of housing stock exceed a level of 200 $Bq.m^3$ of air, in these areas where required.
Authors: J.C.H. Miles, B.M.R Green and P.R.Lomas

National Radiological Protection Board, Chilton, Didcot, Oxon, OX11 0RQ. Telephone: 01235 831600 Fax: 01235 833891 E-mail nrpb@nrpb.org.uk (Headquarters), WWW: http//www.nrpb.org.uk

Post Chernobyl Radionuclide Monitoring

Radiation : a guide to a contaminated countryside. Guardian Newspaper, July 25, 1986
Post Chernobyl Studies. ITE Project 1085. Final Report, 1986.

Surveys were conducted by ITE to determine the extent of contamination within the UK environment following the Chernobyl accident in 1986. An UK wide survey published in the Guardian established levels of caesium-134 and 137 within soil and vegetation. This is periodically updated by surveys undertaken principally in Scotland and Cumbria. Data are stored using Oracle with a Microsoft Access interface, integrated within a PC Raster GIS. Access to the data is restricted to staff searches, for which a charge is likely to be made to cover staff costs.

Contact Details:
Data manager: Dr. Brenda Howard
Organisation: Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands, Cumbria, LA11 6JU.

3.4.2 Regional Data Sets

An Airborne Gamma Ray Survey of Parts of SW Scotland in February 1993.

This report details the methodology and results of an airborne gamma ray survey undertaken for the Scottish Office Environment Department. The primary objective of the survey was to define existing background levels, to locate features worthy of further attention, and to demonstrate the emergency response capabilities of radiometric methods.

Coastal areas were surveyed with 500m line spacing, with up to 1km line spacing undertaken over inland areas. Calibration was initially performed using previous survey data, and subsequently checked against a set of core samples. Further soil sampling and ground level in-situ gamma spectrometry was performed in the summer of 1993 to investigate the applicability of the calibration to a range of upland soil types and topographical environments.

Results of the overall radiometric maps produced during the first stage of the project are presented for Cs-137, K-40, Bi-214, TI-208 and gamma dose rate. Levels of Cs-137 in the environment were found to range from approximately 2kBqm^{-2}, a level consistent with global weapons testing fallout. Activities at sites affected by peak deposition from the Chernobyl accident ranged from 2-40 kBqm^{-2}, and from 40kBqm^{-2} to >200kBqm^{-2} on tide-washed sites which have accumulated marine sediments from the Irish Sea.

Contact Details
Authors: D.C.W. Sanderson, J.D.Allyson, A.N.Tyler, S.NiRiain, S.Murphy
Organisation: Scottish Universities Research and Reactor Centre, Rankin Avenue, Scottish Enterprise Technology Park, East Kilbride, Glasgow G75 0QF, UK. Tel: +44 (0)1355 223332: Fax: +44 (0)1355 229898: e-mail: director@surrc.gla.ac.uk : WWW: http://www.gla.ac.uk/Acad/SURRC

The terrestrial distribution of artificial radioactivity in south-west Scotland

Much research has recently been undertaken into radionuclide contamination of tide washed pastures in estuaries of the eastern seaboard of the Irish Sea, particularly in areas close to the Sellafield discharge point where the highest levels are likely to be found. This investigation by McDonald et al. (1992) extended the coverage of data on dispersion of Sellafield derived radionuclides to the northern Solway area of south-west Scotland. The main objectives were to sample soil profiles representative of sites which had remained undisturbed for a minimum of 20 years. Soil cores were collected at 0-15cm and 15-30cm depths from 46 sites, located on a 10km by 10km grid system. A further series of soil cores were taken near shore along six inland transects, each comprising six sites from near high water mark to 3 km inland. Riverbank soil cores were also collected for radionuclide analysis from the five principal rivers of the Solway region.

Results indicate that with the exception of one site, the inventory of Pu-239 can be assigned to weapons fallout, while the total soil inventory of Cs-137 derives from weapons tests and Chernobyl fallout. Levels of radioactivity encountered are assessed radiologically by comparing them with the Generalised Derived Limits (GDL) published by NRPB for a range of nuclides in a variety of marine and terrestrial matrices. Levels encountered were generally well below the limiting values implied by the GDL, however, in some tidally inundated riverbank areas, Cs-137, Puα and Am-241 levels occasionally exceed 25% of the appropriate GDL values. Published in: The Science of the Total Environment, volume 111, 1993, pages 59-82, Publisher: Elsevier Science

Table 3.9 Summary of radionuclide inventory of Solway inland transect soils ($kBq.m^{-2}$)

Location	Nuclide	Transect position			
		Shoreline	125m inland	500m inland	3km inland
Inner Solvay	Cs-137	55.5	5.2	5.9	5.0
	Pu-239 + 240	5.7	0.087	0.065	0.078
Luce Bay (Outer Solvay)	Cs-137	20.1	14.5	16.8	13.8
	Pu-239 + 240	0.295	0.086	0.082	0.113

Contact Details: Paul McDonald, Gordon Cook, Murdoch Baxter, James Thomson
Organisation: Scottish Universities Research and Reactor Centre, Rankin Avenue, Scottish Enterprise Technology Park, East Kilbride, Glasgow G75 0QF, UK. Tel: +44 (0)1355 223332: Fax: +44 (0)1355 229898: e-mail: director@surrc.gla.ac.uk : WWW: http://www.gla.ac.uk/Acad/SURRC

3.4.3 Local Data Sets

Radioactivity in Food and the Environment (RIFE): 1997 Report

An annual report which presents the results of surveillance programmes for radioactivity carried out during 1997 on behalf of the Joint Food Safety and Standards Group, MAFF, and SEPA. The purpose of the programme is to verify that the levels of radioactivity present within foodstuffs are acceptable, and to ensure that public radiation exposure from the consumption of these foods is within UK and internationally accepted limits. The bulk of the report therefore concerns the local effects of disposals from nuclear sites in England, Wales and Scotland.

The terrestrial programme includes the analysis of grass and soil samples collected near nuclear sites in England and Wales to fulfill requirements of the Euratom Treaty. This monitoring ceased in 1998 in response to changing requirements of the Treaty. The aquatic programme includes the sampling and laboratory analysis of a wide range of indicator materials, including water, sediments, and salt marsh, as well as the direct measurements of external dose rates in areas of known or suspected contamination.

The 1997 programme involved the collection of 1800 food samples and 3900 other samples as indicators of environmental quality, with 18,000 analyses or dose rate measurements completed. The monitoring is independent of similar programmes carried out by nuclear site

operators as a condition of their authorisations to discharge radioactive wastes. Analysis was undertaken by six laboratories, each operating a quality control procedure to the standards required by MAFF or SEPA, involving regular calibration of detectors and inter-comparison exercises with other laboratories.

Results of SEPA monitoring have previously published by the Scottish Office in the 'Statistical Bulletin: Environmental Monitoring for Radioactivity in Scotland'. Results of samples collected in the vicinity of nuclear sites in England and Wales are published as quarterly summaries on the MAFF internet site.

Contact Details

MAFF: Joint Food Safety and Standards Group, Radiological Safety and Nutrition Division, Ergon House, 17 Smith Square, London, SW1P 3JR. Tel: 0171 238 6476.
WWW: www.maff.gov.uk

SEPA: Erskine Court, The Castle Business Park, Stirling, FK9 4TR. Tel: 01786 457 700

3.5 Radiological Surveys

In most cases, radiation contributions from natural radioactivity far exceed those from anthropogenic sources. Radionuclide specific surveys of radiation levels are regularly undertaken in the vicinity of nuclear sites under the Radioactive Substances Act 1993. Such surveys are generally undertaken to monitor levels of radioactivity in the environment as a result of point source emissions. However, they do not provide an indication of background levels of radioactivity, and are not therefore discussed in this report.

Many local authorities in Scotland undertake monitoring of radiation levels and radioactivity. A number of authorities submit data on levels monitored at selected sites to LARRMACC, which publishes data collated from members throughout the UK (LARRMACC, 1998). This data indicates that background gamma dose-rates are seen to increase from the south east to the north of the UK, with areas of Scotland showing levels above the UK mean of $0.271 \mu Gy.hr^{-1}$

3.5.1 Literature Review

Table 3.10 Summary of published information on land contamination by radionuclides throughout Scotland

Location	Title	Summary	Reference
Wales, Scotland, Northern and East Midlands	Gamma-ray Spectrometric Investigations Over Four Selected Non-radioactive Mineral Deposits	Presents maps of U, K and Th gamma-ray measurements over 4 areas and measures U and Th in soil	(Brown and Ball, 1979)
England, Wales, Scotland	Gamma Radiation Levels Outdoors in Great Britain	Terrestrial gamma-ray doses measured outdoors over Great Britain. Results presented as tables, graphs and maps. Average dose rate for the population is 16 uSv. Calculations based on 10km national grid squares, if the square is not all on the given rock ty	(Green, et al., 1989)

Location	Title	Summary	Reference
Eastern Irish Sea	Distribution of Cs-137 and inventories of Pu-238, PU-239/240, Am-241 and Cs-137 in Irish sea intertidal sediments.	Estimated total inventories of radionuclides are calculated for the intertidal sedimants of the Ribble Estary, Morecombe Bay, and Solway Firth.	(Jones, 1999)
Scotland	Uranium in the Old Red Sandstone of Orkney	Analysed stream sediments and waters for U, carried out scintillometer measurements of radioactivity and measurements of radon in soil. Found high U associated with black shales, phosphatic horizons and basal conglomerates. Map of U in stream waters and sediments	(Michie and Cooper, 1979)
Scotland		ITE and the Scottish Development Department should be consulted before quoting from this document	(Miller, 1989)
Scotland, England Wales	Radiation Doses – Maps and Magnitudes	Graphic representations showing radon gas from the ground accounts for 47% of annual radioactive dose to the UK population. Shows radon levels over the UK. Discusses sources of radon and exposure to radon. General information for the public	(NRPB, 1989)
Northern Scotland	Studies of artificial radioactivity in the coastal environment of northern Scotland: a review	Paper reviews measurements of artificial radionuclides including Co-60, Sr-90, Cs-134, Cs-137, Pu-238-240, and Am-241 in various media in the northern- Scottish coastal environment.	(Pattenden and McKay, 1994)
England, Wales, Scotland	Natural levels of uranium in Britain – economic and environmental significance	Displays maps of background radioactivity in the UK	(Plant, et al., 1983)
Sizewell	An Aerial Gamma Ray Survey of the Surrounding Areas of Sizewell Nuclear Power Station, 1 Ocrober- 3 October 1996	Report presents the findings of an airborne gamma ray survey of the area surrounding Sizewell nuclear site, undertaken to establish background levels of radiationfor reference purposes.	(Sanderson, et al., 1996)
Scotland	An Airborne Gamma Ray Survey of Three Ayrshire Districts	Study carried out after Chernobyl to assess the effects on the environment. Showed most of the K, Bi and Ti radioactivity in the region was related to the geology. Maps of Cs, K, Bi and Tl distributions and gamma dose rate throughout the region presented	(Sanderson, et al., 1990)

3.6 Pathogens

A number of local authorities and landowners representing the Ministry of Defence hold information on the presence of anthrax. Site specific information relating to the presence of pathogens is held by the Chemical and Medical Research Centre (CAMR) (contact: Dr G. Lloyd, Porton Down, Salisbury, SP4 0JG. Tel: 01980 612100).

3.7 Munitions

A number of landowners representing the armed forces hold information on the presence of munitions. Amongst these the Defence Estates organisation (DEo) collates records and site data on behalf of the various Ministry of Defence (MoD) establishments. Data is often site specific and is generally only submitted to DEo during the decommissioning or redevelopment of land. Data is generally as paper records and maps included in site investigation reports.

Contact: Mr S Wainwright, Head of Water and Environmental Engineering, DEo, Blakemoor Drive, Sutton Coldfield, West Midlands, B75 7RL. Tel: 0121 311 2146

Addition information and contacts relating to Royal Airforce estates are available from: Flt. Lt. K A.D Burston, Estate Manager, RAF Benson, Wallingford, Oxon. OX10 6AA. Tel: 01491 837766 Ext. 6117.

3.8 Mining Activities and Areas Affected by Undermining

3.8.1 National Data Sets

Coal Authority: Mine Abandonment Records

The Coal Authority (formally British Coal) holds records and plans of mine abandonment (coal mines), areas affected by undermining (coal mines) and a limited number of waste tips. The data is held at two locations:

a) Mine abandonment and tip records: Information mainly as paper maps covering sites in England, Wales and Scotland is available to view at the offices provided a pre-arranged booking is made. Access is free of charge but a small charge is made for any copying.

   Contact: Coal Authority, Bretby Business Park, Ashby Rd, Burton on Trent, Staffs. DE15 0QD. Tel: 01283 553463 Fax: 01283 553464. WWW: www.coal.gov.uk

b) Undermining: Information relating to areas undermined as a result of coal extraction activities are held at the Coal Authorities Offices in Mansfield for Scotland, England and Wales. Information is accessed via a gazetteer of place names and localities in which undermining is likely to have taken place, or where a search is required for property transactions. Data is generally provided in a format designed for property transactions but general commercial inquires are also provided giving information on past, present and future mining, subsidence damage claims and working rights are available for a charge of £40.

   Contact: Coal Authority, Mining Reports, 200 Litchfield lane, Berry Hill , Mansfield, Notts, NG18 4RG Tel: 0845 7626848 WWW: www.coal.gov.uk

MINGOL Minerals Database

MINGOL provides a state-of-the-art Geographical Information System (GIS) on the nature and distribution of British metallic, industrial and construction mineral deposits, in the context of current planning and environmental constraints. It forms an easily accessible minerals information system, based on the capture and integration of BGS mineral resource datasets, from which value-added products can be developed to meet customer needs.

The datasets include information on 2500 active mines and quarries, several thousand metalliferous mineral occurrences and metalliferous mineral exploration areas. There is also an increasing amount of mineral resource and mineral planning consent information as the on-going DETR Mineral Resource Planning Map series is converted to GIS format. The new BGS Coal Resources map data will shortly also be incorporated within the MINGOL system. The datasets are viewed using the national 1:250K OS Strategic topography. A range of planning constraint data is also available, including areas of National Parks, Areas of Outstanding Natural Beauty (AONBs), SSSIs, Heritage Coasts and Scheduled Monuments in England and Wales. Much of this constraint data is obtained from other organisations (and in some cases from licensed third party suppliers of digital data).

The individual datasets are all in the process of development and gathering of additional data. There is national coverage of active mines and quarries and metalliferous mineral exploration. Mineral occurrence data is mainly complete for northern England and Wales, with limited data for Scotland. Additional functionality is under development, including Internet developments to allow access or even download of selected information. The datasets are combined within an ArcView GIS system. Particular applications are tailored to the individual needs of clients since the entire data holdings are rarely required.

The MINGOL system is on-going with data collection and verification concentrating on particular areas or datasets at any given time. Digital and paper output is currently available on request, following discussions with the client to ascertain their particular needs or applications.

Contact: British Geological Survey, Keyworth, Nottingham.
Tel: 0115 9363241; Fax: 01487 773488; WWW: http://www.bgs.ac.uk

British Geological Survey Borehole Records Database

The British Geological Survey holds records of site investigations, waste sites, borehole records and mine plans from 160 years of surveying and research. In addition to borehole records from investigations undertaken by BGS, records and reference material are also donated by a range of commercial organisations including oil and construction companies.

Contact: Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG, Tel: 0115 936 3241, Fax: 0115 936 3488

DETR Environmental Geology Map

Since 1980, the former Department of the Environment has commissioned 57 applied geological mapping studies of selected areas of Great Britain. Many of these were undertaken within coalfields to improve information on areas which might be liable to mining subsidence. The remainder of the areas was selected to cover a broad range of geological characteristics

and planning issues. The aim of these was to develop better approaches to collection, collation and presentation of geological information as a basis for planning.

Output consists of summary and technical reports and sets of thematic geological maps containing information on land use, landfill locations, made ground, land stability, the existence of underground cavities and areas of sub-surface water resources vulnerable to pollution.

Data is available as hardcopy published maps and handbooks. Some digitally produced thematic map sets may be available by application to the relevant authors.

Source for AGM reports by BGS: Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG, Tel: 0115 936 3241, Fax: 0115 936 3488

Sources for other AGM reports:

Plymouth (for reference only at), Department of the Environment, Transport and the Regions, Minerals & Waste Planning Division, Zone 4/A2, Eland House, Bressenden Place, London SW1E 5DU

Chacewater: Freeman Fox Consulting Engineers, 25 Victoria Street (South Block), Westminster, London SW1H 0EX

Bristol: Howard Humphries & Partners, Thorncroft Manor, Darking Road, Leatherhead, KT22 8JB

Torbay & St Helens: Rendel Geotechnics, Norfolk House, Smallbrook Queensway, Birmingham, B5 4LJ

Further information on the availability of these studies can be obtained from:

Department of the Environment, Transport and the Regions, Minerals & Waste Planning Division, Zone 4/A2, Eland House, Bressenden Place, London, SW1E 5DU

Mining Instability Maps

As part of a series of nationwide review projects covering ground-related issues, the Department of the Environment commissioned a series of reports on mining instability. This was performed by Arup Geotechnics and was published in 1992.

The outputs from the project were:

Summary report: three volumes of technical reports and two 1:625 000 summary maps

Volume 1: Contains 10 Geographical Reviews in the form of Regional reports with associated maps at 1:250 000 scale of counties with Ordnance Survey topographical base and plastic overlays with mining information.
Volume 2 i: The Effects of Mines,
Volume 2 ii: Investigation methods for disused mines,
Volume 2 iii Mining Subsidence Preventive and Remedial Measures

Volume 2 iv: Mining Subsidence Monitoring Methods
Volume 2 v: Procedures for Locating Disused Mine Entries.

Each regional report is allocated a series of mining area codes. Within these are mining area schedules, each of which consists of data sheets with information, including the mineral or minerals worked, method and dates of working, geology, drainage and incidences of subsidence. Information is divided into mineral types, namely metalliferous, including associated vein minerals (e.g. copper and barite), rock (e.g. sandstone), coal and associated minerals, iron (not including coalfields) and evaporites (e.g. salt, gypsum).

Areas where mining is known or suspected are depicted on the 1:250 000 scale maps in 1km square pixels. Each area of mining is colour coded by mineral type and cross referenced to a mining area code and a data sheet.

Reference: Arup Geotechnics, 1992. Review of Mining Instability in Great Britain, Summary Report. (London: HMSO).

Additional information relating to this project may be obtained from: DEFRA, Transport and the Regions, Minerals & Waste Planning Division, Zone 4/A2, Eland House, Bressenden Place, London, SW1E 5DU

Areas Affected by Natural Cavities

As part of a series of nationwide review projects covering ground-related issues, the then Department of the Environment commissioned a series of reports on instability caused by natural underground cavities in Great Britain. This was performed by Rust Environmental and the reports were published in 1994.

The outputs from the project were:

- A summary report;

- Volume 1: regional reports in 10 volumes with associated regional maps at 1:250 000 scale which are plastic overlays with a national grid for referencing against Ordnance Survey topographical base; and

- Volume 2: technical reports dealing with the nature and occurrence of natural cavities and their significance for planning and development (Vol. 2.1), a review of site investigation techniques (Vol. 2.2), and a review of ground treatment methods (Vol. 2.3).

Volumes 1 and 2 of this report contain map overlays showing locations where natural cavities are recorded. There is also supporting information and guidance notes to assist planners. On the maps, each cavity type has a different symbol and the details about each locality are held in a separate database. This database has been combined with the national data on man-made cavities collated during the DoE funded review of mining instability (see below). It is not exhaustive but is considered to be representative.

The digital database is now maintained by Rust Environmental who provide site reports (cost £195) which include detailed information from the mining instability and natural cavities databases.

Contact: Rust Environmental, Cranford, Kenilworth Road, Blackdown, Leamington Spa, CV32 6RG.

Reference: Applied Geology Limited. 1994. A review of instability due to natural underground cavities in Great Britain, 2 Vols. Available from Rust Environmental.

Additional information relating to this project may be obtained from: Department of the Environment, Transport and the Regions, Minerals & Waste Planning Division, Zone 4/A2, Eland House, Bressenden Place, London, SW1E 5DU.

3.9 Landfill Sites

3.9.1 National Data Sets

Landfill Site Digests

A directory of waste disposal and treatment sites, "The Sitefile Digest" was formerly compiled by Aspinwall & Company from publicly available information such as the registers of licences held by SEPA. In addition to a comprehensive listing of waste disposal sites by county, it contains a useful introduction to the licensing of waste management, duty of care, legal liabilities and practical considerations. The information held in the digest is a condensation of that held on a computer database, which can be used to search for sites by category, such as geographical area, site type and waste type.

Data is available in hard copy (book) for £225 including VAT or digitally for £600 + VAT.

Contacts:
(1) Eviros-Aspinwall., Walford Manor, Baschurch, Shrewsbury, SY4 2HH.
Tel: 01939 261144; Fax: 01939 261146; email:marketing@aspinwall.co.uk;
WWW: http://www.aspinwall.co.uk
(2) Landmark, 7 Abbey Court, Eagle Way, Exeter, EX2 7HY.
Tel: 01392 441700, email:mailbox@landmark-information.co.uk;
WWW: http://www.landmark-information.co.uk

3.10 Land-use information

3.10.1 National Data

The Land Cover Map of Great Britain

The Land Cover Map of Great Britain is a digital dataset produced by a semi-automated classification of satellite images from Landsat's Thematic Mapper. The map shows 25 classes of land cover, including 18 classes of semi-natural, cultivated and urban landscapes, recorded on a 25 metre grid. The Land Cover Map will be updated and upgraded by the year 2000.

Satellite imagery is used to map types of land cover. A method validation assessment was undertaken by comparison with independent ground reference data. The assessment concluded that Land Cover Map accuracy is approximately 80-85%. Further details of how the map was generated from satellite images have been published by Fuller et al. (1994), and details of the map cover types are described by Wyatt et al. (1994).

Contact: Mrs S. Wallis, Environmental Information Center, Institute of Terrestrial Ecology, Merlewood Research Station, Grange over Sands, Cumbria, LA11 6JU.
Tel: 015395 32264; Fax: 015395 34705; e-mail: S.Wallis@ite.ac.uk:
WWW: http://www.nmw.ac.uk/ITE/lcm.html

National Country Side Monitoring Scheme (NCMS)

NCMS covers approximately 7.5 % of Scotlands land area and is based on a comparison of snap shots of areal photography made in the late 1940s, early 1970s and late 1980s. With in each area 31 areal and 5 linear components of land cover features that may be related to land quality issues or contextual parameters have been identified. The resultant classification includes, built land, recreational land, transport corridor, tracks, quarries, bare ground and grass land. Data is held in a number of GIS (ARC-INFO) formats and it is geo-referenced to the British National Grid.

Contact Details: Mr Gavin Tudor, Scottish National Heritage, 12 Hope Terrace, Edinburgh, EH9 2AS., Tel: 0131 447 4784. Fax: 0131 446 2277. E-mail: Gavin.Tudor@snh.gov.uk. WWW: http://www.snh.org.uk

Land Cover Map of Scotland (LCS88)

LCS88 was the first national land cover census of Scotland and provided baseline information on rural land cover at a scale of 1:25,000. The cover features were interpreted from aerial photographs and mapped onto the OS 1:25,000 pathfinder map series. The classification system was developed specifically to provide information on semi-natural cover features, so that the greatest detail (at the lowest level in the hierarchy) relates to natural and management features within these cover types. It was always intended that the 1988 LCS be used as a baseline for monitoring change and there are current projects at the MLURI investigating the best methods for this. Due to the advances in technology over the past decade, future LCS will be able to provide a series of other products along with an updated cover map.

A maximum number of 1300 classes exists within the data set which may be sub classified into a minimum of 27 units. Data is available digitally and available in GIS (ARC-INFO) and database (Oracle) formats. It is geo-referenced to the British National Grid. QA and QC has been undertaken through use of standardized procedures and was validated by point to point ground truthing. A revised survey is currently being proposed to highlight temporal changes.

Contact details: Dr L. Comber, Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen, AB15 8QH., Tel: 01224-318611. Fax: 01224 311556. E-mail: L.comber@mluri.sari.ac.uk. WWW: http://www.mluri.sari.ac.uk

4 INFORMATION OF RESTRICTED ACCESS AND VALUE ADDED RESELLERS

4.1 National Data Restricted Access

4.1.1 British Waterways

British Waterways maintain a database of sediment quality for its waterways network within England, Wales and Scotland. Sediment sampling was originally carried out in 1992, with samples of sediment collected every 2km. Sampling was performed using a bucket and rope from the bank, or where this was not possible material was dug using a dredger or excavator. The following range of parameters were tested, with results stored as hard copy and Lotus spreadsheet package to enable subsequent data manipulation.

Air dried solids (at 30^{o}C)
pH
Cadmium (Total)
Chromium (Total)
Copper (Total)
Nickel (Total)
Lead (Total)
Zinc (Total)
Arsenic (Total)
Mercury (Total)
Total sulphide
Phenols (Total monohydric)
Cyanide (Total)
Antimony (Total)
Barium (total)
Beryllium (total)
Boron (total)
Boron (available)
Cobalt (available)
Molybdenum (total)
Phosphorus (total)
Selenium (total)
Silver (total)
Tin (total)
Thallium (total)
Tungsten (total)
Vanadium (total)
Total polycyclic aromatic hydrocarbons (PAH)
Loss on ignition
Organic matter content

A six point classification system of sediment quality was devised to provide guidance on disposal options, and present sediment quality of the British Waterways network in map format. The classification system focuses on contamination issues and their potential environmental significance in disposal, but does not address nutrient content and physical characteristics such as grain size or refuse content.

Contact Details:
Data manager: Further information may be obtained from Dr. Paul Beckwith, Llanthony Warehouse, Gloucester Docks, Gloucester, GL1 2EJ. Tel: 01452 318040, Fax: 01452 318077. WWW: www.britishwaterways.co.uk

4.1.2 Local Authority Radiation and Radioactivity Monitoring Advice and Collation Centre (LAARMACC)

LARRMACC undertakes the collation and co-ordination of monitoring results of Local Authorities (LAs) carrying out radiation monitoring following the Chernobyl accident. Membership currently comprises 236 LAs, located within England, southern Wales, Scotland and Northern Ireland. The monitoring of radiation levels and radioactivity by LAs within LARRMACC is carried out throughout the year at selected sites. Each LA implements one or more of the following techniques:

- Measurement of the radiation level 1 metre above the ground using a portable dose rate meter (MINI 6-80);
- Measurement of the radiation level 1 metre above the ground using installed integrated dosemeter (TLD);
- Continuous measurement of radiation levels and display on a VDU;
- Sampling of environmental materials (e.g. soil, grass, water, sediment) and laboratory assay for radioactive content, including specific nuclides; and
- Sampling of foodstuffs (e.g. fish, meat, milk) and laboratory assay for radioactive content, including for specific nuclides.

LAs are required to undertake monitoring and measurement in accordance with quality procedures produced by LARRMACC, and to develop and maintain Quality Manuals in order to gain full accreditation. Following accreditation, regular audits of procedures are conducted by the LARRMACC Technical Contractor.

Monitoring data generated by LARRMACC members are presented in the LARRMACC annual report.

Contact Details:
Further details may be obtained from David Miley, LARRMACC, Layden House, 76-78 Turnmill Street, London, EC1M 5QU. Tel: 0171 296 6600, Fax: 0171 296 6666.

4.2 Site-specific Data Restricted Access

4.2.1 Information from National Institutions

In addition to geographically well-defined land quality information provided by R&D institutions and local authorities, several private companies hold data on specific sites throughout England. Each holds site investigation information for numerous sites in archives. The types of information held by these organisations include: the results of desk studies and site assessment reports; the presence and abundance of inorganic and organic contaminants, radionuclides, pathogens, munitions and other environmental quality indicators; environmental impact statements, geophysical data, sludge application, landfill and radioactive sources

Water companies, authorities and boards generally undertake top-soil sample analysis to satisfy guidelines on the application of sewage sludge. Details concerning the spatial resolution of sample analysis are held in the UK Sewage sludge archive by the Agency (see above). Inorganic contaminants, which are determined, include As, Cd, Cr, Pb, Hg, Se, B, Cu,

Ni, and Zn. Samples are commonly submitted to a NAMAS accredited laboratory. Soil pH is also determined. The data are held in a digital database. Interpretation involves comparison with the sewage sludge application regulations. Sampling and analysis are ongoing. Information is already supplied to the Agency in an electronic format as part of the sludge register.

Major civil engineering projects commonly collate and manage land quality information. Data generally refers to specific sites within the project corridor. Information is generally categorised according to former land use type, geographic location, and the location within project specific boundaries. Site investigation data of soil, water and gas monitoring for a wide range of contaminants are often undertaken, depending on site history and setting, including baseline environmental data. Aerial photo reconnaissance data of the project corridor is also commonly stored in analogue form.

4.3 Value Added Resellers

Value added reselling of land quality information is undergoing rapid development and significant change. A number of companies provide data either in digital form or as paper reports including Landmark, ICC Site Search, Catalytic Data (Site-scope), Data Enhancements, Environmental Auditors Ltd (ContamiCheck). Land quality information available from a selection of environmental data suppliers is summarised below. Land quality information available from such sources is generally based on the presence of current or previous potentially contaminative land uses, as indicated by historic Ordnance Survey mapping and various land use registers. Information may be supplied as 'raw' data sheets and maps, while a number of companies also provide interpretative reports.

Data searches are normally centred on a specific site or location, with costs related to the radius of search and number of databases searched.

Land quality information available from a selection of environmental data suppliers is summarised below.

Landmark Information Group Ltd.

Landmark provide environmental and historical data derived from data sets shown in Table 4.1.

Table 4.1 Data Sets Used by Landmark

Data Source	Dataset Title	Data Type
Thomsons Trade Directories	Potentially Contaminative Industrial Uses (from 1995)	Point & text
Local Authorities	Air Pollution Control (from 1991)	Point & text
	Local Nature Reserves	Polygon
	Planning Applications (from 1988)	Point & text
	Planning Hazardous Substance Consents and Enforcements (from 1992)	Point & text
Ordnance Survey	County Series Maps (usually pre-WWII)	Raster mapping

Data Source	Dataset Title	Data Type
	National Grid Maps (from 1938)	Raster mapping
	Land-line	Digital mapping
	Strategi (1:250,000)	Digital mapping
British Geological Survey	BGS Landfill Survey (1973)	Point & text
	BGS Mines, Quarries and Minerals (1993)	Point & text
	BGS Solid Geology (1:625,000)	Polygon & text
Environment Agency	Discharge Consents (England & Wales) (from 1950)	Point & text
	Red List Discharge Consents (from 1991)	Point & text
	Water Abstractions (from 1995)	Point & text
	Substantiated Pollution Incidents Relating to Controlled Waters (from 1990)	Point & text
	Groundwater Vulnerability Mapping	Text only
	Integrated Pollution Control (IPC) (from 1991)	Point & text
	IPC Enforcements & Prosecutions (from 1991)	Point & text
	Landfill Sites (Aspinwall) (from 1974)	Point & text
	Waste transfer, treatment or disposal site (Aspinwall) (from 1976)	Point & text
	River Quality Data (1:200,000) (1995)	Polygon
	Registered Radioactive Substances (from 1991)	Point & text
SEPA	Discharge Consents (1950-1996)	Point & text
	Groundwater Vulnerability Mapping	Text only
	Integrated Pollution Control (IPC) (1992-1996)	Point & text
	IPC Enforcements and Prosecutions (1993-1996)	Point & text
	Air Pollution Control	Point & text
	Landfill Sites (1974-1996)	Point & text
	Waste Transfer, Treatment or Disposal Sites (from 1975)	Point & text
	Registered Radioactive Substances (1970-1996)	Point & text
	River Quality Data (1990)	Polygon
	Prosecutions Relating to Controlled Waters	Under development
	Substantiated Pollution Incidents Relating to Controlled Waters	Under development
English Nature Countryside Council for Wales Scottish Natural Heritage	Sites of Special Scientific Interest (SSSI)	Polygon
	Marine Nature Reserve (MNR)	Polygon
	National Nature Reserves (NNR)	Polygon
Department of the Environment, Transport and the Regions (DETR)	Areas of Outstanding Natural Beauty	Polygon
	Planning Hazardous Substance Consents and Enforcements (from 1992)	Point & text

Data Source	Dataset Title	Data Type
Ministry of Agriculture, Fisheries and Food (MAFF)	Environmentally Sensitive Areas (Scotland)	Polygon
Scottish Office	Public Water Abstractions (1995)	Point & text
Welsh Office	Planning Hazardous Substance Consents and Enforcements (from 1992)	Point & text
Farming and Rural Conservation Conservation Agency	Nitrate Vulnerability Areas	Polygon
	Nitrate Sensitive Areas	Polygon
	Environmentally Sensitive Areas (England & Wales)	Polygon
Forest Enterprise	Forest Parks	Polygon
National Radiological Protection Board (NRPB)	Radon Affected Areas (England)	Text only
Institute of Hydrology	River Network (1:50,000)	Polygon
	Flood Plain (flood hazard mapping)	Raster cells
Derived data Sets	Electro-Magnetic Fields (electricity transmission lines extracted from OS Land-line)	Digital mapping
	Infrastructure OS Strategi mapping, 1:250,000)	Digital mapping

Landmark provide information in two main reporting formats, marketed as 'EnviroCheck' and 'SiteCheck'. The Envirocheck service includes raw data sheets, a site-sensitivity map (1:10,000) and historical maps (1:10,000/ 1:10,560), while SiteCheck also provides a desk-based analysis of the information.

Contact Details
Address: 7 Abbey Court, Eagle Way, Exeter, EX2 7HY
Tel: 01392 441700
Fax: 01392 441709
Email: mailbox@landmark-information.co.uk
WWW: www.landmark-information.co.uk

Cost of data
EnviroCheck report: £295 (volume discounts may apply)

ICC Site Search Ltd

Established in 1992 as a specialist property search company, ICC Site Search provide information derived from the following SEPA, Agency and Local datasets:

Table 4.2 Data Sets Used by ICC Site Search

Data Source	Dataset	Standard Search Radius
SEPA/Agency	Water Abstractions	2km
	Groundwater Vulnerability	2km
	Surface Water Quality	2km
	Discharge Consents	2km
	Pollution Incidents	2km
	Waste	2km
	Part A IPC Processes	1km
Local Authority- Environmental Health Department	Part B Processes	Site only
	Closed Landfill Sites	1km
Local Authority- Planning Department	Planning History	Site only
	'Conditions relating to contamination issues'	Site only
	Environmentally sensitive features	1km
	Local Plan designation	-
	Previous environmental reports	Site only

Data searches are also undertaken for historical land uses, as well as geological and hydrogeological information. A variety of desk-study reports are available, including the 'Search for Contaminative Uses Report', and 'The Land Quality Statement', which includes an opinion on the impact of contamination on market value.

Cost of data
The cost of a Search For Contaminative Uses report range from £250 to £625, depending on the size of site and the reporting time required, and a Land Quality Statement £1250.

Contact Details:
ICC Site Search Ltd, Nutmeg House, 3rd Floor, 60 Gainsford Street, London, SE1 2NY.
Tel: 0171 357 6757, Fax: 0171 357 6181, Email: site.search@dial.pipex.com

5 DISCUSSION

5.1 Land Quality Information

5.1.1 Inorganic substances

Direct information on soil contamination is summarised by Appleton (1995). The study highlights regions where secondary enrichment and former metalliferous mining give rise to anomalously high concentrations (Dumfries and Galloway, Glasgow and Edinburgh). A significant degree of correlation between concentrations of PHES in stream sediments and soils were demonstrated in the UK natural contamination review (Appleton, 1995). There is potential for identifying land contamination indirectly from sediment data collected as part of the Geochemical Baseline Survey of the Environment, completed throughout Scotland at a resolution of 1 sample per 1.5 km^2. One potential advantage of these surveys is that the range of elements determined includes not only those subject to current UK legislation, but also elements such as molybdenum and uranium which are of increasing international concern. Such elements may be the subject of forthcoming legislation in soil, surface and groundwaters. The National Soil Inventory of Scotland also explains more localised elevated levels in terms of mining and smelting and the application of sewage sludge. Details of sewage sludge composition and the extent of its contamination are available from the UK Sewage Sludge Survey which also holds information on the effects of such sludge on the land to which it is applied.

Indirect contextual information on soil chemical parameters is provided by the critical loads database. Susceptibility of soils to acid deposition has significant implications regarding enhanced mobility and toxicity of PHE species. Data from ECN and Countryside 2000, despite being national surveys of more limited spatial resolution than other comparable surveys are valuable in that they incorporate a temporal component and they are linked directly to contextual information in the form, for example, of the land use classification. Data for sulphate content in soils and rocks are available for some parts of southern Scotland and provide contextual evidence focusing on a different set of soil functions (e.g. basis for structures) to those typically affected by enhanced PHES.

In the context of accurately pinpointing land contamination, data sets collected on a local scale are particularly valuable. Local authority data sets are available for Glasgow and Dundee. A number of other studies on the local scale have highlighted atmospheric and anthropogenic/industrial contaminant hot-spots. It appears that high salinity is not a problematic issue in Scotland. In general, local authority information on the local scale is of a disparate nature. Such consequent gaps in knowledge are potentially filled by information (of a local or site-specific nature) from environmental impact assessments. Such information is in collated form but is of restricted access.

Contextual information on mining activity and areas of mineralisation can provide corroborative evidence pinpointing areas where levels of PHES may be elevated above what may be expected from natural background. Table 5.1 below indicates the extent of this land. The presence of landfill may have significant implications for land quality and enhance the likelihood of elevated levels of contaminants. Extensive nation wide collations of this information are available. Land-use can explain much of the scatter inherent in elevated levels of contaminants as well as in background levels and this is also well documented at a national level. Land classification may also define land quality in a more specific sense, having direct

implications for soil functioning (eg classification of brownfield and derelict land). The limitation associated with using these contextual sources of essentially descriptive information lies in the scale-resolution. National land classification schemes, for example, may be unable to highlight contaminants which in many cases are impersistent and intermittent above a much more local scale.

Table 5.1 The extent to which metallogenic, coal mining and sludge derived contamination may influence levels of contaminant substances in Scotland. Areas are in km^2.

Total area	Area MRP reports	Area coal field	Area tilled land impacted by sludge application	% metallic mineralisation	% coal fields and mines	% sludge impacted	% total area affected
78772	27300	5000	100	34	6.3	0.1	40.4

A number of surveys of inorganic contaminants have been undertaken throughout Scotland which may be used to define the background concentration and the potential mobility of a wide range of contaminants. The surveys of greatest sample resolution were based on the collection and analysis of stream sediment (British Geological Survey, 1978a, 1978b, 1979, 1982, 1983, 1987, 1990 and 1991) which has been demonstrated to yield robust spatial distributions reflecting background inputs from natural, mineralogical and anthropogenic sources (Cooper and Thornton, 1994). One potential advantage of these surveys is that the range of elements determined includes not only those subject to current UK legislation, but also elements such as molybdenum and uranium which are of increasing international concern. Such elements may be the subject to forthcoming legislation in soil, surface and groundwaters.

A significant degree of correlation between concentrations of PHES in stream sediments and soils were demonstrated in the UK natural contamination review (Appleton, 1995). Whilst the National Soil Inventory of Scotland (Macaulay Land Use Research Institute) was conducted at a lower resolution, these samples were also analysed for available and total (acid leachable) metals. Within these national surveys, differing degrees of emphasis have been placed on upland and lowland environments, reflecting their relative susceptibility to change and importance as an agricultural resource, respectively.

Few urban centres, despite being the most densely populated parts of the UK, have been systematically surveyed for the determination of background levels of contaminants. This balance is now being redressed through the NERC URGENT thematic programme and through on-going studies undertaken by national and international bodies such as the Macaulay Land Use Research Institute. Surveying of urban environments remains problematic due to their characteristic temporal and spatial heterogeneity, and the presence of made ground.

In respect of site-specific studies, background concentrations are commonly made from off site measurements in line with best practice. However, whilst this data covers a wide range of inorganic, organic and radioactive substances it resides in individual site investigation reports. This complicates the collation of this potentially valuable data even if similar sampling, analytical methodologies and QA procedures are employed in its collection.

Table 5.2 Typical background values (mg kg^{-1}) for top-soils (< 2 mm fraction) in Scotland based on data from the Natural Contamination Review of Great Britain (Appleton, 1995)

Contaminant (total)	Estimated upper limit of background in soils (Appleton, 1995)
Cd	1.4
Cr	na
Cu	46
Ni	na
Pb	115
Zn	120

In terms of data for chemical contaminants at a national scale Scottish soil data coverage, whilst sampled at a lower resolution than stream sediment surveys, by definition gives a more accurate picture of background levels of chemical elements in Scottish soils. For a number of elements that remain undetermined in soil there is potential for the prediction of levels of these elements in soils from sediments given the large amount of data available to define an empirical regression model for this purpose. However, although patterns of soil and streams sediment chemistry are similar for the majority of contaminants actual values cannot be related so easily. This reflects the complexity of the suite of weathering and depositional processes active in the stream sediment environment and the marked differences in importance of processes in soil environments.

5.1.2 Organic Substances

Surveys have been undertaken to define the nature and distribution of a limited range of organic contaminants in UK soils, principally comprising PCBs, PCDDs and PCDFs, and PAHs. A survey of Scottish soils sampled at 36 locations between Girvan and Stonehaven found PCDDs and PCDFs in all but three samples (Scottish Office, 1987), with a maximum concentration of 20ng kg^{-1} reported. Data predominantly comprise localised surveys undertaken in the vicinity of potential contamination sources, with few data available indicating background levels of these contaminants at a regional or national scale. The majority of available information is in the form of published papers or reports.

Until the late 1980s, little background data on the distribution of organic compounds in soils were available. Studies undertaken in other industrialised countries indicated a range of compounds to be ubiquitous in the environment, largely as a result of long range transport of emissions from industrial processes. The persistence of such compounds in different environmental compartments depends on their physico-chemical properties; in particular volatility, aqueous solubility and lipophilicity. Many are resistant to degradation, and strongly adsorb onto organic material, enabling them to accumulate in top soils.

The monitoring of organic contaminants in soils has arisen partly out of public concern over their persistence and possible health risks. A number of studies reported PCB concentrations in soil samples taken in the vicinity of incineration facilities for PCBs, including a comparison of results with samples collected at locations remote from these sources. Surveys undertaken in the vicinity of chemical waste incinerators and other combustion sources plants reported various concentrations of PCDDs and PCDFs, but did not indicate background levels of these compounds, with the result that interpretation of the data was problematic.

In recognition of the paucity of baseline information, the then HMIP (now the Environment Agency) commissioned a survey of PCDD and PCDF compounds in UK soils, undertaken between 1985 and 1989 (HMIP, 1989). Sampling density for this survey was low, with only 78 sample locations spread on a 50km grid covering England, Wales and part of Scotland. A second phase of this research was undertaken (Cox and Creaser, 1995) to further investigate PDDD/PCDF concentrations in urban areas and in the vicinity of potential point sources. This survey suggested that mean levels in urban soils were significantly higher than at previous background sites. Detailed investigations have since been undertaken at a number of localities, either in order to establish the degree of contamination occurring in the vicinity of such plants (e.g. Fernandes et al, 1994, Sandalls et al, 1997), or to establish baseline data at proposed sites. (e.g. Stenhouse and Badsha, 1990).

Organic contaminants are normally present in UK soils at very low concentrations, generally at the level of ng kg^{-1} for PCDD and PCDF compounds, and μg kg^{-1} for PAH and PCB compounds. A key component of the HMIP study was the development of analytical methods and criteria for the quantitative identification of PCDDs and PCDFs at such low levels, which may be economic and practical for use in other laboratories. In consequence, subsequent studies have generally followed similar sampling and analytical procedures, enabling comparison of results between surveys.

A number of studies have established temporal trends in PCBs and PCDDs/PCDFs in soils. These studies have generally involved the comparison of contemporary soil samples with archive samples collected from long term control plots at various sites across the UK. Although none of these were located in Scotland, results have been found to be broadly representative of trends in other developed countries, PCDD/F concentrations have shown a progressive increase in PCDD/PCDF throughout this century, while. PCB concentrations showed a distinct peak during the 1960s, reflecting maximum production rates, followed by a gradual decline (e.g. Alcock et al., 1993 (pcb); Alcock et al., 1998 (PCDD/F)). A summary of surveys conducted at a national or regional scale in Scotland is shown in Table 5.3, together with a selection of surveys of temporal trends.

Table 5.3 National and regional surveys of organic compounds in soils undertaken in Scotland, including studies of temporal trends.

Reference	Contaminants	Spatial Extent	Temporal Extent	No. of sites	Congener specific?	I-TEQ values?	Individual sample data?
(Cousins et al, 1997)	PAH	England, Scotland, Wales	1951-1993	46	✔	NA	✔
(Lead et al., 1997)	PCB	England, Wales, Scotland	NR				
(HMIP, 1989)	PCDD, PCDF	England, Wales, southern Scotland	1986-7	78	✔	✘	✔
(Cox and Creaser, 1995)	PCDD, PCDF	England, Wales, southern Scotland	1988	NR		✘	✔
(Cox and Creaser, 1995)	PCDD, PCDF PCB	England, Wales, southern Scotland	1988	28* 98	✔ ✔	✔ NA	✔ ✔

*No. of sites sampled within entire survey.
** Urban sites
NR= Not recorded
NA= Not applicable

In order to accurately define background levels, samples containing PCDD or PCDF concentrations in excess of 2.5 standard deviations above the mean were rejected as outliers. The reduced data set was then used to define the distribution range of background levels in soils. The mean of this group showed a close similarity with median values for both the reduced and complete data sets, and was therefore considered to provide a reasonable estimate of typical background levels in soils. Similar approaches have been used to define background levels in other national and regional UK surveys, enabling intercomparison of survey results. Surveys have indicated that PCDDs, PCDFs and PCBs are ubiquitous in UK soils, and are likely to be found in significantly higher concentrations in soils taken from urban areas as compared to those from rural locations.

The measurement of PCDDs and PCDFs in soil is subject to considerable uncertainty as a result of the difficulties of obtaining a representative soil, and the possibility of considerable short range variability in soil concentrations. The imprecision of the analysis is also a crucial factor, particularly when analysing at trace levels. A key component of the HMIP survey was the development of analytical methods and criteria for the quantitative identification of PCDDs and PCDFs at such low levels, which may be economic and practical for use in other laboratories.

The second phase of the HMIP survey included the derivation of International Toxicity Equivalent (I-TEQ) concentrations of PCDDs and PCDFs in 11 rural soil samples, which indicated a mean of 28.4 ng TEQ/kg. A number of more detailed local surveys have calculated ITEQ values, as part of exposure assessments of existing potential sources.

Only one large-scale survey of PAH concentrations in UK soils has been undertaken to date (Cousins et al, 1997), involving the collection of soil samples at 11 locations in southern and northern Scotland. Results indicated a relatively uniform pattern of individual PAHs, although the ΣPAH varied considerably between samples. This may be due to atmospheric deposition of PAHs on a regional basis having a fairly uniform qualitative pattern, even though the quantity of PAH deposited at each site varies markedly.

The principal national and regional scale data sets defining background levels for organic compounds Scotland are summarised in Table 5.4.

Table 5.4 Typical background values of organic contaminants in soils in Scotland based on published data

Contaminants	Location	Reference	Location	No. of samples	Range	'Background' level	'Background' criteria
PAH	Eng land, Wales, Scotland	(Cousins et al, 1997)	Rural	46*	20 -7400µg/kg	460µg/kg	Median of ΣPAH
PCB	Scotland	(Bracewell et al, 1993)	Rural	60	21-362µg/kg	88.5µg/kg	Median of ΣPCB
PCB	England, Wales, S. Scotland	(HMIP, 1989)	Rural/Urban	100*	1.7- 32µg/kg	6.1µg/kg	Median of ΣPCB (+- 2.5 std dev)
PCB	England, Wales, Scotland	(Lead et al., 1997)	Rural	46*	0.5- 20µg/kg	4µg/kg	Mean of ΣPCB
PCDD, PCDF	Scotland	(Scottish Office, 1987)	Rural/ Urban	36	10-20µg/kg	-	-
PCDD, PCDF	England, Wales, S.Scotland	(HMIP, 1989)	Rural/Urban	78*	51-2602 ng/kg 19- 1220 ng/kg	237ng/kg (ΣPCDD) 95ng/kg (ΣPCDF)	Median of reduced data sets (+- 2.5std dev)

5.1.3 Radionuclides

The monitoring of radiation levels and radionuclides has been undertaken principally to assess the risks to which the human population may be exposed as a result of both natural and anthropogenic sources of radioactivity. Surveys have also been undertaken to establish the economic significance of mineral deposits. Levels of natural radioactivity, due to both cosmic and geological sources, generally far outweighs contributions from artificial sources, such as discharges to sea from nuclear establishments, and fallout derived from historic atmospheric weapons testing, and more recently as a result of the Chernobyl accident.

Information on the distribution of radionuclides in the UK environment has been derived from three principal survey methodologies:

- aerial radiometric surveys undertaken to establish environmental levels of radioactivity;

- direct measurements of external doses in areas of known or suspected contamination; and
- analysis of environmental samples, including soil, sediment and vegetation.

The use of these survey techniques to obtain information on land quality in Scotland is summarised in Table 5.5.

Aerial radiometric surveys have been undertaken to map the deposition of radioactive fallout following the Chernobyl accident in 1986. Prior to development of such techniques, knowledge of deposition patterns was based on measurements at ground level and laboratory analysis of environmental samples, together with inferences from meterological data. Aerial surveys have since enabled total radiation fields to be measured at relatively high resolution at regional scales. Aerial surveys have included those conducted within an area of Chapelcross (Sanderson, 1992), and three Ayrshire districts (Sanderson, 1990), both undertaken in order to define baseline levels.

The monitoring of radionuclides in environmental samples collected in the vicinity of nuclear establishments in Scotland is routinely performed on behalf of MAFF and SEPA. Results of these monitoring programmes are published annually (MAFF and SEPA, 1997), including radionuclide specific analyses of soil and intertidal sediment samples in the vicinity of nuclear sites, as well as a limited number of landfill sites.

Following the Chernobyl incident, surveys were conducted by ITE to determine the extent of Cs-134 and Cs-137 contamination in soil and vegetation as a result of radioactive fallout (Allen, 1986). There has been considerable interest in the spread of anthropogenic nuclides discharged into the marine environment from nuclear facilities, their impact on intertidal sediments, and potential transfer routes to the terrestrial environment. Little information on radionuclide inventories is however available for the majority of coastal areas, although detailed surveys have been undertaken in Solway Firth (eg. Jones et al, 1999) to investigate the distribution of Sellafield-derived radionuclides.

Natural background radioactivity levels are related principally to the geological and pedological characteristics of the ground. Radon Potential Maps of England, Wales and Scotland have been published by BGS at a scale of 1:625,000, based on a classification of different groups of rocks and unconsolidated deposits. Radon measurements made in dwellings are published by the NRPB, showing the estimated fraction of housing stock above the Action Level in Scotland (NRPB, 1993). Areas where 1% or more of homes exceed the Action Level of 200 becquerels per cubic metre of air (Bq m^{-3}) are defined as Radon Affected Areas.

The monitoring of direct gamma ray dose rates throughout Great Britain has been undertaken by NRPB (Green et al, 1989), while SEPA and MAFF monitoring programmes also include dose rate measurements in the vicinity of nuclear facilities. Many local authorities also undertake the monitoring of radiation levels and radioactivity, including gamma dose rate measurements and gamma spectrometry of environmental samples. The majority of local authorities participate in a quality assurance scheme operated by LARRMACC.

Table 5.5 Summary of survey techniques used to obtain information on radioactivity levels in Scotland

Scale	Aerial radioactivity survey	External dose survey	Environmental sampling
National	Natural levels of Uranium in Britain	Great Britain (NRPB)	'Post Chernobyl Radiation Monitoring' (ITE)
Regional	Chapelcross SW Scotland Ayrshire		SW Scotland N Scotland
Local			Solway Firth
		Agency Monitoring Programme (Radioactivity in the Environment) MAFF & SEPA Monitoring Programme (RIFE)	

National Radiological Protection Board, 1989. Gamma Radiation Levels Outdoors in Great Britain. Publication R191, February 1989.

5.1.4 Pathogens

It is generally considered that a wide variety of pathogens are probably ubiquitous within the UK environment (e.g. the bacteria *Clostridium tetani* and *Bacillus anthracis*). Public water supplies are routinely screened and analysed for microbiological agents that are indicative of contamination. However, little information is available regarding the distribution of pathogens in soils, partly reflecting the extremely low potential for human exposure to such organisms and our natural, and technologically enhanced, immunity. Samples collected during ground investigations at sites of known or suspected previous uses involving the processing or disposal of cattle and horses are commonly submitted for analysis for the presence of anthrax. However, no large-scale soil surveys of any pathogens were identified during the study.

5.1.5 Munitions

Little information is available regarding the distribution of munitions throughout the UK. Information identified during the study was limited to site specific survey reports held by local authorities, often based on the presence of known or suspected munitions storage or disposal rather than ground investigations.

5.2 Consultation Responses

5.2.1 Determinands

Table 5.6 below shows that the majority of consultees which provided information hold data on inorganic and organic contaminants, radionuclides and environmental quality indicators (such as pH). Few information providers hold data on pathogens and munitions. A significant proportion of these data relate solely to Scotland rather than UK-wide studies.

Table 5.6 Number of consultees holding land quality information on a range of determinands

Parameter	UK only[1]	UK + Scotland[2]
Inorganic	7	12
Organic	4	9
Radionuclides	4	7
Pathogens	1	1
Munitions	1	1
Environmental Quality Indicators	6	10

Note. [1] The numbers denote studies conducted at sites throughout the UK,
[2] Numbers denote studies undertaken within Scotland and throughout the UK.

5.2.2 Sample media and impacts

Table 5.7 below shows that the majority of land quality data held by information providers relates to made ground, top soil and both surface and groundwater. These data are used to assess a broad range of impacts.

Table 5.7 Details of sample media and impacts to which land quality information relates

Sample Media	Number	Impacts	Number
Made ground	11	Soil fertility	5
Top soil	13	Groundwater pollution	9
Stream/River Sediment	1	Ecological harm	6
Drift geology	6	Surface water pollution	8
Solid geology	6	Air quality	5
Surface water	8	Human health risk	9
Groundwater	6	Damage to built environment	7
		Socio-economic	3

5.2.3 Data format and archives

Research institutes generally store real data (such as measurements of the concentration of metals in soil) relating to land quality in electronic databases, and in many cases the information is geo-referenced in GIS packages. Land quality information is also generally stored in an electronic format by private companies, although many also retain paper copies of data. The majority of land quality information held by the local councils contacted during the review procedure, such as site investigation reports and records relating to landfill, are held only in paper format. However, a number are currently entering this into desktop GIS.

5.2.4 Data categorization

Data from site investigations, undertaken by consultants on behalf of local councils, is typically categorized and stored with the associated planning application. By contrast, research institutes often categorize land quality information on the basis of land use (or land cover) type using a GIS. Few details are available concerning categorization in private company holdings.

5.2.5 Sampling and analytical quality control and assurance

Research institutes and university departments increasingly adopt standard procedures for sampling environmental media in large spatial or temporal monitoring programmes (e.g. the Environmental Change Network), including the collection of duplicates and the use of random number sampling schemes. They also subscribe to inter-laboratory comparison exercises (QC) or laboratory accreditation schemes (e.g. NAMAS). Reference standards, blanks, spiked samples and sub-sampling are included during analysis.

Few details of quality control procedures were reported by county councils and private bodies as the responsibility for ensuring data quality falls to the consultants undertaking site investigations. Certain councils reported internal methods for ensuring appropriate procedures are followed by consultants, e.g. adherence to British Standards and the recommendations of professional bodies. In some cases larger organisations operate pre-qualification procedures based on inter-comparison exercises and/or adherence to specific quality assurance protocols.

Despite the inclusion of (international) reference standards during sample analyses in large spatial surveys, the same standards have not been included for analysis by all research departments. In addition, sampling and sub-sampling procedures, whilst internally consistent, generally lack harmonization. This is, in part, due to the continual development of analytical procedures and the ever-widening use of land quality information.

5.2.6 Temporal variability

Few organisations undertake long-term monitoring programmes relating to land quality information. The most frequently reported information relating to temporal monitoring undertaken by councils is methane from landfill sites. The ITE's ECN and Countryside 2000 survey programme are the only long-term programmes which consider temporal changes in land quality due to anthropogenic impacts.

5.2.7 Data availability

In general most organisations contacted would be willing to provide regulators with information, although many already have agreements in place for its provision. The format in which this data would be available would vary greatly, in most cases councils would be able to provide paper copies of site reports. Maps of landfill site locations may also be available. In the case of research institutes much of the data is already summarised in the form of published reports. The provision of data in electronic format

The Natural Environment Research Council (through its research institutes, including BGS and CEH and the NERC Data Strategy Group) and the various environment agencies have been negotiating a Memorandum of Understanding concerning the exchange of data. The cost of retrieving land quality information from organisations depends on the scale and the format of requirements.

5.3 Background Considerations

With the exception of the DETR funded Natural Contamination Review (Appleton, 1995), none of the national data sets presented for inorganic substances attempted to define a background concentration for any given analyte at either national or regional scales. Indeed, rather than attempting to define either natural background or background concentrations, the majority of the reported studies emphasise the wide regional and local scale variations in the concentrations of a range of elements that may be attributable to natural backgrounds, mineralisation, diffuse or point source pollution. Figure 5.1 defines a number of issues related to the definition of background ranges both from an empirical viewpoint and from additional information based on measures of land classification.

The operational definition of:

- natural background (the concentration of a substance that is derived solely from natural sources (i.e. of geogenic origin)) including mineralisation;
- background (the concentration of a substance characteristic of a soil type in an area or region arising from both natural sources and non-natural diffuse sources such as atmospheric deposition) .

as defined in ISO 11074-1:1996, also renders the calculation of a background concentration extremely difficult to achieve in practice on a non site-specific basis. For example, it can be argued that the majority of land within the United Kingdom has been subjected to some form of site-specific contamination resulting from land-use change over the past 10,000 years.

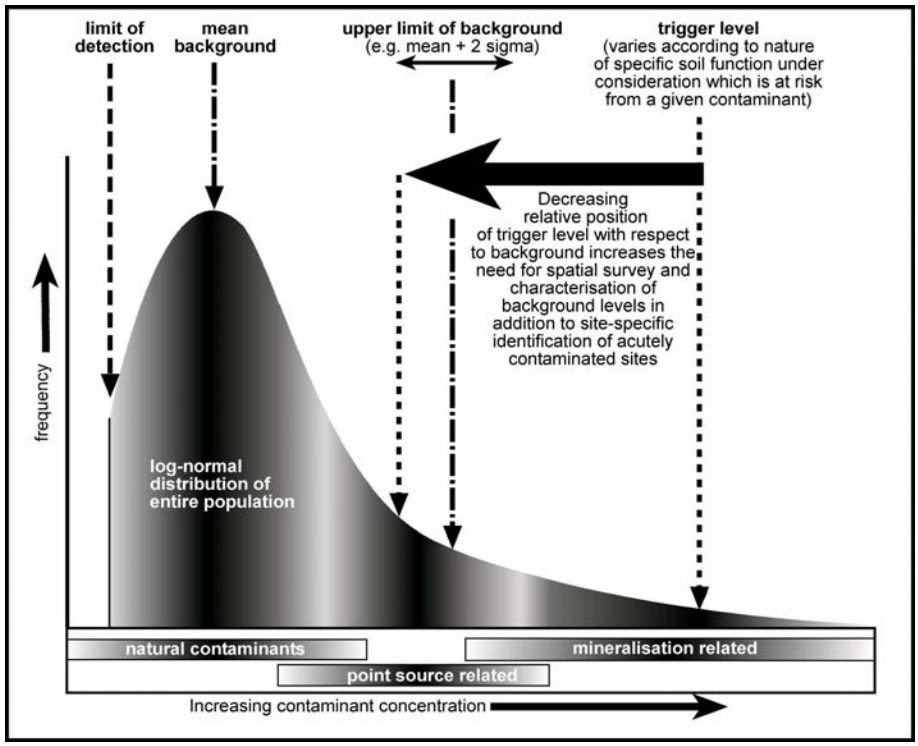

Figure 5.1 Diagram showing a typical (log-normal) distribution of a potentially harmful element or species in a single spatial survey dataset. The diagram indicates the differing nature of components of the distribution illustrating sources of the contaminant in question. A definition of background levels can be made empirically, based purely on the distribution of the observed data. The upper limit of background is often defined as being 2 standard deviations above the mean value.

Empirical definitions of background

In the case of the Natural Contamination review, "Natural background" was defined as the normal range of concentrations of an element, or elements, in an area (excluding mineralised or "contaminated" samples). The upper limit of the background range is defined as the threshold value. Concentrations above this threshold value represent natural mineralisation, diffuse or point source pollution, or some combination of each of these sources. Although there is no universally accepted method of determining the threshold value, some authors (Birke and Rauch, 1993) define the background concentration as:

- the average or geometric mean concentration of an element or substance, and;
- the threshold as the mean plus two standard deviations of the background population.

Others use the approach adopted by Appleton (1995) in the Natural Contamination review of statistically interpreting cumulative probability plots to define the normal background range of elements or compounds. However, by definition neither of these methods differentiates between either natural background (as defined by ISO to include natural mineralisation), background and contamination resulting from non-natural point sources.

Alternatively, if temporal data is collected over a sufficiently large time span, extrapolation may be made to background concentrations prior to the onset of significant anthropogenic inputs (i.e. pre-industrial revolution). For example, monitoring the changes in soils at the Rothamsted experimental station since 1843 (Catt and Henderson, 1993) or the analysis of the changes in lead content of sediment cores from upland areas (Donald et al., 1990). Whilst such methods offer considerable utility in defining background concentrations, they have limited scope due to the relatively small number, and consequently unrepresentative nature, of historically accurate sample sets for many elements.

Relating empirical definitions of background to sources of contamination

Figure 5.1 shows a typical log-normal distribution exhibited for a given contaminant in a given data set. The situation is equally typical at a range of scales of spatial survey from national down to site-specific. Background levels, which may be defined statistically from the distribution alone, reflect natural (geogenic) sources of contamination. Variation in background is due to a number of factors. Diffuse sources of pollution are important in this respect and may be directly anthropogenically induced (eg fertiliser application) or sourced via atmospheric deposition. At the national and regional scales in particular, bedrock lithology (lithogeochemistry), land-use, topographic and climatic factors will show greater variation. Such factors may have considerable influence on land quality parameters and will be reflected in a considerable level of variation in contaminant concentrations.

The skewness apparent in the distribution is due to point sources of contamination (eg from landfill, sewage sludge applications, spoil tips) and can also be ascribed to soils impacted by the effects of mineralisation. In this respect, samples within a survey can be categorised using contextual information of the type collated in this review (e.g. maps depicting the extent of coalfields and the BGS mineral reconnaissance programme extent; Figures 5.2 and 5.3 respectively). The categorisation process is most easily achieved using GIS-based approaches. From such categorisations, entire distributions can be separated into component distributions, relating to sub-classification dependent on whether sites have or have not been exposed to point source contamination. Hence there is potential to further refine the definition of background and make its distinction from anomalous values using a categorical approach.

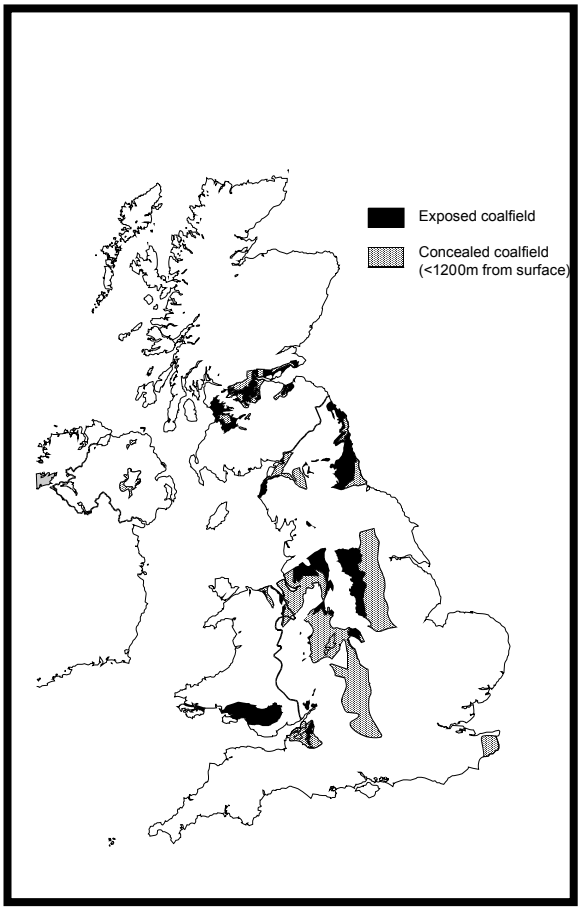

Figure 5.2 Map depicting the extent of exposed and concealed coalfields in the UK where the presence of elevated levels of trace elements map be influenced by the presence of elevated levels of potentially toxic trace elements associated with coal. NB. This map does not indicate areas of glacial drift in which coal fragments have been observed.

Background and action levels: the relationship and its implications

Setting the position of an action or intervention level depends on a suite of factors. The need to minimise harm to the population is obviously a key issue needing consideration in defining and appropriate levels at which to require action. However, this demand may be offset under certain circumstances by the increasing costs of remediation required to meet excessively stringent guidelines. Consequently a risk based approach is currently being developed. Figure 5.1 illustrates how the relative position of an action, intervention or "trigger" level with respect to this distribution in concentration may vary greatly. Trigger levels or risk quotients may differ from one contaminant substance to another. For example trigger levels for As may be much closer to mean background than for Cr. The position of the trigger level, or risk quotient will also differ for the same contaminant substance depending on which function of soil quality is being considered. The need for delineation areas of excessive contamination is paramount regardless of trigger level and as such, characterisation and risk assessment is typically achieved on the site-specific scale. However, if levels are close to background, the need for more detail during surveys at the local, site-specific scale and upwards is magnified.

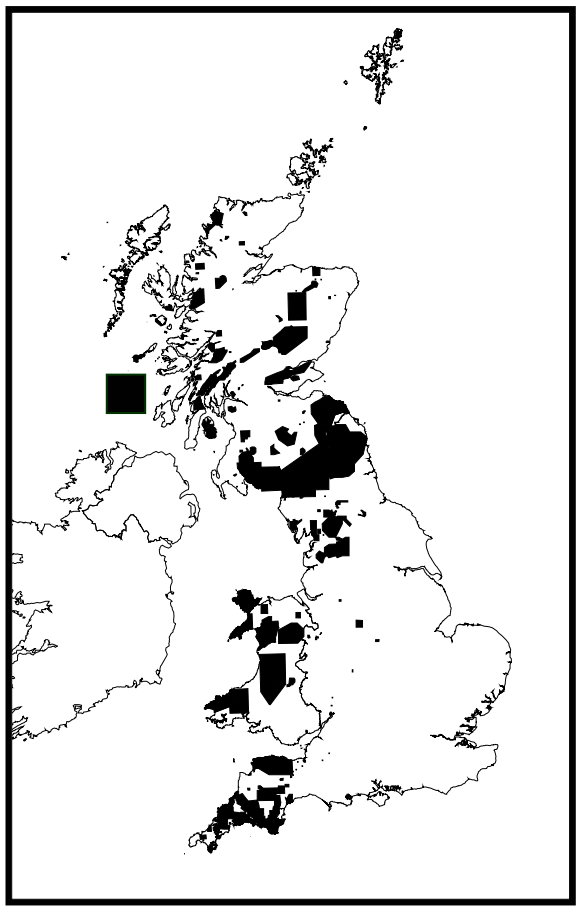

Figure 5.3 Map indicating areas of the UK investigated in the course of mineral exploration programmes. These areas may consequently be associated with the presence of elevated levels of potentially toxic trace elements resulting from natural mineralisation. NB it should be noted that this map does not include areas of mineralisation which have not been considered to be commercially exploitable or those that have been historically exploited (these are described in Appleton, 1995).

5.4 Limitations and Difficulties

The term 'land quality' encompasses a broad range of information (as described in section 2.1.2). As a result, it was necessary to consult a wide range of organisations and literature. The quantity of information available to this review study was somewhat dependent on the willingness of consultees to provide it. Of the 250 questionnaires which were sent, 105 (42%) were returned. A certain number of consultees indicated that they had been asked to provide what they considered to be very similar information in recent months for the National Land Use Database and a survey of brownfield sites. Hence, 'questionnaire fatigue' may partly explain the relatively low response rate of some local authorities and landowners. A large proportion of the research institutions which were asked to provide information were willing to do so. However, certain institutions have such large data holdings that it was only possible for them to provide an overview of the most relevant studies.

Few consultees provided an estimate of the cost of providing land quality information to the Agency because further details were required concerning exactly what information was needed. Although 'real data' was not requested from consultees, issues of commercial confidentiality and intellectual property rights were often raised as a barrier to providing details of what data is held. In virtually all cases consultees agreed to discuss these issues further directly with SEPA and/or the Agency.

6 CONCLUSIONS

6.1 Knowledge gaps

In terms of inorganic substances, specific requirements most notably highlight a need for a national scale soil survey of improved spatial resolution. More generally, the availability of information on individual contaminants such as As and, particularly, Hg and inorganic CN^- in soil is poor. However, on a regional and local scale data for As are available as is data for the concentration of trace elements in stream sediments at a national and local scale, although such data is only indicative of concentrations in soil on which regulations are based.

Only a very limited range of organic contaminants have been analysed compared to those which are of primary concern to human health and which consequently may form a basis for future legislation. The impacts of such compounds on other receptors have not been necessarily addressed at a national scale, while the low resolution of national and regional survey data for organic compounds limits the ability to interpret the distribution of organic contaminants at local scales.

Comprehensive data sets are available indicating the level of public exposure to outdoor and indoor radiation from geogenic sources. Although regular monitoring of radioactivity and radiation levels is undertaken by regulatory authorities, little information on radionuclide inventories is available for the majority of coastal areas. Little information is available indicating the distribution of pathogens in soils.

An improved understanding of temporal trends in land quality is also necessary, although this gap will be filled to some extent in the near future. The coverage of urban areas in national surveys has not necessarily been a priority in the past. Urban areas are typically considered in more localised studies. At present information from such studies does not cover Scotland to a consistent level. An improved characterisation of urban environments would be one of the main benefits from enhanced availability of site-specific information for collation. However, in many cases, this information is partially redundant, as amelioration has subsequently taken place on such sites.

There is a more fundamental need to define where data collection should be focused for the future. More specific characterisation of hazards, together with improved identification of the most harmful species and an enhanced confidence in defining adverse effect levels will undoubtedly be provided by researchers in the future in terms of a range of soil functions. As a result, knowledge gaps will become more clearly more defined, thereby allowing a more focused approach to the collection of fundamental survey data.

The majority of data relating to background levels of organic contaminants in soils was collected more than ten years ago, and there are no monitoring programmes to determine current background levels. The persistence of organic chemicals in the environment suggests that existing data are likely to be broadly representative of current soil loading. However, the pattern of emission may have altered significantly since the background trends were established, and less stable compounds will have degraded to varying degrees since the original surveys. For these reasons, it is understood that the Agency may wish to propose repeat surveys to establish contemporary baseline trends.

In terms of contextual data, few surveys include analysis of organic matter content of soils, which is acknowledged to control not only the mobility but also the toxicity of inorganic and organic pollutants in the soil, and a wide range of soil functions.

The extent to which corroborative information can be used in a reliable predictive sense needs to be addressed. Such investigation will highlight data gaps. Currently information may be unreliable and/or poorly used. For example, detrimental inferences should not be made regarding land quality simply as a result of the known presence of an industrial facility. The quality of land in such a region is only potentially of a poor nature. Much of the land quality information widely available on a national scale is ill-conditioned for use in predicting specific direct information about soil contamination at a smaller scale. In this respect, at the local scale a better integration of corroborative information at the relevant resolution with soil contaminant information is necessary. Extensive gaps may however be revealed in the availability of basic corroborative information. Classification schemes, for example of land cover, may not accurately reflect land quality at a site within a large-scale survey. A requirement for further information results from the need to (i) validate corroborative information by comparison with actual site data and (ii) integrate this information with national and regional scale direct data.

6.2 Recommendations

In general, the study has found existing national and regional data sets to be of inconsistent spatial and temporal resolution, with limited range of contaminants and contextual soil properties affecting the mobility and toxicity of contaminants. The study forms a basis on which knowledge gaps, discussed in the preceding section, may be addressed in order to prioritise research needs and formulate national policies. Recommendations are:

- Currently, the spatial resolution of information is better for sediments than for soils. In the absence of higher resolution soil data the prediction of soil quality from sediment data needs refining and additional soil data needs to be collected for validation purposes.
- A sharp focus is needed in prioritising research and data collection efforts on those substances of most concern to land quality, and particularly in identifying those substances present at natural background levels close to concentrations known to cause harm.
- Further research is necessary into the long-term effect, on land quality, of persistent organic chemicals in soils, and the potential ecological and human health risks of exposure to toxic organic chemicals in sewage sludge applied to agricultural soils.
- Consideration should be given to the communication of data between Local Authorities, regulators and national organisation. Specific issues concern the degree to which data should be collated and to what extent do mechanisms for communication need to be set up, improved or harmonised.
- Guidance for the use of data must be transparent, incorporating clear description from collection of data through to interpretation methods, recording QA.
- Consideration is also needed as to what level information should be transparent to non-experts in addition to professionals. For example, an appreciable but not excessive degree of simplification may be necessary when describing criteria for the assignment of trigger levels.

- Research is needed to identify how best to communicate information on land quality to the general public to avoid causing unnecessary blight.
- The increasing use of geographical information systems as an opportunity both to integrate data sets and also to manipulate collated data needs to be made available for unskilled users in addition to geographical information systems experts.

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8 APPENDICES

8.1 Appendix A. Land Quality Questionnaire

Environment Agency Research Project P5-019: Information on Land Quality in the UK

The Environment Agency has commissioned the British Geological Survey and LGC (formerly the Laboratory of the Government Chemist) to research currently available information on land contamination in England, Wales, Scotland and Northern Ireland. As part of this research, we are seeking to identify and assess all potential information sources. The research emphasis is placed on identifying land quality information representative of local and regional areas rather than individual sites.

The following questionnaire forms an important part of this research, and your time and assistance in completing it would be much appreciated. Please answer each of the main questions in presented in capital typeface, by placing a ✓ in the appropriate boxes, and complete relevant sub-questions, if necessary providing any additional information as an attachment.

Any information you provide will be treated in strictest confidence, and will be used by the Environment Agency purely as a research tool to assess current knowledge and identify future information needs.

Section A. Information Sources

1. WHAT IS YOUR ORGANISATION'S ROLE IN LAND QUALITY ISSUES?
E.g. Regulatory/ Local Authority/ Consultancy/ Research Institution/ Professional Body/ Information Provider…

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2. APPROX. HOW MANY ARTICLES/ REPORTS ON LAND QUALITY WITHIN THE UK DOES YOUR ORGANISATION HOLD?_____

3. **WHICH OF THE FOLLOWING SOURCES OF LAND QUALITY INFORMATION DOES YOUR ORGANISATION HOLD?**
- ❑ **A JOURNAL/ CONFERENCE PAPERS**
- ❑ B Books
- ❑ C Land quality or contamination reports
- ❑ D Desk study research
- ❑ **E RESEARCH PROJECTS**
- ❑ F Others:

---

4. HOW DOES YOUR ORGANISATION OBTAIN INFORMATION ON LAND QUALITY?
- ❑ A In-house literature reviews
- ❑ B Land use desk studies
- ❑ C Collation of environmental monitoring data
- ❑ D Undertaking research contracts
- ❑ E Commissioning research contracts
- ❑ F Undertaking site investigations
- ❑ G Commissioning site investigations
- ❑ H Ad-hoc collation of articles
- ❑ I Others:

---

5. IS YOUR ORGANISATION ENGAGED IN ONGOING RESEARCH ON LAND QUALITY?
- ❑ Yes
- ❑ No

5a Who is this research being undertaken for, and what is the project title?
Organisation(s):

Project(s):

---

6. HAVE YOU OR YOUR ORGANISATION PUBLISHED ANY INFORMATION ON LAND QUALITY WITHIN THE UK?

- ❑ Yes
- ❑ No

6a Please provide details of these publications below or as an attachment.

Author, Year:

Serial

Title:

Author, Year:

Serial:

Title:

Author, Year:

Serial:

Title:

---

7. WHAT FORM OF ARCHIVING OF LAND QUALITY INFORMATION DOES YOUR ORGANISATION UNDERTAKE?

- ❑ A Central library/collection
- ❑ B Departmental or regional libraries/collections
- ❑ C Personal collections
- ❑ D Ad-hoc department collection
- ❑ E Other type of archive

8. PLEASE PROVIDE A BRIEF DESCRIPTION OF THE ARCHIVE(S).

---

9. WHO ARE THE APPROPRIATE CONTACTS FOR THE ARCHIVE (IF NOT YOURSELF)?

Contact details:

Contact details:

---

10. DO YOU CATEGORISE OR ARCHIVE LAND QUALITY INFORMATION ACCORDING TO LAND USE TYPE?

- ❑ Yes
- ❑ No

10a Please provide details of land use criteria.

---

11. PLEASE PROVIDE DETAILS OF ANY OTHER CRITERIA YOU USE FOR CATEGORISING OR ARCHIVING LAND QUALITY INFORMATION.

---

12. PLEASE DESCRIBE ANY QUALITY CONTROL PROCEDURES YOU FOLLOW WHEN COLLATING LAND QUALITY INFORMATION. (e.g. checking accuracy/ appropriateness of sampling and analytical methodologies and data)

---

13. DO YOU MAINTAIN LAND QUALITY INFORMATION ON A COMPUTERISED DATABASE?

- ❑ Yes
- ❑ No

13a Which database package do you use?

---

14. DO YOU GEO-REFERENCE LAND QUALITY INFORMATION?

- ❑ Yes
- ❑ No

14a What grid reference system do you use? (eg. NGR, regional grid etc.)

14b Is the information integrated within a GIS package?

- ❑ Yes
- ❑ No

14c Which GIS package do you use?

14d Who is responsible for managing the GIS?
Contact details:

Section B. Information Type

15. WHICH CONTAMINANT CAUSES DOES YOUR INFORMATION INCLUDE?

- ❑ A Anthropogenic causes only
- ❑ B Natural causes only
- ❑ C Both causes, does not distinguish between them
- ❑ D Both causes, does distinguish between them
- ❑ E Unknown causes

16. WHICH CONTAMINANT SOURCES DOES YOUR INFORMATION INCLUDE?

- ❑ A Point sources
- ❑ B Diffuse pollution sources
- ❑ C Both point and diffuse sources but does not distinguish between them
- ❑ D Both point and diffuse sources, does distinguish between them
- ❑ E Unknown sources

17. WHICH TYPES OF CONTAMINANT RELEASE DOES YOUR INFORMATION INCLUDE?

- ❑ A Sudden release
- ❑ B Gradual release
- ❑ C Both sudden and gradual releases, but does not differentiate between them
- ❑ D Both point and diffuse releases, does differentiate between them
- ❑ E Unknown

18. DO YOU HOLD ANY INFORMATION INDICATING THE TEMPORAL VARIATION IN LAND QUALITY ? (eg. regular monitoring data, historic trends etc)

- ❑ Yes
- ❑ No

18a Please provide details

---

19. WHICH OF THE FOLLOWING MEDIA DOES YOUR LAND QUALITY INFORMATION RELATE TO?

- ❑ A Made ground
- ❑ B Topsoil
- ❑ C Stream/ river sediment
- ❑ D Drift geology
- ❑ E Solid geology
- ❑ F Surface water
- ❑ G Groundwater
- ❑ H Others:

---

20. Which of the following impacts Does your land quality information consider?

- ❑ A Soil fertility
- ❑ B Surface water pollution
- ❑ C Groundwater pollution
- ❑ D Ecological harm
- ❑ E Human health risks
- ❑ F Impact on air quality
- ❑ G Damage to materials and buildings
- ❑ H Socio-economic costs
- ❑ I None specifically
- ❑ J Others:

20a Do you hold case studies of the quantitative risk assessment of any of these impacts?

- ❑ Yes
- ❑ No

20b Please provide brief details

20. DOES YOUR LAND QUALITY INFORMATION INCLUDE ANY ASSESSMENT OF THE BIOAVAILABILITY OF CONTAMINANTS?

- ❑ Yes
- ❑ No

Please provide brief details

21. DO YOU HOLD LAND QUALITY INFORMATION DERIVED FROM PAST OR PRESENT SITE ACTIVITIES, OR THE PRESENCE OF MADE GROUND OR GEOHAZARDS? (eg. closed/ open landfill sites, industrial sites, mining areas)

- ❑ Yes
- ❑ No

21a Please indicate the spatial coverage and describe the scale of this information?

Coverage	Scale (eg 'site specific' or grid density etc)	Geographic area
❑ A UK-wide		
❑ B Country-wide		
❑ C County/Region-wide		
❑ D District-wide		
❑ E Site specific		
❑ F Other:		

21b What is the nature and format of this data?

21c How has land quality information been derived from this data?

22. DO YOU HOLD LAND QUALITY INFORMATION DERIVED FROM SITE INVESTIGATION MEASUREMENTS?

- ❑ Yes
- ❑ No

23a Please indicate the spatial coverage and describe the scale of this data.

Coverage	Scale (eg 'site specific' or grid density etc)	Geographic area
❑ A UK-wide		
❑ B Country-wide		
❑ C County/Region-wide		
❑ D District-wide		
❑ E Site specific		
❑ F Other:		

23b What is the nature and format of this data?

23. DO YOU HOLD LAND QUALITY INFORMATION DERIVED FROM ENVIRONMENTAL MONITORING DATA?

- ❑ Yes
- ❑ No

24a Please indicate the spatial coverage and describe the scale of this data.

Coverage	Scale (eg 'site specific' or grid density etc)	Geographic area
❑ A UK-wide		
❑ B Country-wide		
❑ C County/Region-wide		
❑ D District-wide		
❑ E Site specific		
❑ F Other:		

24b What is the nature and format of this data?

24c How has land quality information been derived from this data?

24d What further processing, if any, does the data require in order to derive land quality information?

25. DO YOU HOLD LAND QUALITY INFORMATION DERIVED FROM GEOPHYSICAL SURVEY DATA?

- ❑ Yes
- ❑ No

25a Please indicate the spatial coverage and describe the scale of this data?

Coverage	Scale (eg 'site specific' or grid density etc)	Geographic area
❑ A UK-wide		
❑ B Country-wide		
❑ C County/Region-wide		
❑ D District-wide		
❑ E Site specific		
❑ F Other:		

25b What is the nature and format of this data?

25c How has land quality information been derived from this data?

25d What further processing, if any, does the data require in order to derive land quality information?

26. DO YOU HOLD LAND QUALITY INFORMATION DERIVED FROM REMOTELY SENSED DATA?

- ❑ Yes
- ❑ No

26a Please indicate the spatial coverage and describe the scale of this information?

Coverage	Scale (eg 'site specific' or grid density etc)	Geographic area
❑ A UK-wide		
❑ B Country-wide		
❑ C County/Region-wide		
❑ D District-wide		
❑ E Site specific		
❑ F Other:		

26b What is the nature and format of this information?

26c How has land quality information been derived from this data?

26d What further processing, if any, does the data require in order to derive land quality information?

Section C. Contaminant Type

27. DOES YOUR LAND QUALITY INFDORMATION INCLUDE INORGANIC CONTAMINANTS?

- ❑ Yes
- ❑ No

27a Please indicate the range of inorganic contaminants included

- ❑ A Heavy metals: arsenic, cadmium, chromium, lead, mercury, selenium, boron, copper, nickel, zinc, others:
- ❑ B Other elements: sulphur, phosphorus, others
- ❑ C Inorganic salts: cyanide, ammonium, sulphide, sulphates, nitrates, phosphates, others
- ❑ D Acids and alkalis; specific compounds?
- ❑ E Other inorganic compounds:

28. DOES YOUR LAND QUALITY INFORMATION INCLUDE ORGANIC CONTAMINANTS?

- ❑ Yes
- ❑ No

28aPlease indicate the range of organic contaminants included

- ❑ A Aliphatic hydrocarbons: low molecular weight hydrocarbons, mineral oils, others:
- ❑ B Aromatic hydrocarbons: BTEX, phenols, others:
- ❑ C PAHs: naphthalene, pyrene, fluoranthene, anthracene, others:
- ❑ D Substituted aliphatic compounds; TCE, PCE, Tributyl-tin, others:
- ❑ E Substituted aromatic compounds; PCBs, others:
- ❑ F High molecular weight hydrocarbons; coal tars, others
- ❑ G Insecticides or herbicides:
- ❑ H Others :

29. DOES YOUR LAND QUALITY INFORMATION INCLUDE RADIONUCLIDES?

- ❑ Yes
- ❑ No

29a Please indicate the range of radionuclides included

- ❑ A Radium
- ❑ B Caesium
- ❑ C Actinides
- ❑ D Others:

---

30. DOES YOUR LAND QUALITY INFORMATION INCLUDE PATHOGENS OR OTHER BIOLOGICAL HAZARDS?

- ❑ Yes
- ❑ No

30a Please indicate the range of biological hazards included

- ❑ A Anthrax
- ❑ B Polio
- ❑ C Tetanus
- ❑ D Weil's
- ❑ E Others:

---

31. DOES YOUR LAND QUALITY INFORMATION INCLUDE MUNITIONS?

- ❑ Yes
- ❑ No

31a Please indicate the range of munitions included

---

32. DO YOU HOLD INFORMATION ON ENVIRONMENTAL QUALITY INDICATORS AS INDICATORS OF LAND QUALITY?

- ❑ Yes
- ❑ No

32a Please indicate the range of environmental quality indicators included

- ❑ Yes
- ❑ No
- ❑ A. pH
- ❑ B. Soil Temperature
- ❑ C. Redox potential
- ❑ D. Soil microflora
- ❑ E. Soil conductivity
- ❑ F. Macrofauna
- ❑ G. Soil moisture content
- ❑ H. Macroflora
- ❑ I. Others

Section D. Access to Information

33. WHAT DEGREE OF ACCESS DO YOU ALLOW TO YOUR LAND QUALITY INFORMATION?

- ❑ A Full access for private inspection
- ❑ B Restricted access for private inspection
- ❑ C Access only via searches undertaken by staff
- ❑ D No external access; internal access only
- ❑ E Not relevant/ no prior requests for access

34. DO YOU PUBLISH A DIRECTORY OF LAND QUALITY PUBLICATIONS WHICH YOU HOLD?

- ❑ Yes
- ❑ No

34a Please provide details

_____

35. WOULD YOU BE WILLING TO PROVIDE THE ENVIRONMENT AGENCY WITH LAND QUALITY INFORMATION?

- ❑ Yes
- ❑ No

35a In what format(s) would you be able to supply information? (eg electronic, paper etc)

_____

35b Can you provide an indication of the cost of providing information to the Environment Agency?

_____

36. WOULD YOU BE WILLING TO PROVIDE THE ENVIRONMENT AGENCY WITH A LISTING OF LAND QUALITY INFORMATION YOU HOLD?

- ❑ Yes
- ❑ No

37. **PLEASE PROVIDE DETAILS OF SELECTED KEY LAND QUALITY REFERENCES YOU RECOMMEND, EITHER BELOW OR AS AN ATTACHMENT TO THIS QUESTIONNAIRE.**

_____

_____

_____

_____

38. PLEASE PROVIDE DETAILS OF ANY INDIVIDUALS OR ORGANISATIONS WHOM YOU BELIEVE COULD CONTRIBUTE TO THIS RESEARCH.

Name:_____

Contact details:_____

_____

ADDRESS DETAILS

Any information you provide will be treated in strictest confidence, and will be used by the Environment Agency purely as a research tool to assess current knowledge and identify future information needs.

Please complete details below, or affix business card

Name: _____ **Tel:**_____

Organisation:_____ **Fax:**_____

Job Title/ Department: _____ **Email**_____

Address: _____

_____

Please send or fax completed questionnaire to:

Dr. Barry Rawlins, British Geological Survey, Keyworth, Nottingham, NG12 5GG.
Fax 0115 936 3264, Tel 0115 936 3610, email b.smith@bgs.ac.uk

Mr David Barr, LGC, Queens Road, Teddington, Middlesex, TW11 0LY.
Fax 0181 943 2767, Tel 0181 943 7505, email db@lgc.co.uk

Thank you for your help in undertaking this research

8.2 Appendix B. Detailed information for G-BASE atlas areas

Atlas: Shetland
Sampling Period: summer 1970
Resolution: 1 sample per 1.16 sq km
Media (number sites sampled): stream sediment (1254), stream waters (124).
Sample Preparation: The < 150 micron fraction ground until 95 % was < 100 micron using a mechanical agate mortar.
Determinands (methods): Ba, Be, B, Cr, Co, Fe, Mn, Mo, Ni, Sn, V and Zr (OES); Cu, Pb and Zn (acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 15 elements; Ba, Be, B, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, U, V, Zn and Zr in sediment and for pH, conductivity and U in water. Interpreted images for Sn were not presented due to the detection of a significant level of within site variance.

Atlas: Shetland follow up survey conducted in collaboration with the Shetlands Islands Council and Highlands and Islands Enterprise
Sampling Period: summer 1990
Media (number sites sampled): stream sediment (1240 + 124 in pilot study), stream waters (1240 + 124 in pilot study), heavy mineral panned concentrates (1240 + 124 in pilot study).
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ag, As, Al_2O_3, B, Ba, Be, Bi, Ce, CaO, Cd, Co, Cr, Cu, Fe_2O_3, Ga, K_2O, La, Li, MgO, Mn, Mo, Nb, Nd, Ni, P, Pb, Rb, Sb, SiO_2, Sn, Sr, TiO_2, U, V, W, Y, Zn and Zr (DR-ES and XRF); alkalinity, conductivity, F^- (specific ion method); pH; U (laser-induced fluorometry).
Atlas content: Interpolated geochemical maps and accompanying text are presented for As, Ba, Cu and Zn in stream sediments and fluoride in stream water.

Atlas: Orkney
Sampling Period: summer 1970
Resolution: 1 sample per 1.4 sq km
Media (number sites sampled): stream sediment (437), stream waters (88).
Sample Preparation: The < 150 micron fraction ground until 95 % was < 100 micron using a mechanical agate mortar.
Determinands (methods): Ba, Be, B, Cr, Co, Fe, Mn, Mo, Ni, Sn, V and Zr (OES); Cu, Pb and Zn (acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 15 elements; Ba, Be, B, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, U, V, Zn and Zr in sediment and for pH, conductivity and U in water. Interpreted images for Sn were not presented due to the detection of a significant level of within site variance.

Atlas: South Orkney and Caithness
Sampling Period: summer 1969
Resolution: 1 sample per 2.3 sq km
Media (number sites sampled): stream sediment (672), stream waters (104).
Sample Preparation: The < 150 micron fraction ground until 95 % was < 100 micron using a mechanical agate mortar.
Determinands (methods): Ba, Be, B, Cr, Co, Fe, Mn, Mo, Ni, Sn, Ti, V and Zr (OES); Cu, Pb and Zn (acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 16 elements; Ba, Be, B, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Ti, U, V, Zn and Zr in sediment and for pH, conductivity and U in water. Interpreted images for Sn were not presented due to the detection of a significant level of within site variance.

Atlas: Sutherland
Sampling Period: summer 1968–1972
Resolution: 1 sample per 1.8 sq km
Media (number sites sampled): stream sediment (2460), stream waters (155).
Sample Preparation: The < 150 micron fraction ground until 95 % was < 100 micron using a mechanical agate mortar.
Determinands (methods): Ba, Be, B, Cr, Co, Fe, Mn, Mo, Ni, Sn, V and Zr (OES); Cu, Pb and Zn (acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 14 elements; Be, B, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, U, V, Zn and Zr in sediment and for pH, conductivity and U in water. Interpreted images for Sn were not presented due to the detection of a significant level of within site variance and Ba was also omitted due to concern over a change in background level thought to be attributable to analytical error.

Atlas: Hebrides
Sampling Period: summer 1975
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (3370), stream waters (455), heavy mineral panned concentrates (approx. 70% of sediment sites).
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ba, Be, B, CaO, Cr, Co, Cu, Fe, La, Pb, Li, MgO, Mn, Mo, Ni, K_2O, Rb, Sr, Sn, TiO_2, V, Y, Zn and Zr (DR-ES); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 25 elements; Ba, Be, B, CaO, Cr, Co, Cu, Fe, La, Pb, Li, MgO, Mn, Mo, Ni, K_2O, Rb, Sr, Sn, TiO_2, U, V, Y, Zn and Zr in sediment and for pH, conductivity and U in water.

Atlas: Great Glen
Sampling Period: summer 1974
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (7270), stream waters (424), heavy mineral panned concentrates (approx. 70% of sediment sites).
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ba, Be, B, CaO, Cr, Co, Cu, Fe, La, Li, MgO, Mn, Mo, Ni, K_2O, Rb, Sr, Sn, TiO_2, V, Y and Zr (DR-ES); Pb and Zn (acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 25 elements; Ba, Be, B, CaO, Cr, Co, Cu, Fe, La, Pb, Li, MgO, Mn, Mo, Ni, K_2O, Rb, Sr, Sn, TiO_2, U, V, Y, Zn and Zr in sediment and for pH, conductivity and U in water.

Atlas: Argyll
Sampling Period: summer 1976 and 1977
Resolution: 1 sample per 1.6 sq km
Media (number sites sampled): stream sediment (9560), stream waters (1500), heavy mineral panned concentrates (approx. 70% of sediment sites).
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ba, Be, Bi, B, Ca, Cr, Co, Cu, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Sr, Sn, Ti, V, Y, Zn and Zr (DR-ES); Sb and As (5215 samples were analysed by acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpretative maps using proportional vector symbols and accompanying text are presented for 28 elements; Sb, As, Ba, Be, Bi, B, Ca, Cr, Co, Cu, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Sr, Sn, Ti, U, V, Y, Zn and Zr in sediment and for pH, conductivity and U in water.

Atlas: East Grampians
Sampling Period: summer 1977–1980
Resolution: 1 sample per 1.6 sq km
Media (number sites sampled): stream sediment (9920), stream waters (4230), heavy mineral panned concentrates (9920).
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ba, Be, Bi, B, Ca, Cr, Co, Cu, Ga, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Ag, Sr, Sn, Ti, V, Y, Zn and Zr (DR-ES); Sb and As (5338 samples were analysed by acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS); U (delayed neutron activation analysis).
Atlas content: Interpolated geochemical maps and accompanying text are presented for 30 elements; Sb, As, Ba, Be, Bi, B, Ca, Cr, Co, Cu, Ga, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Ag, Sr, Sn, Ti, U, V, Y, Zn and Zr in sediment and for pH, conductivity, bicarbonate, fluoride and U in water.

Atlas: Southern Scotland and Parts of Northern England
Sampling Period: summer 1977, 1981-1986
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (19,000), stream waters (4230), heavy mineral panned concentrates (19,000)
Sample Preparation: The < 150 micron fraction was ground until 95 % was < 53 micron using an agate ball mill.
Determinands (methods): Ba, Be, Bi, B, Ca, Cr, Co, Cu, Ga, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Ag, Sr, Sn, Ti, V, Y, Zn and Zr (DR-ES); Sb and As (sites to the west of 4°W were analysed by acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS). To the east of 4°W Sb and As were analysed by X-ray fluorescence); U (delayed neutron activation analysis)
Atlas content: Interpolated geochemical maps and accompanying text are presented for 30 elements; Sb, As, Ba, Be, Bi, B, Ca, Cr, Co, Cu, Ga, Fe, La, Pb, Li, Mg, Mn, Mo, Ni, K, Rb, Ag, Sr, Sn, Ti, U, V, Y, Zn and Zr in sediment and for pH, conductivity, bicarbonate, fluoride and U in water.

8.3 Appendix C. Additional Information

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
Solway Firth	Radionuclides in Irish Sea Intertidal Sediments.	Jones, D.G., Roberts, P.D., Strutt, M.H., Higgo, J.J. and Davis, J.R.	1997	Technical Report, WP/97/8.			British Geological Survey.
Caithness and Sutherland	Environmental radioactivity in Caithness and Sutherland. Part 7: Measurements of americum-241 and caesium-137 in soils from coastal locations close to the AEA Technology Establishment.	Walker, M.I., McKay, W.A., Colvin, G.G.	1990	Nuclear Energy	29	419-429	
Sellafield	Mass spectrometric analysis of plutonium in soils near Sellafield.	McCarthy, W. and Nicholls, T.M.	1990	Journal of Environmental Radioactivity	12	1-12	
Caithness and Sutherland	Studies of Environmental Radioactivity in Caithness and Sutherland.	Cawse, P.A.,	1988				UK AEA
Sellafield	Environmental monitoring in the vicinity of Sellafield following the deposition of radioactivity from the Chernobyl accident.	Jackson, D., Jones, S.R., Fulker, M.J. and Coverdale, N.G.M.	1987	Journal of the Society of Radiological Protection	7	75-87	
Sellafield	Radioactivity around the Sellafield Nuclear Complex, UK: a review of ITE studies, 1990-1994.	(Sanchez, 1997)					

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
Irish Sea	Radionuclides in Intertidal Sands and Sediments from Morecombe Bay to the Dee Estuary.	Carpenter, R.C., Burton, P.J., Strange, L.P., and Pratley, F.W.	1991	AERE-R-13803			AEA Technology
Britain	A survey of radioactive caesium in British soils: comparison of accumulations pre- and post-Chernobyl.	Cawse, P.A. and Baker, S.J.	1990				UK AEA
	Post Chernobyl studies.	(Horrill,).	1987	ITE Project 1085. Final report to MAFF.			ITE, Grange-over-Sands.
UK wide	Radiation: a guide to a contaminated countryside.	Allen, S.E.	1986	The Guardian.	July 25	17	
	Chernobyl and its aftermath.	(Horrill, 1989)					
	Chernobyl: six years after.	(Howard, 1992)					
	Radioactive contamination of tide-washed pastures. A review of current knowledge of contamination levels of radionuclides in tide-washed pastures and their implications for radionuclide levels in food products from these areas.	Howard, B.J. and Livens, F.R.	1991	TFS Report No.T07051i1. 49pp. MAFF			
	Radioactive contamination of tide-washed pastures. A review of current knowledge of contamination levels of radionuclides in tide-washed pastures and their	(Howard et al., 1996)					

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
	implications for radionuclide levels in food products from these areas.						
Site specific, England and Wales	Radionuclides around nuclear sites in England and Wales	Sanchez, A.L., Horrill, A.D., Singleton, D.L. and Leonard, D.R.P	1996	The Science of the Total Environment	181	51-63	
Solway Firth	Arificial radioactivity in tide washed pastures in south west Scotland.	McKay, W.A., Bonnett, P.J.P., Barr, H.M, Howarth, J.M.	1991	DoE Report DoE/HMIP/RR/ 91/056			DoE
Dounreay, Scotland	An assessment of onland transfer of radioactivity near Dounreay, Scotland.	Toole, J., MacKrell, A., Cook., G.T., Baxter, M.S.	1990	Journal of Environmental Radioactivity	12	299-329	
Scotland	Environmental Monitoring for Radioactivity in Scotland, 1983 to 1987.		1989	Statistical Bulletin, 2(E).			Scottish Office, Edinburgh.
Dumfries and Galloway	Manm made radionuclides in the environment of Dumfries and Galloway.	Garland, J.A., McKay, W.A., Cambray, R.S., and Burton, P.J.	1989	AERE-R13223			UK AEA, HMSO, London.
Scotland	Radioactivity in Scottish soils and grazing vegetation. Final report.	Miller, G.R., Horril, A.D., Thomson, A.J., Howson, G.	1989	Scottish Development Department/NERC.			ITE.
Scotland	Environmental Monitoring for Radioactivity in Scotland, 1985 to 1989.			Statistical Bulletin, Environment Series, ENV/1992/2.			
Outer Hebrides	Some environmental radioactivity measurements from Harris, Outer Hebrides, UK.	Horrill, A.D.	1991	The Environmentalist	11	181-184	