Information on Land Quality in England:

Sources of Information (including background contaminants)

R&D Technical Report P291

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This report identifies and summarises sources of information relating to land contamination in England. 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, baseline, England.

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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 report 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, 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 which have contributed information for incorporation into this report.

EXECUTIVE SUMMARY

This report presents an overview of information on land quality in England, carried out for the Environment Agency who are required, 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 identify data sets that can be used to assess land contamination . This includes a review of existing knowledge on background levels of contaminants in English soils 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 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 (eg 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. The study also identified the nature of data availability from individual data holders together with costing information. It has been revealed through the study that whilst a wide variety of methods have been employed to estimate background levels and the upper limit of background concentrations, few national studies have adopted this approach. 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 information relating to data access.

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 is particularly high in urban environments. Contextual descriptive data, for example in the form of land classification, for example in the form of land use coupled to industrial profiles, 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. Terms used to indicate the presence of some form of contamination include 'brownfield land', 'derelict land', and 'degraded land'. Such land does not necessarily pose a risk of harm to receptors exposed to it, but is generally not considered to be fit for beneficial use without some form of remediation. It should be noted that land use surveys typically define 'contaminated land' on the basis of the known or suspected presence of potentially contaminative practices. This differs substantially from the statutory definition applied by the Environmental Protection Act 1990 as amended, which requires the land to present a significant risk of harm to the environment or defined receptor. 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 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 for 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 data sets for use in geographical information systems, and ii) the inter-comparability of existing data sets.

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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 target (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. Because of 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)
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'*
Regolith	*'Layer of unconsolidated, weathered material, mineral grains and all other superficial deposits, that rests on unaltered, solid bedrock'*
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.
DETR	Department of the Environment, Transport and the Regions
DEFRA	Department of the Environment, Food and Rural Affairs
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
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 Environmental 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.

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), as follows

- 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 in 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. This project forms a key step in this process.

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 England. 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

Land quality information is relevant to a wide range of organizations, 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 organizations and individuals were, therefore, consulted during this project. The list included officers within the Environment Agency, SEPA 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 to the Agency for further assessment. In order to facilitate access to this 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/ or confidential. The extent of information available to the Agency may, therefore, be limited to some degree. In order to enable the Agency to prioritize data sets for conducting further research, access restrictions were assessed along with indicative costs of obtaining the information.

The determination of natural background levels forms an integral component of contaminated site investigation protocols. However, such data are 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.

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 the presence of a contaminant causes harm, but 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 also determined 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. Thus, 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.

The Environment Agency receives data from a range of surface water monitoring networks established throughout the UK, whilst groundwater pollution arising from point sources has been the subject of a number of recent reviews (Environment Agency, 1996). Information relating solely to groundwater or surface water quality was not, therefore, 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 other agricultural products. The quality of agricultural land is often reported as a grade, which reflects its crop yield potential. For example, MAFF maintain an Agricultural Land Classification (ALC) scheme throughout England and Wales (MAFF, 1988). 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 recognized 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 will often suffice. This is particularly so where such methodology makes reference to nationally and internationally recognized standard procedures, such as those published by the British Standards Institute, the International Standards Organisation (ISO) or the United States Environmental Protection Agency. 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

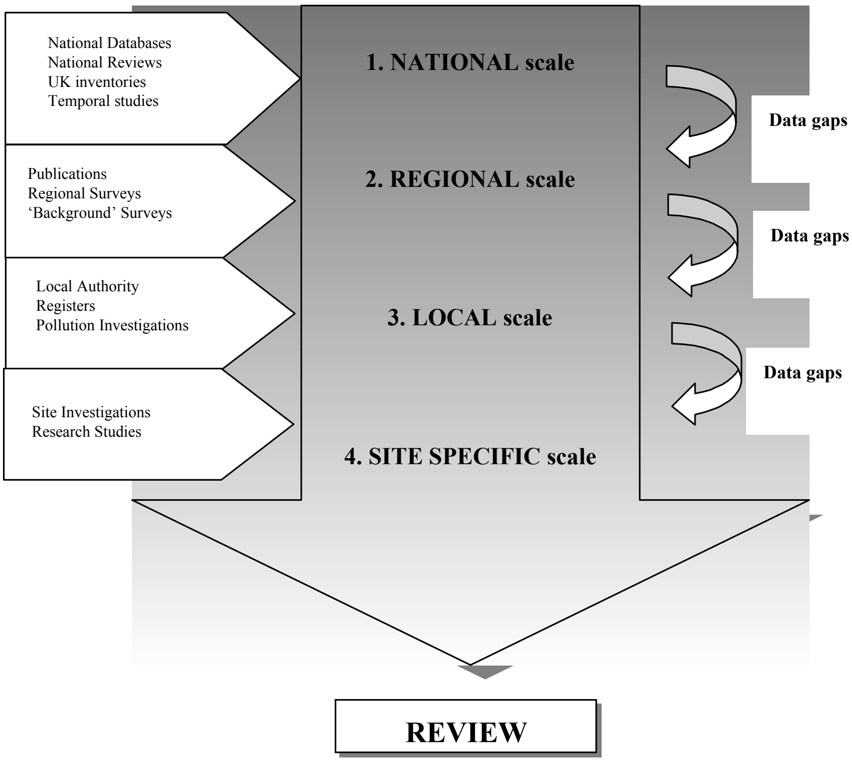
After identifying information sources and data holdings, land quality information was collated using two mechanisms: literature review and consultation with information providers.

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.

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),
- 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 localized 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. 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.

Environment Agency

Environment Agency Officers, responsible for the collation and storage of land quality information within each Region and within relevant Functions, 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. Information normally takes 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:

- Metropolitan Borough Councils and City Councils in whose areas previous industrial activities may have resulted in extensive land contamination;
- local authorities situated in rural areas; and
- local authority officers attending Environment Agency sponsored conferences on contaminated land.

Other organisations

Land quality information may be held internally by a wide range of organisations, rather than 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.

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 (Webb et al., 1978) and Geochemical Baseline Survey of the Environment programme of the British Geological Survey. The G-BASE programme of the British Geological Survey was used to provide data for the North of England and Scotland. Data for the southern England and Wales were derived from the Wolfson geochemical atlas of England and Wales as data from the more recent G-BASE programme was not yet available for these areas.

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 and to correlate and extrapolate the concentrations of these Potentially Hazardous Elements (PHEs) found in stream sediment to those found in soils (subset of the National Soil Inventory). Although the range of natural background concentrations varies in different geological settings, a national average background (NAB) 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). This format was chosen to avoid the identification of areas subject to specific levels of contamination and to lead the reader into undertaking local site specific studies. From a comparison between stream-sediment and soil data, it was concluded that areas with >4 x NAB 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). Such areas with >4 x NAB, whilst tending to be associated with areas of mining are not uncommon throughout lowland England.

The map indicates that relatively large areas of the land surface of England are characterised by concentrations of the five PHEs above NAB. This is most notable in parts of the Lake District which exhibited above national average background concentrations of As, Cd, Pb, and Zn due to secondary enrichment. In addition to these obvious areas of elevated background a noteworthy feature of the map is the relatively large number of discrete areas showing enhanced background concentrations of contaminants throughout England.

The most extensive areas with the highest values of above national background values occur throughout the Pennines and south-west England. These values can be attributed to areas of former metalliferous mining.

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. This conclusion was derived on the basis of the ICRCL guideline values which applied at that time (ICRCL, 1987).

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The Wolfson Geochemical Atlas of England and Wales

This atlas provides an overview of the chemical composition of the geological and surface environment throughout the whole of England as part of a continuous data set, which also covers Wales. Data was based on the collection of stream sediment samples at the junctions of small streams (those with an upstream catchment of <$25km^2$) with roads. This provided data points at an average density of 1 per $2.5km^2$. A range of trace elements were analyzed by a spectrographic technique on a direct reading ARL 29000B Quantometer. Zn, Cd, Molybdenum (Mo) and As cannot be adequately determined spectrographically and were thus analyzed by different techniques. Zn and Cd were analyzed by Atomic Absorption Spectroscopy (AAS) following a nitric acid digestion. Solutions of As and Mo, produced after fusion with potassium hydrogen sulphide, were analyzed by established methods: As by the Gutzeit method (colorimetry after formation of arsine) and Mo by spectrophotometry after formation of the toluene dithiol complex and extraction into toluene. Sets of computer generated maps are shown for Aluminium (Al), As, Barium (Ba), Calcium (Ca), Chromium (Cr), Cobalt (Co), Copper (Cu), Gallium (Ga), Iron (Fe), Lead (Pb), Lithium (Li), Manganese (Mn), Mo, Nickel (Ni), Potassium (K), Scandium (Sc), Strontium (Sr), Vandium (V) and Zn displaying the data in percentile classes and in empirical class divisions.

Quality control was carried out to monitor systematically the precision and accuracy of analytical and numerical data. However, reanalysis was only undertaken where errors would cause significant deviations in the overall geochemical distribution of a given parameter. This methodology was compatible with the aim of the study, which was to delineate broad scale geochemical patterns, rather than to provide point source information.

According to the Wolfson Atlas, Cd concentrations in stream sediments only exceed 5 mg kg^{-1} at a limited number of sites associated with the northern Pennines, central Derbyshire and Gloucester / Avonmouth. The majority of other sites having stream sediments less than 2 mg kg^{-1} Cd. Lack of resolution in this respect was partially due to the poor detection limit for the determination of Cd. Concentrations of Pb in stream sediments were greatest (> 320 mg kg^{-1}) in areas of known geological mineralisation (Cornwall, Mendips, Derbyshire, Lake District and Northern Pennines). However, local areas of enhanced Pb concentrations could also be associated with urbanisation (notably West Midlands / London). An overall median of around 40 mg kg^{-1} was observed throughout England. Moderately elevated Ni concentrations (> 40 but < 80 mg kg^{-1}) were observed in stream sediments overlying coal measures and metamorphic rocks throughout the southern Pennines, south west England and the Lake

District. Some moderate levels were also spatially correlated with urbanisation in the south east and north east of England. The highest observed Ni concentrations (> 160 mg kg^{-1}) were observed in sediments derived from the Lizard complex (south east Cornwall). Perhaps due to their more widespread use within society the presence of enhanced Cu and Zn concentrations within stream sediments appear to be more equally dispersed throughout England. Cu and Zn concentrations above 32 mg kg^{-1} and 150 mg kg^{-1} respectively are observed throughout Cornwall, the Lake District and Northumberland (mineralisation), in association with coal measures (south Lancashire and the central Pennines) and on the periphery of urban environments. Notable high Zn anomalies in the central northern Pennines do not show elevated levels of Cu. Arsenic concentrations were elevated (between 15 and >433 mg kg^{-1}) over much of Cornwall and west Devon, the Northampton ironstones and the Lake District. Sporadic levels exceeding 20 mg kg^{-1} were present throughout the south east, and central England. Cr concentrations in stream sediments ranged from <20 to > 217 mg kg^{-1}. Elevated concentrations (> 61 mg kg^{-1}) being observed in the Lizard Complex, east Cornwall, the central Pennines and the Lake District. A number of local anomalies were observed close to areas of industry (Northumberland, Carlisle and Chester / Queensferry).

Correlation between stream sediment and soil concentrations has not been undertaken in this atlas and it is therefore difficult to directly relate concentrations derived in stream sediments to soil based guideline values suggested by various bodies. However, as pointed out in the Natural Contamination Review (described above), areas with elevated concentrations of potentially toxic trace elements in stream sediments are also likely to contain elevated levels in soils.

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The Soil Geochemical Atlas of (England and Wales)

This atlas presents and interprets soil maps of England and Wales (from the National Soil Inventory, 1978-1982) for pH, organic carbon, total (acid extractable) and extractable concentrations of major elements, nutrients and some trace metals in top-soil samples at a resolution of 1 sample per 25 km^2. Samples were collected in non-urban areas. Following sieving to 2mm, "total" concentrations were determined by ICP-AES (inductively coupled plasma atomic emission spectrometry) after an *aqua regia* digestion in nitric and hydrochloric acid. Extractable concentrations were determined by a range of standard procedures i.e. (P, 0.5 M sodium bicarbonate; K and Mg, 1.0 M ammonium nitrate; remaining trace elements, 0.05 M EDTA pH 7.0). Organic carbon contents were determined by loss on ignition or dichromate digestion, whilst pH measurements were obtained by shaking 10 ml of soil for 15 minutes with 25 ml of distilled water and inserting a pH electrode into the solution. Quality control procedures included: the incorporation and analysis of control samples; the use of reference soils and blank digests (to check for contamination); repeat analyses and sample randomisation.

This atlas provides a broad scale picture of variations in top-soil geochemistry at the national scale. Maps and summary statistics are shown for the distributions of soil pH, organic carbon, total and extractable concentrations of Al, Ba, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, P, K, Na, Sr and Zn. Interpretations are made of the distributions in relation to soil type, geology (and mineralogy), fertiliser applications and mining contamination. Comparisons are made between the distributions of total and extractable concentrations. Localised increases in metal concentrations are attributed to mining and smelting, and the application of sewage sludge.

Of particular general relevance to land quality and the mobility of pollutants are the maps of soil pH, organic matter content, and to a lesser extent phosphorous. These maps give an indication of the likely variation in the natural attenuation of potentially harmful elements.

Data are available digitally and in hard copy (maps etc). It is spatially referenced using national grid coordinates (Ordnance Survey) and additionally may be made available in a number of GIS formats.

Data presented for Cd, Pb, Ni, Cu, Cr and Zn generally reflects similar trends to those shown in the various stream sediment data sets described in this report. However, data presented in the soil atlas also covers areas in which the sampling of stream sediments is precluded by a lack of surface streams (i.e. the limestone environments of the Pennines and Chalk Downlands of southern England). For Cd, data indicates highest concentrations in soils associated with Jurassic clays running from north Avon, north eastwards towards Nottinghamshire, and in certain areas of the chalk Downlands in southern England where the presence of Cd has been attributed to the application of phosphate fertilisers. Samples exceeding 1 mg kg^{-1} were generally found only in areas of old mining areas and close to urban and industrial areas. These areas also correlated with areas of high extractable Cd where up to 25 % of the total Cd was present in an extractable form. The highest Pb concentrations were observed in the central and northern Pennines, the Lake District, the Mendips and in a halo surrounding London. The former being associated with mineralised soils whilst the latter being a product of urbanisation and industry. In conjunction with these obvious areas of high Pb a sporadic number of sites throughout England appear to exhibit locally enriched levels of Pb. These may be due to the presence of anthropogenic sources such as household wastes (tin cans, old bottles) or the application of sewage sludge. Extractable concentrations of Pb follow a generally similar pattern to those observed for total Pb with extractable concentrations of between 13 mg kg^{-1} and 50 mg kg^{-1} being common throughout northern England and the Mendips. Areas with particularly low levels of extractable Pb (< 8 mg kg^{-1}) include much of eastern and central England, and the Midlands.

Nickel concentrations (both total and extractable) were particularly poorly correlated with concentrations observed in the Wolfson stream sediment atlas (and the Natural Contamination Review of Great Britain, which in the case of England used data derived from a combination of the national Wolfson atlas and the regional G-BASE atlases). Higher concentrations being observed over the Jurassic rocks of the Midlands, rather than the coal measures as demonstrated in the Wolfson atlas. Similarly elevated levels of Ni to those observed in the Wolfson atlas were however observed in the Lizard complex (> 60 mg kg^{-1}). Elevated concentrations of Cu (typically > 40 mg kg^{-1} total and >13 mg kg^{-1} extractable) were primarily restricted to Devon and Cornwall, the Mendips, southern Lancashire and the central Peak District. Elevated concentrations of Cu were also evident in the immediate vicinity of urban centres such as Newcastle on Tyne, the West Midlands, London and Sheffield.

Levels of Cr correlate well with available stream sediment data showing enriched levels (> 50 mg kg^{-1}) throughout Cornwall, the Mendips, the Midlands and parts of the Lake-District. Anomalous concentrations observed in the stream sediment data around Chester/Queensferry were not observed in the soil data. Such disparities at a local scale may be due to the differing sample collection densities used in these studies. Elevated concentrations of Zn (typically > 100 mg kg^{-1} total and >8 mg kg^{-1} extractable) were primarily restricted to Cornwall, the Mendips, Peak District and Northumberland.

In addition to the soil geochemical atlas the Soil Survey and Land Research Centre also publish a series of Regional Bulletins, County, District and Special soil surveys at a more local scale. These publications include some additional data on soil parameters that may be used to infer the mobility of potentially toxic trace elements such as soil wetness and organic matter. The more regional surveys however tend to include reference to data presented in the soil geochemical atlas.

Table 3.1 Summary of statistical data for the total concentration of a selection of potentially toxic trace elements soils from England and Wales (from McGrath and Loveland, 1992)

Element	Minimum	Median	Maximum
Cd	<0.2	0.8	40.9
Pb	3.0	40.0	16,338
Ni	0.8	22.6	440
Cu	1.2	18.1	1,508
Cr	0.2	39.3	838
Zn	5.0	82.0	3648

Data is available digitally and in hard copy (maps etc). It is spatially referenced using national grid co-ordinates (Ordnance Survey) and additionally may be made available in a number of GIS formats.

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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 (including NERC, DETR and the Agency). 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).

The ECN Objectives are as follows:

- 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.

The network comprises 42 freshwater (lakes and rivers) and 11 terrestrial sites (a total of 27 of which are in England). Starting in 1993, data has been collected from the terrestrial sites 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 categorised using the ITE land classification. A standardised 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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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.

One of the areas most sensitive to acid deposition is the Northern Pennines, which is dominated by peats and poorly-buffered millstone grit lithologies. In addition to these regional maps, thematic maps are being produced for a number of sensitive ecosystems.

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

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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 Lake District, North-east England and North-west England. Atlases covering the Welsh Borders and the West Midlands are scheduled for publication in 2000. It is expected that data will be released for the Humber Trent region in 1999. Sampling of the East Midlands is ongoing. The data for England are part of a continuous data set, which also encompasses Wales, Scotland 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, pure 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.

Data presented for the potentially toxic trace elements As, Cd, Pb, Ni, Cu, Cr and Zn in G-BASE regional atlases for North East England, the Lake District and North West England and North Wales, generally reflect similar trends to those shown in the earlier Wolfson stream sediment survey of England and Wales (see above). G-BASE data for northern England has also been used in the construction of the Natural Baselines Review and hence spatial trends observed in this review are also observed in this data. Data from these individual atlases covering northern England has yet to be compiled into a single coverage. However the following observations demonstrate typical features.

For Cd, data indicates highest concentrations (typically >5 mg kg^{-1}) in stream sediments associated with the naturally mineralised areas of the Lake District, Northern Pennine Orefield and Craven Basin. These areas generally correlate with areas of enhanced Cd in soil highlighted in the lower spatial resolution soil geochemical atlas. The highest Pb concentrations (typically between 100 and 16,000 mg kg^{-1}) were more dispersed than for Cd. High concentrations being present throughout the Lake District and the Northern Pennine Orefield (e.g. Weardale, Swaledale, Wensleydale and the Craven fault zone), and in a halo surrounding the urban environments of Manchester, Liverpool and Newcastle on Tyne. The former being associated with mineralised soils whilst the latter presumably being a product of urbanisation and industry. In conjunction with these obvious areas of high Pb concentrations a sporadic number of discrete sites throughout northern England appear to exhibit locally enriched levels of Pb. These may be due to the presence of anthropogenic sources such as household wastes (tin cans, old bottles) in streams, the presence of Pb shot from field sports or the application of sewage sludge to local fields. Areas with notably low Pb levels in stream sediment include the north York Moors. Again there is a generally high degree of spatial correlation between stream sediment and soil data derived from the soil geochemical atlas. There is, however, a marked disparity between the absolute concentrations of Pb measured in profile soils (45-50 cm) collected over the Yorkshire Wolds by the G-BASE survey and top soils collected during the preparation of the soil geochemical atlas. The G-BASE data suggesting a much greater average background dominated by locally elevated concentrations of up to 3,000 mg kg^{-1} compared to the soil atlas data in which no sample exceeded 40mg/kg^{-1}. This may be at least partially consistent with differences in sample collection and preparation between the two surveys, but also suggests the need for a higher sampling density in the case of the latter survey. Absolute concentrations of Pb in the limited subset of profile soil samples collected during the G-BASE Wales and North West England survey (covering North Manchester and Southport) is largely consistent with that derived from the national soil geochemistry atlas (top soils).

Nickel concentrations in Northern England are reasonably well correlated, given differences in the sampling densities, with data from the Wolfson atlas and soil geochemical atlas. Locally elevated levels of Ni (>60 mg kg^{-1}) are present throughout County Durham and south Lancashire. In addition to these potentially natural sources anthropogenically derived highs associated with the former steel-working sites at Shotton (Connah's Quay) and Brymbo (Wrexham) yield Ni concentrations in stream sediments of between 160 and 760 mg kg^{-1}. These anthropogenically enriched sites are not observed in data from either the soil geochemical survey or the Wolfson atlas. Levels of Ni in soils of the Yorkshire Wolds are broadly similar to those reported in the soil geochemical atlas.

Elevated concentrations of Cu in stream sediments in northern England (typically >40 mg kg^{-1}) are primarily restricted to the northern Pennine orefield, south Lancashire and the urban environment around Manchester. This spatial distribution correlates well with data from the soil geochemical atlas. Levels of Cr correlate reasonably well with other available stream sediment and soil data showing enriched levels (>100 mg kg^{-1}) throughout the north York Moors, the southern half of the Lake District and southern Lancashire. Elevated concentrations of Zn (typically > 300 mg kg^{-1}) are present in stream sediments throughout the northern Pennine orefield, eastern Lancashire (Forrest of Bowland) and around the urban fringe of Liverpool and Manchester. Concentrations of As were elevated (> 20 mg kg^{-1}) throughout the Lake District, in eastern Lancashire (Forrest of Bowland) and in association with Pb mineralisation in the northern Pennine orefield.

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 coordinates (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 P.M. Green, Analytical and Regional Geochemistry Group, British Geological Survey, Keyworth, Nottingham.
Tel: 0115 9363100; Fax: 0115 9363200; WWW: http://www.bgs.ac.uk/bgs/w3/argg/argg

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

A total of 1,255 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 England, 615 samples were collected from 123 km squares (approximately 5 samples in each square). Following *aqua regia* extraction, the samples will be analyzed 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 is 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. Initial data are due to be available towards the end of 2000 in either paper or digital form (spatially referenced using GB national grid coordinates) in a number of GIS formats (including Map Info, Arc Info and Arc View).

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Regional Distribution of Sulphate in Rocks and Soils of Great Britain

Sulphate salts in soils can have damaging effects on concrete structures buried below the water-table in sulphate-bearing soils. Little information has been published on the regional distribution of sulphates 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 sulphate content. Areas for which databases have been assembled include Ashington, Bath, Coventry, Castleford and Pontefract, south-west Essex, Leeds, Nottingham, Southampton, Stoke-on-Trent, Thame and Wrexham. These records have been derived from commercial site investigations, geotechnical consultants and records at the British Geological Survey. The British Standard Procedure for assessing sulphate 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 sulphate content. The authors also describe five classes of potential hazard to construction presented by soils developed from different geological formations.

The potential for sulphate 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)

UK Sewage Sludge Survey

The UK Sewage sludge survey was undertaken on behalf of the Agency by WRc. 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 percentage 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, Bath, BA2 9ES. Tel: 01225 444 066. Fax: 01225 469 393

3.1.2 Local Data Sets

MINGOL Minerals Database: Geochemical Data

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 addition to providing data relating to quarries and mines MINGOL also holds data on the chemical composition of soil and stream sediment samples collected during mineral exploration activities in the UK. Data is of varying resolution (> 50 samples per sq km to < 1 per sq km) and contains a variety of analytical determinands mainly orientated to mineral exploration. These determinands include Pb, As, Cu, Sn, Bi, Sb, Cd, Zn. QA and QC protocols are orientated to the requirements of mineral exploration rather than the identification of contaminated land. Data collection and verification concentrating on particular areas or datasets at any given time are ongoing. Digital and paper output is currently available on request, following discussions with the client to ascertain their particular needs or applications.

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Geochemical Baseline Survey of the Environment (G-BASE) -Urban Surveys

In 1993, the G-BASE rural geochemical mapping programme was extended to include sampling in urban areas. Systematic urban geochemical mapping is based on the collection of top (10 – 20 cm) and deeper (35 – 45 cm) soil samples at a sampling density of 4 per km^2. Within the sampled area, each 1 km national grid square is subdivided into four sub-squares with 500m x 500m dimensions. A soil sample is collected as close as possible to the centre point of each 500m square, access and ground characteristic limitations permitting. Top soils are oven dried and sieved to – 2 mm and deeper soils to – 150 µm. Soils are collected with a hand auger.

Sieved soil samples are ground until 95% is less than 53µm in agate planetary ball mills and split for analysis. 12g of sample are ground with 3g of Elvacite in an agate planetary ball mill for 30 minutes. The mixture is then pressed into pellets for determination of total element concentrations by X-ray Fluorescence. A list of urban centres sampled, and data available to date, is listed in Table 3.3.

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. 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 analyzed. Duplicate analyses allow the determination of inter-site and intra-site variance, and the calculation of practical detection limits and of precision.

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. 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).

Much of the land contamination work conducted in urban areas to date has focussed on identifying potentially contaminative current and former land uses. The systematic geochemical sampling of urban areas, carried out under the G-BASE programme, allows determination of actual levels of inorganic contaminants in urban environments, and enables the comparison of different urban centres.

Lead in the urban environment of Wolverhampton shows a marked enrichment over that of the immediate rural environment. In the deeper profile samples (45-50 cm) levels reach a maximum concentration of 1,930 mg kg^{-1} with a median concentration of 125 mg kg^{-1}. Similarly Cu is also enhanced in profile soils collected within the urban bounds of Wolverhampton reaching a maximum of 4,414 mg kg^{-1} with a median of 71 mg kg^{-1}. In both cases there is a strong correlation with the presence of made ground in known industrial areas and/or sewage treatment works, rather than with the presence of major road junctions as was observed in studies performed in Richmond Park, London by Imperial College. A broadly similar trend is observed in top soils where some of the elements (Pb and Zn) are present at an enhanced level compared to the deeper profile samples. This is particularly marked for Pb whos maximum and median concentration in surface samples were 2,853 and 158 mg kg^{-1} respectively. Ranges of other potentially toxic elements (in mg kg^{-1}) observed in top soils in Wolverhampton were as follows: As: 3 – 157; Cd <1 – 70; Cr 39 – 1297; Cu 14 – 3056; Ni 12 –264 and Zn 61 – 7186.

Similarly in the urban environment of Stoke on Trent concentrations of many elements, in both surface soil and profile soil samples exceed those observed in the immediate rural environment. Ranges of potentially toxic trace elements (expressed as mg kg^{-1}) in top soils were: As: 2 – 136; Cd 0.5 – 43; Cr 22 – 441; Cu 7 – 1729; Ni 5 –124, Zn 6 – 2,589 and Pb 10 – 4,208. Whilst, those in profile soils were: As: 4 – 167; Cd 0.45 – 408; Cr 41 – 574; Cu 7 – 1260; Ni 6 – 250, Zn 20 – 7408 and Pb 15 – 4,207. The similarity in levels of PHEs between top and profile samples infers that either the soil profile is well mixed, that atmospheric deposition represents a relatively small proportion of the total PHE inventory or that leaching of PHEs from the surface soil has been efficient. A good correlation was observed between the presence of made ground (e.g. landfill and ground made from coal wastes, furnace slags, pottery wastes) and the presence of enhanced PHE concentrations. The minimum and median recorded pH values of surface soils (3.0 and 5.36 respectively) indicate that heavy metals such as Pb and Cd are likely to be available for both plant uptake and assimilation throughout much of Stoke on Trent. However, mobility and availability are likely to be reduced due to the presence of organic matter (measured as LOI) which was observed to range from 0.6 to 73 % with a median value of 11%. Spatial analysis of these factors together with other data is currently being undertaken to evaluate the potential risk to various receptors from areas containing hazardous levels of PHEs.

Data is available through the G-BASE data officer at BGS, Keyworth 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 (Ordinance Survey). Data are available in a number of GIS formats (including Map Info, Arc Info and Arc View).

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3.2 Radionuclides

Information on background levels of radionuclides and radioactivity in England has been derived from principal survey methodologies:

- aerial radiometric surveys undertaken to establish environmental levels of radioactivity;
- analysis of environmental samples, including soil, sediment and vegetation;
- radiological surveys, involving the direct measurement of external doses in areas of known or suspected contamination; and
- radon potential mapping

3.2.1 Aerial Surveys

An aerial radiometric survey was initiated in 1988, in an area of West Cumbria which had remained under livestock movement restrictions since the Chernobyl accident in 1986 (Sanderson and Scott,1989). The study was in part a demonstration of an economical and promising method for mapping deposition, and in part to provide the first detailed map of the fallout pattern within this zone. Principal radionuclides of interest during the survey were Tl-208, Bi-214, K-40, and modern additions from Cs-137 and Cs-134. Results are presented as radionuclide and total dose contour maps, and indicate mean deposition levels of Cs-134 and Cs-137 of approximately 5 kBq m^{-2} and 18kBq m^{-2} and respectively.

3.2.2 Environmental Surveys

Surveys were conducted by ITE to determine the extent of contamination within the UK environment following the Chernobyl accident in 1986. A UK wide survey published in the Guardian established levels of caesium-134 and 137 within soil and vegetation. As part of this work, a ground survey of radiocaesium activity concentrations in vegetation and soils was conducted in south west Cumbria (Beresford et al, 1990). The ground survey was undertaken to investigate anomalies identified during the aerial survey conducted by SURRC (Sanderson and Scott, 1989). Three areas were surveyed, each 3km x 5km, and where possible, samples of soil collected down to bedrock.

Summary results indicate that levels of Cs-137 and K-40 encountered during the ground survey are lower than those determined by the aerial survey, as shown in Table 3.2.

Table 3.2 Comparison of aerial and ground survey results of radiocaesium deposition (kBq.m-2) in three areas of West Cumbria

Radiocaesium	Black Combe		Corney Fell		Thwaites	
	Aerial	Ground	Aerial	Ground	Aerial	Ground
Cs-134	12.3	5.3	18.6	4.8	3.4	3.9
Cs-137	34.3	19.9	18.8	15.1	21.5	11.8

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. Radionuclide activity concentrations in such areas are high compared to those of inland pastures in the same area, since contamination of the areas occurs primarily through tidal inundation with contaminated seawater and suspended sedimentary material. Howard et al. (1996) provides a review of current knowledge of contamination levels of radionuclides in tide-washed pastures from these areas.

3.2.3 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 by the Agency in the vicinity of nuclear sites, in support of the Agency's regulatory functions 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 England 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. Dose rates in lowland chalk and clay areas of the south east were generally at or below the country mean of $0.271\mu Gy.hr^{-1}$, whilst areas such as the South Pennines showed levels above this.

3.2.4 Radon Potential Mapping

The Natural Contamination Review of Great Britain (Appleton, 1995) includes a number of reports indicating the distribution of radon in the environment (Appleton and Ball, 1995, Appleton, 1995). The review was based on literature and data from readily accessible library and archive sources.

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.

Highest radon potential was predicted (and observed) over the granitic rocks of Cornwall and West Devon. Moderately elevated levels of radon were observed over the southern Pennines and locally above ironstone deposits (Northampton).

Surveys of Radon levels in houses are undertaken by the National Radiological Protection Board (NRPB). Results are published as maps which delineate Radon Affected Areas, defined as areas in which 1% or more of housing stock exceed a level of 200 $Bq.m^3$ of air.

Table 3.3 Summary of urban soil geochemistry data held by the British Geological Survey

Urban Area	Soil Depth	Number Samples	Analysis Complete	Determinands
Wolverhampton	Top	311	yes	Ti, Mn, Fe, Mg, Al, V, Cr, Sn, Sb, Ba, Cd
	Deeper	311	yes	Co, Ni,, Cu, Zn, As, Se, Mo, W, Pb
Stoke on Trent	Top	743	yes	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo Cd, Sn, Sb, Ba, Pb, U, Loss on ignition
Stoke on Trent	Top	743	no	Ca, Mg, Al, Si, P, K
Stoke on Trent	Top	192	yes	pH
Stoke on Trent	Deeper	743	yes	Ti, Mn, Fe, Mg, Al, V, Cr, Sn, Sb, Ba, Cd, Co, Ni,, Cu, Zn, As, Se, Mo, W, Pb, LOI
Stoke on Trent	Deeper	743	no	Ca, Mg, Al, Si, P, K
Telford	Top	291	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
Telford	Deeper	291	No	Cd, Sn, Sb, Ba, Pb, U
Hull	Top	407	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	407	No	Cd, Sn, Sb, Ba, Pb, U
York	Top	190	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	190	No	Cd, Sn, Sb, Ba, Pb, U
Scunthorpe	Top	192	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	192	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K
Sheffield	Top	580	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	580	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K
Doncaster	Top	292	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	292	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K
Mansfield	Top	258	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	258	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K
Lincoln	Top	216	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	216	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K
Derby	Top	276	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	276	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K, pH
Nottingham	Top	649	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	649	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P, K, pH
Peterborough	Top	274	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	274	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P,K, pH
Corby	Top	139	No	Ti, Mn, Fe, V, Cr, Co, Ni, Cu, Zn, As, Mo,
	Deeper	139	No	Cd, Sn, Sb, Ba, Pb, U, Ca, Mg, Al, Si, P,K, pH

Local Authority Information

The majority of Metropolitan Borough/City and local councils hold data on the concentration of a range of inorganic contaminants from site-specific studies. Further details are provided in section 4.0

3.2.5 Literature Review

Table 3.4 Summary of published information on land contamination by inorganic substances throughout England

Contaminant Location	Nature of Contamination	Summary	Reference
As, Cu, Pb SW England	Mining-related	Several studies with reference to mining-related contamination throughout SW England including As, Cu and Pb.	(Abrahams, 1983; Abrahams and Thornton, 1987; Abrahams and Thornton, 1994) (Aguilar Ravello, 1974; Andrews et al., 1987; Badham et al., 1979; Colbourn et al., 1975; Goodyear et al., 1996; Haswell, 1983)
Heavy Metals Tyneside	Urban	Heavy metal contamination in soils of Tyneside; a geographically-based assessment of environmental quality in an urban area	(Aspinwall et al., 1988)
Heavy Metals Staffordshire	Metalliferous geology	Heavy metals in the Hamps and Manifold valleys, North Staffordshire	(Bradley and Cox, 1987)
Trace element Pb, I, F Derbyshire	Mining-related Metalliferous geology	Trace element distribution in the superficial deposits of northern Derbyshire, England A Study of the Behaviour and Bioavailability of Lead on Sites Contaminated by Past Mining and Smelting Activity in Derbyshire Iodine in the soils of north Derbyshire Fluorine and metal enrichment of soils and pasture herbage in the old mining areas of Derbyshire, UK	(Burek and Cubitt, 1979) (Elliot, 1989) (Fuge and Long, 1989) (Geeson et al., 1998)
Heavy metals, Pb London	Urban / Industrial	Heavy metal land contamination: background levels and site case histories in the London Borough of Greenwich Lead pollution of London soils: a potential restriction on their use for growing vegetables	(Cooney, 1980) (Davies et al., 1979)
Heavy metals, Pb, Cd, Zn Somerset	Mining related Metalliferous geology	Heavy metals in soils in north Somerset, England, with special reference to contamination from base metal mining in the Mendips The Dispersion of Cd, Pb and Zn in Agricultural Soils in the Vicinity of	(Davies and Ballinger, 1990) (Goodman, 1979) (Morgan, 1988) (Shipham Survey and

Contaminant Location	Nature of Contamination	Summary	Reference
		Old Mines at Shipham, Somerset Metal contamination at Shipham	Committee, 1980) (Swarbrick, 1980)
Heavy metals, Pb Yorkshire	Metalliferous geology Mining related Mining Related	Investigation of the Heavy Metal Contamination of Preston-Under Scar, Wensleydale, North Yorkshire The significance of pollution from historic metal mining in the Pennine orefields on river sediment contaminant fluxes to the North Sea A Study of Contamination of Agricultural Soils by Past Lead Mining and Smelting Activities in the Southern Peak District	(Hyde, 1981) (Macklin et al., 1997) (Merry, 1988)
Heavy metals West Midlands	Urban / Industrial	Contaminated Sites in the West Midlands, a prospective survey	(JURUE, 1981)
Trace element Southern England	Metalliferous geology	The distribution of certain trace elements in the Lower Lias of southern England	(Le and Riche, 1959)
Heavy metals Northern England	Metalliferous geology	Heavy Metals in Northern England: Environmental and Biological Aspects	(Say and Whitton, 1981)

Region / Area	Summary	References
Lancashire	Trace element distribution in some Lancashire soils	(Butler, 1954)
Southern England	The distribution of certain trace elements in the Lower Lias of southern England	(Le and Riche, 1959)

3.3 Organic Contaminants

3.3.1 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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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. Seventy-eight 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. Fifty-four of the sites were located within England. 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.

A further 13 samples were collected from locations in London and Birmingham in order to add to the database of urban soils. 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 outliers. 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). Comparison of urban samples to the background mean indicate generally elevated concentrations in urban areas, with congener group profiles generally similar to those previously reported in soils and sediments.

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ISBN: 011 7522686
Publishers: The 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 1,200m 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 analyzed 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 localized sources and short-range transport mechanisms.

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Publisher: The Stationery Office

3.3.2 Dioxins (PCDDs) and Furans (PCDFs)

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.

A survey undertaken for HMIP in 1986 indicated the ubiquitous presence of PCDDs and PCDFs in soils throughout England, Wales and lowland Scotland (HMIP, 1989). A total of 78 samples were obtained from rural and semi-rural areas, based on the intersects of a regular 50km grid. A further 13 samples were taken in central urban areas in Birmingham and London.

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}. Information on 'typical' background levels of PCDDs and PCDFs in soils remote from urban and industrial locations was obtained by excluding samples with concentrations in excess of 2.5 standard deviations above the mean. These were considered to provide a reasonable estimate of typical concentrations in UK soils, with the corresponding standard deviations defining the typical distribution range. In general, higher concentrations of PCDDs and PCDFs were found in urban areas compared to rural locations.

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. A total of 19 samples were collected from sites in London, Birmingham, Leeds, Sheffield and Port Talbot. As with the initial HMIP survey, total concentrations were found to be higher than reported for rural locations, with concentrations of the lower congener groups showing the greatest elevation above background levels, as indicated in Table 3.5. Trends indicated that major contributions of PCDDs and PCDFs in urban areas arise from localised sources and short range transport mechanisms.

Table 3.5 Mean concentrations (ng kg^{-1}) of PCDD and PCDF in UK soils (HMIP, 1989, 1995)

Congener	'Rural' data set (66 samples)	'Urban' data set (London, Birmingam)	Urban Survey (London, Birmingham, Leeds, Sheffield, Port Talbot)
TCDD	6.0	58	65
PeCDD	4.6	56	69
HxCDD	31	160	154
HpCDD	55	350	817
OCDD	140	950	9980
TCDF	16	140	232
PeCDF	17	120	189
HxCDF	32	120	156
HpCDF	15	130	152
OCDF	15	71	196

Surveys have been undertaken at a number of localities to determine the distribution and source of PCDDs and PCDFs. A number of these surveys include information on background levels, with which concentrations in the immediate vicinity of potential emission sources are compared. A survey to establish baseline concentrations of PCDDs and PCDFs in soils around the site of a proposed chemical waste incinerator near Doncaster reported concentrations in the range 20 to 64 ng kg^{-1} for PCDD congeners, and 20 to 102 ng kg^{-1} for PCDF congeners (Stenhouse and Badsha, 1990).

Similar results were reported in a survey undertaken in the vicinity of four municipal waste incinerators in Hampshire (Abbot et. al, 1997). Results suggested that the past operation of the incinerators had contributed significantly to the PCDD and PCDF loading in the soils. A survey undertaken in the vicinity of the Coalite Works in Bolsover, Derbyshire, revealed concentrations of PCDDs and PCDFs close to the site to be well in excess of the 1986 HMIP survey and a single sample taken in the rural Peak District (Environment Agency, 1997). This sample reported a total PCDD and PCDF concentrations (Tetra- to Octa- congeners) of 121ng kg^{-1} and 85ng kg^{-1} respectively, compared to over 1000ng kg^{-1} detected in a number of samples close to the works.

The toxicity of PCDDs and PCDFs are reported by a number of surveys, measured using I-TEQ values. These are summarised in Table 3.6. Total I-TEQ values for soils sampled in the HMIP surveys were only established on a sub-set of samples from each survey (11 rural and 5 urban). The absence of reported median values for the HMIP surveys prevents a comparison between I-TEQ median values.

Table 3.6 I-TEQ concentrations reported in UK soil surveys.

Survey	Mean I-TEQ (ng kg^{-1})	Median I-TEQ (ng kg^{-1})	Reference
UK (rural sites)	5.17	not available	HMIP, 1989
London, Birmingham, Leeds, Sheffield, Port Talbot	28.37	not available	HMIP, 1995
Walsall	35	19	Fernandes et al, 1994
Doncaster	8	7	Stenhouse and Badsha, 1990
Hampshire	19-20	11	Abbot et al, 1997

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 (Alcock et. Al, 1993). Results indicate that concentrations started 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. It is suggested that the increases in soil and herbage PCDD/Fs observed are likely to be representative of agricultural systems in many industrialised countries. Similar temporal trends were identified in a study by Alcock et al. (1998), which provides evidence of the validity of data indicating the presence of these contaminants in the environment prior to the widespread development of the chloroaromatics industry in the 1930s.

Polychlorinated Biphenyls (PCB) 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.

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Publication: The Science of the Total Environment, v193, 1997, pages 229-236
Publisher: Elsevier Science

3.3.3 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.

Badsha and Eduljee (1986) have reported concentrations of PCBs in soil and grass samples collected from 22 urban and rural locations in England and Wales, including sites in Berkshire, Hampshire, London, Manchester and Pontypool. The survey was undertaken in order to provide data on background levels of PCBs in the environment, against which levels encountered in the vicinity of waste incinerators could be compared.

A survey undertaken in the English Midlands and parts of London indicated that PCB concentrations may be significantly higher for urban areas and for semi-rural sites close to major cities such as Birmingham (Creaser and Fernandes, 1986). This survey followed a limited number of localised studies in the vicinity of waste incineration facilities, and was designed to establish and validate a general method for the determination of PCBs in different soil types, at levels down to less than 1 $\mu g\ kg^{-1}$, and to analyse a sufficiently large and representative range of samples to obtain an estimate of the present background distribution of PCBs in British soils.

Results indicate a wide range of PCB concentrations, but with 80 of the samples falling within the range $2.3 \mu g\ kg^{-1}$ to $19.2 \mu g\ kg^{-1}$. It is concluded that this range provides a good estimate of background levels of PCB in rural British soils. In general, concentrations were found to increase closer to the more industrialised Midlands, although local conditions such as land use, wind direction, soil type and organic content are considered to be important in determining the concentrations at individual sampling sites.

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, notably south Wales, the English Midlands and the industrial north of England (Creaser et. al. 1989). A small number of high concentrations were attributed to local sources, including open-ended usage or spills.

The results were found to be in good agreement with earlier reported data on PCB concentrations in UK soils as shown in Table 3.7 .

Table 3.7 PCB concentrations in UK soils

Survey	Mean ($\mu g\ kg^{-1}$)	Median ($\mu g\ kg^{-1}$)	Range ($\mu g\ kg^{-1}$)	Reference
UK (‘urban’ sites)	62*	not available	11 – 141	Badsha and Eduljee, 1986
UK (‘rural’ sites)	8*	not available	1 – 23	Badsha and Eduljee, 1986
English Midlands	7.5	6.8	2.3 – 19.2	Creaser and Fernandes, 1986
UK (HMIP ‘rural’ sites)	6.1	9.5	1.7 – 32	Creaser et. al., 1989
NW England	28	not available	14 – 53	Alcock et. al., 1993
UK (46 sites)	4.0*	not available	0.3 – 8.7	Lead et. al., 1997

*Mean of all samples- other values are for reduced data sets.

An investigation undertaken in rural, semi-urban and urban areas of NW England detected somewhat higher PCB concentrations than in the English Midlands survey (Alcock et. al., 1993, although such differences may be attributable to differences in analytical methods used. Both surveys identified a distinct sub-group distinct sub-group, in this case with 85% of the samples falling below 60$\mu g\ kg^{-1}$ total PCB.

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 3.8.

Table 3.8 Summary PCB results at selected sites (after Lead et al, 1997)

Soil type	Land use	Organic matter (%)	Total PCB ($\mu g\ kg^{-1}$)
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

The 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 (see Section 3.3.1). 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 3.9.

Table 3.9 Total PCB concentrations 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
Broadbalk	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	-

Data on temporal trends in PCB soil loading is also provided by Lead et al (1997), which included analysis of archive soils collected at the same sites between 1951 and 1974. Results show increasing concentrations of PCBs up to the late 1960s/ early 1970s. A substantial decline was evident in samples collected after this time, to the extent that contemporary UK soil samples were found to be approximately five times lower than in archived the archived samples. This loss of PCBs in soils is attributed largely to volatilisation and biodegradation of these compounds.

3.3.4 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.

Only one large scale survey of PAH concentration in UK soils has been undertaken to date (Cousins et. al., 1997). 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 7,400µg 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.

The results indicate that the location and therefore the history of atmospheric deposition has the greatest influence on the PAH burden in soils. As a result, the sample with the lowest total PAH content (20µg kg^{-1}) was collected in an area remote from any anthropogenic sources in the north of Scotland, while most of the contaminated soils were collected in populated areas near to urban centres which are likely to have high air concentrations.

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 fertilisers 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 semi-rural character of the site (see Table 3.10). 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 3.10 Summary of PAH concentrations in UK soils (μg kg^{-1} dry weight) (after Jones et al., 1989)

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

3.3.5 Regional data sets

Background levels of Polychlorinated Biphenyls in British soils

This survey followed a limited number of localized studies in the vicinity of waste incineration facilities. The survey was designed to establish and validate a general method for the determination of PCBs in different soil types, at concentrations approaching less than 1μg kg^{-1}. In addition, it was aimed to analyse a sufficiently large and representative range of samples to obtain an estimate of the present background distribution of PCBs in British soils.

A total of 95 soil samples were obtained to a depth of 3cm, principally from rural and semi-rural sites. The majority of these were located on a regular sampling grid within an area stretching from Derby to Salisbury, with western and eastern extremities approximately aligned with Bath and Basingstoke respectively. Samples were also obtained at random sites in Dartmoor National Park, rural Norfolk, rural Cambridgeshire, and residential areas of South East London.

Samples were air dried and ground to yield a fraction of less than 2mm diameter. A two stage clean-up was undertaken with a hexane/acetone mixture, acid treatment, and water wash, followed by chromatography. Analysis was performed by gas chromatography and electron detection, using nitrogen as a carrier gas. Samples that showed excessive interference were analyzed by capillary column gas chromatography.

Total PCB concentrations were presented for each sample, together with frequency distribution plots. Results indicated a wide range of PCB concentrations, but with 80 of the samples falling within the range 2.3μg kg^{-1} to 19.2μg kg^{-1}. It was concluded that this range provides a good estimate of background levels of PCB in rural British soils.

Contact Details:
Authors: Colin Creaser, Alwyn Fernandes
Organisation: School of Chemical Sciences, University of East Anglia, Norwich.
Publication: Chemosphere, v.15, no.4, pages 499-508, 1986
Publisher: Pergamon Press Ltd.

3.3.6 Local data sets

A Survey of Dioxins and Furans in Surface Soil in the Vicinity of the Coalite Works, near Bolsover, Derbyshire

The report summarizes the findings of a survey undertaken to establish the extent, distribution and magnitude of PCDDs and PCDFs in surface soils in the vicinity of the Coalite Works at Bolsover. The study was initiated following surveys by MAFF, which found elevated levels of PCDDs and PCDFs in cow's milk.

Sample locations were chosen on open land that appeared not to have been disturbed for some years. The sites represented an approximately equal selection of permanent pasture, public recreation areas and private land. Limited sampling was undertaken on land to the south-west and east of the Coalite Works, which comprised predominantly tilled arable land. At each location, five soil cores of 5.5cm diameter were collected to a depth of 15cm. This sampling method followed that of the national HMIP survey (HMIP, 1989; HMIP, 1995), and was similar to that used by MAFF in earlier surveys in the locality.

Cores from each location were bulked, weighed and dried to constant weight. An internal standard of $^{13}C_{12}$- labelled 2,3,7,8-chlorine substituted PCDDs and PCDFs was added, and the soil was then extracted using a mixture of n-hexane and acetone. Following clean up by acid, analysis was carried out by capillary gas chromatography/ high resolution mass spectometry (GC/HRMS).

Data are presented illustrating congener profiles for all 46 samples. Summary tables of statistical analysis are also provided. The highest concentrations which might be expected without a local pollution source is determined by calculating the mean plus three standard deviations for the 10 PCB congeners, and for two individual congeners (2,3,7,8-TCDD and 1,2,3,7,8-PeCDD) from the UK background survey. Toxic equivalent data are also presented for each sample.

Results indicated that within 5km of the Coalite Works, PCDDs and PCDFs are present in soil at mass concentrations well in excess of the UK background levels reported by Creaser et al, 1989a. Generally, concentrations of TCDD, which was found to be the most prominent congener group, were in the region of several hundred ng/kg. However, within approximately 2km of the site, 9 samples showed concentrations in excess of 9,000ng/kg. The report concludes that this may be due to continuing influence of two past incidents at the

Coalite Works. Toxic equivalent concentrations indicated that only four samples exceeded a mean value derived from soils in urban areas.

Contact Details:
Authors: F.J. Sandalls, R.J. Berryman, S.L. Bennett, S.K.C. McCrorie, P.F.Ambridge and P.J.Coleman
Organisation: AEA Technology plc, Emissions Monitoring and Abatement Department, E1 Culham, Abingdon, Oxon.
Publisher: Environment Agency

A survey of the dioxin content of soils in Walsall

This survey was initiated following a relatively high level of PCDD/Fs found in soil samples collected during the initial HMIP survey (HMIP, 1989). Walsall Metropolitan Borough Council commissioned a survey of the soils across the borough, to consider the impact of three non-ferrous refiners. Samples were collected between November 1992 to February 1993, using the following strategy: 25 sites sampled on a regular 5km by 5km grid; 55 samples located along arcs and/or transects around each of the three metal refiners; duplicate and multiple samples collected from approximately 15 sites; and approximately 5 other specific locations. Quality control procedures included the use of method blanks, repeated extractions and internal reference materials.

Analytes chosen for the study were the seventeen 2,3,7,8 –chloro substituted PCDDs and PCDFs. Results are presented as TEQ concentrations. Data for individual isomers were prepared, but not included, in the report. Results indicate elevated dioxin levels in the vicinity of the metal refiners in Walsall. Elevated concentrations were also encountered along the western boundary of Walsall, which is interpreted as possibly indicating atmospheric transport of dioxins from the adjoining borough. There were a wide range of concentrations, and a considerable difference between mean and median values.

Authors: A. Fernandes and R. Timmis
Organisation: Warren Spring Laboratory
Reference: Warren Spring Laboratory Report CR3780
Status: Commercial in confidence

An investigation of terrestrial dioxin distributions with respect to secondary non-ferrous refiners

This paper provides a summary of the above study into PCDD and PCDF concentrations of soils in Walsall.

Authors: A Fernandes, R. Timmis and C. Dawes
Organisation: Warren Spring Laboratory, Walsall Metropolitan Borough Council
Reference: Chemosphere, vol. 29, pages 2147-2156, 1994

PCB, PCDD and PCDF concentrations in soils from the Kirk Sandal/ Edenthorpe/ Barnby Dun Area

This survey was undertaken to establish baseline levels of PCDDs and PCDFs in soils in the vicinity of a proposed chemical waste incinerator at Kirk Sandall near Doncaster. A total of 12 soil samples were taken within a radius of 2.5km from the proposed site, where possible located on undisturbed soil. Sampling protocol followed that of the HMIP survey (HMIP, 1989), comprising of a series of cores of 5cm diameter taken to a depth of 5cm, providing a total sample size of at least 2kg.

Sample clean-up and analysis essentially followed that of the HMIP survey (HMIP, 1989). Results are presented as concentration (ppb) of total PCB, 9 individual PCDD congeners, and 10 individual PCDF congeners for each sample. Standard deviation and mean concentrations of each congener are also presented, indicating the results to lie within the range found for rural backgrounds, although with slightly elevated TCDD and TCDF figures. TEQ values indicate no significant contamination of the soils.

Contact Details:
Authors: Stenhouse and Badsha
Reference: Chemosphere, 1990, v21, p563-573.

A study of dioxins and trace metals in soils around four MWIs in Hampshire- Part 1: PCDDs and PCDFs.

The survey of PCDD and PCDF levels in England, Wales and Scotland reported comparatively high concentrations in the vicinity of the Otterbourne MWI (municipal waste incinerator), Hampshire (HMIP, 1995). HMIP subsequently commissioned AEA Technology to undertake soil sampling around the four MWIs then operating in Hampshire, and to analyse the samples for PCDDs and PCDFs. This report contains the results of the analyses of the samples, together with dispersion modelling of emissions from the incinerators and an assessment of the significance of the results.

Sampling locations were determined on the basis of available dispersion modelling information. Samples were taken at distances of up to 5km along three transects centred on each incinerator. In addition, three samples were collected at greater distances to the west of the interceptors to indicate background levels. Where possible, samples were taken from undisturbed patches of grassland which showed no signs of ploughing, were not close to public roads, nor treated with pesticides or herbicides.

Sample clean-up involved the dissolution in hexane, followed by passage through a pre-washed multi-layer chromatography column. PCDDs and PCDFs were then removed by a series of elutions, performed within a dichloromethane fraction to which an isotope reference standard was added. The resulting solutions were analysed by GC-MS attached to a high resolution mass spevctrometer, and quantification carried out against the extraction standard and relative response factors. Blank samples were processed to indicate levels of detection and precision of the analysis.

Concentrations of PCDD and PCDF congeners and individual isomers are presented, indicating levels to vary widely both between and within test locations. The trends tend to match the pattern expected from the modelled dispersion around each incinerator, which it is suggested indicates that the past operation of the incinerators has contributed significantly to the PCDD and PCDF loading in the soil. Results are compared with a number of other UK soil surveys.

3.3.7 Local Authority responses

The majority of Metropolitan Borough/City and local councils hold data on the concentration of a range of organic contaminants from site-specific studies. A selection of responses from local authorities is included in Section 4.1 (National Data Restricted Access).

3.3.8 Literature review

Table 3.11 Summary of published information on land contamination by organic substances throughout England

Contaminants	Location	Title	Comments(1)	Reference
PAHs	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)
PCBs	UK wide	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)
PCDDs, PCDFs	Rothamsted Experimental Station	Evidence for the presence of PCDD/Fs in the environment prior to 1900 and further studies on their temporal trends	Experiment comparing concentrations of PCDD/Fs in archive soil collected in 1881 with present day soil from same field plot at Rothamsted Experimental Station. Increased concentrations in modern soil, due to cumulative atmospheric deposition.	(Alcock et al., 1998)
PCBs	NW England	Polychlorinated biphenyls in the British Environment: sinks, sources and temporal trends	Paper estimates the present UK environmental loading of PCBs. PCB persistence broadly increases with increasing chlorination.	(Harrad et al., 1994)
PCBs	Midlands	Background levels of polychlorinated biphenyls in British soils.	99 soil samples collected on approximately regular grid across Southern to Midlands region. PCBs detected in all samples, broadly consistent with other industrialised countries.	(Creaser and Fernandes, 1989)
PAH	Luddington	The long-term persistence of polynuclear aromatic	PAH data presented from long-term field experiment in which soil plots were amended with a sewage sludge	(Wild et al., 1991)

Contaminants	Location	Title	Comments(1)	Reference
		hydrocarbons (PAHs) in an agricultural soil amended with metal-contaminated sewage sludges	addition. Results indicated 90% loss of PAH over 20 years.	
PCDDs, PCDFs	Bolsover, Derbyshire	Concentrations of PCDD/PCDFs in soil around a point source.	Soil samples taken from several locations within 2km of chemical waste incinerator which ceased operation in 1991. Paper comments on the congener profiles of the samples and reports concentrations of PCDD/Fs between 1992 and 1997.	(Holmes et al., 1998)
PAH	Birmingham	Polynuclear aromatic hydrocarbon concentrations in road dust and soil samples collected in the United Kingdom and Pakistan	Concentrations of PAH measured in samples of soils, surface and road dusts and air from various locations in Birmingham. Soil concentrations found to be comparable with other urban areas of the UK, correlating well with airborne particulate matter.	(Smith et al., 1995)
PCDDs, PCDFs	Walsall	Warren Spring Laboratory Report CR380: Walsall- A survey of dioxin levels in soils.	Survey commissioned following findings elevated dioxin concentrations in Walsall by HMIP 1989 survey (2nd Tech. Report). Results indicate highest dioxin levels in vicinity of three metal refiners.	(Fernandes and Timmis, 1993)
PAHs	Birmingham	Some observations on the polycyclic aromatic (PAH) content of surface soils in urban areas.	PAH content of surface soils in the vicinity of heavy vehicular traffic near the M6-A38 interchange are reported. Elevated concentrations encountered at up to at least 100m from traffic.	(Butler et al., 1984)
PCBs	Fawley	Environmental monitoring for PCB and trace metals in the vicinity of a chemical waste disposal facility-3	Metal and PCB analysis of a range of grass and soil samples collected from the area surrounding the ReChem incinerator at Fawley are considered to indicate that the area is not affected by significant point source emissions.	(Badsha et al., 1986)
PAHs, petroleum hydrocarbons	Wolverhampton	BGS Technical Report WI/95/15: Organic Geochemical Studies in Wolverhampton	Survey of distribution of selected organic contaminants in surface waters and sediments within Wolverhampton. Significant cocnetrations of PAH and petroleum hydrocarbons in water course sediments, correlating with TOC and extractable organic matter.	(Hughes et al., 1996)
PAH	Rothamsted	Organic contaminants in an agricultural soil with a known history of sewage sludge amendments: polynuclear aromatic hydrocarbons		(Wild et al., 1990)
Chlorobenzene	Rothamstead	Chlorobenzenes in field soil with a history of multiple sewage sludge applications	Reports long-term experiment that received 25 separate sewage sludge applications from 1942 to 1961. Chlorobenzene content increased	(Wang et al., 1995)

Contaminants	Location	Title	Comments(1)	Reference
			markedly during 1960s; trace level impurities in pesticides and/or atmospheric deposition are possible sources.	
Chlorobenzenes, PCBs, PAHs	Luddington, Warwickshire	Long-term persistence of organic chemicals in sewage sludge-amended agricultural land: a soil quality perspective	Investigation of effect of application of sewage on cultivated soil horizon during field trial. Results showed increased concentrations of CBs, PCBs, PAHs following sewage application. Atmospheric deposition also identified as major source.	(Beck et al., 1995)
PAH	Harpenden, Hertfordshire	Increases in polynuclear aromatic content of a sludge-amended soil over the last century.	Presents the results of analysis of soil samples collected at Rothamsted Experimental Station since the mid-1800s. Total PAH burden has increased 4-fold from 1880/1890s, at similar rates to contemporary atmospheric deposition rates.	(Jones et al., 1989)
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.	(Wild and Jones 1990).
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.	(Wild and Jones, 1990)
Pentachlorophenol	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)
PCDDs, PCDFs	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 PCDFs in British soils.	(Creaser et al., 1989a)
PCBs	Fawley, Southampton	Environmental monitoring for PCB and heavy metals in the vicinity of a chemical waste disposal facility	PCBs and heavy metals determined on a monthly basis in soil and foliage samples collected from 13 sites, generally located within a 2 km radius of toxic waste disposal facility.	(Eduljee et al., 1985)
PCDDs, PCDFs	Luddington, Stratford upon Avon	Persistence of PCDD/Fs in a sludge-amended soil	Data presented on PCDD/F persistence in a sludge-amended soil sampled from a long-term field experiment started in 1968. Concentrations of all congeners reduced gradually over time, with 50% still present in 1990.	(McLachlan et al., 1996)
PCBs	UK wide	Background levels of polychlorinated biphenyls in British soils;2	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.	(Creaser et al., 1989b)
PAHs	Tamar Estuary	A record of polycyclic	Concentrations of PAH were	(Readman et

Contaminants	Location	Title	Comments(1)	Reference
		aromatic hydrocarbons (PAH) pollution obtained from accreting sediments of the Tamar Estuary, UK: Evidence for non-equilibrium behavior of PAH	quantified throughout a Po-210 dated intertidal sediment taken from the Tamar Estuary.	al., 1987)
Organochlorines	Thames Estuary	Organochlorine contamination in sediments of the Inner Thames Estuary	Analysis of sediment samples within a 5km area of the inner Thames Estuary, provided evidence of extensive organochlorine pesticide and PCB contamination.	(Scrimshaw and Lester, 1995)
PCBs	Essex	Organochlorine contamination of UK Essex coast salt marsh sediments.	Determination of concentrations of insecticides and PCBs in marsh sediment cores from north Norfolk and Essex identified a degree of contamination which may be considered as background in this area.	(Scrimshaw et al., 1996).
Poly-chlorinated naphthalenes and polynuclear aromatic hydrocarbons	River Severn	Poly-chlorinated naphthalenes and polynuclear aromatic hydrocarbons in Severn Estuary sediments.	Analysis of sediment samples taken from the upper part of the Severn Estuary revealed a variety of organic pollutants including alkenes and several PAHs.	(Cooke et al., 1979)
PAH	Rothamsted, Hertfordshire	Increases in the polynuclear aromatic hydrocarbon content of an agricultural soil over the last century.	Soil samples collected at Rothamsted since the mid 1800s show increasing PAH concentrations, considered to be representative of soils in many industrialised countries.	(Jones et al., 1989)
PCDDs, PCDFs	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)
PCDDs, PCDFs	Rothamsted, Hertfordshire	Evidence for a decline in atmospheric emissions of PCDD/Fs in the UK.	Evidence from analysis of archived samples that contemporary rural UK herbage PCDD/F concentrations have declined 8 fold since a peak in 1961-65.	(Kjeller et al., 1996)
PCDDs, PCDFs	UK wide		Discussion of known sources of dioxins in the environment and the various ways in which they may be controlled, reduced and monitored.	(Department of the Environment, 1989)
PCDDs, PCDFs	UK wide	Determination of PCBs, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. First Technical Report to Her Majesty's Inspectorate	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)

Contaminants	Location	Title	Comments(1)	Reference
		of Pollution		
PCDDs, PCDFs	Birmingham, Leeds, Sheffield	Levels and sources of PCDDs and PCDFs in urban British soils	Soil samples from London, Birmingham, Leeds, Sheffield and Port Talbot were found to contain significantly higher concentrations of PCDD/Fs. Principal component analysis shows combustion processes to be principal source of PCDD/Fs in the soils.	(Creaser et al., 1990)
PCDDs, PCDFs	Rothamsted, Hertfordshire	Increases in the polychlorinated dibenzo-p-dioxins and –furan content of soils and vegetation since the 1840s	Archived soil samples collected from the same semi-rural plot at Rothamsted Experimental Station between 1846 and 1986 were analysed for PCDD/Fs. Concentrations rise over this period, due mainly to atmospheric deposition.	(Kjeller et al., 1989)
PCBs, PCDDs, PCDFs	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)
PCB, PCDD, PCDF	Doncaster	PCB, PCDD and PCDF concentrations in soils from the Kirk Sandal/ Edenthorpe/ barnby Dun Area		(Stenshouse and Badsha, 1990)
PCDD, PCDF	England, Scotland. Wales	Levels and sources of PCDDs and PCDFs in urban British soils	Paper reports results of analysis of samples collected from five cities during the HMIP survey of England, Wales and lowland Scotland (HMIP, 1989). Mean concentrations for a range of congeners are found ot be significantly higher than rural samples previously reported. Principal component analysis indicates combustion sources to be the principal source of PCDDs and PCDFs in the soils.	(Creasser et al., 1990)
PCB	Rothamsted, Hoosfield, Woburn, Luddington, Lee Valley	Long-Term Changes in the Polychlorinated Biphenyl Content of United Kingdom Soils	Archived soils collected from 5 different long-term agricultural experiments were analysed for range of PCB congeners. Soil samples exhibited a sharp rise in PCB concentrations from 1940 to early 1960s. Dramatic reduction to present day.	(Alcock et al., 1993)

3.4 Salinity

3.4.1 Regional data / literature review

Saline soils in Eastern England

The areas most seriously affected by problems associated with soil salinity are the salt-marshes of Essex and Kent. High exchangeable sodium contents of such soils leads to the deflocculation of clays, which are subsequently redeposited in the soil profile, leading to drainage and soil management problems, and lower crop yields.

Following the raising of sea defences in Eastern England after floods in 1953, arterial drainage was improved. After the installation of field drainage, these areas were subsequently converted from grassland to arable production (Hodgkinson and Thorburn, 1996). Following initially promising yields, problems were encountered in 1981 due to the deflocculation of clays and impeded drainage. In a review of the problems of salt-affected soils in the UK (Rands et al., 1986) it was reported that the problem was less widespread on the Essex coast than in north Kent, despite both areas having similar soil types. A survey of saline soils in North Kent was undertaken by the Soil Survey of England and Wales (Hazelden et al., 1986).

3.5 Radionuclides

3.5.1 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.

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

Post Chernobyl radionuclide monitoring

Radiation : A guide to a contaminated countryside. Guardian Newspaper, July 25, 1986, p17.
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. A 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 is 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.

3.5.2 Regional data sets

Aerial radiometric survey in West Cumbria, 1988

This project was initiated to undertake a brief aerial radiometric survey of the area in West Cumbria which had remained under livestock movement restrictions since the Chernobyl accident in 1986. The study was in part a demonstration of an economical and promising method for mapping deposition, and in part to provide the first detailed map of the fallout pattern within this zone.

Monitoring was undertaken from a helicopter flying at an altitude of 100m, with a spatial resolution of 500m. Principal radionuclides of interest during the survey were Tl-208, Bi-214, K-40, and modern additions from Cs-137 and Cs-134. Calibration of the data set was achieved by monitoring at locations with established ground survey data and known deposition levels. Details of the calibration procedure are included in the report.

Results are presented as radionuclide and total dose contour maps. Raw and calibrated data sets are presented in a separate technical annex.

Contact Details:
Authors: D.C.W. Sanderson and E.M. Scott
Organisation: SURRC, East Kilbride, Glasgow.
Report: MAFF Project No. N611

Vegetation and soil survey in Cumbria to validate the aerial survey of 1988

A ground survey of radiocaesium activity concentrations in vegetation and soils conducted in south west Cumbria. The ground survey was undertaken to investigate anomalies identified during the aerial survey conducted by SURRC. Three areas were surveyed, each 3km x 5km. A total of 36 ground survey samples were collected within each area. Where possible, samples of soil were collected down to bedrock. Samples were oven dried, milled, and counted on hypercure GE detectors for between 10,000 and 80,000 seconds.

Summary results are presented, indicating that levels of Cs-137 and K-40 encountered during the ground survey are lower than those determined by the aerial survey. The report includes a dicussion of the practicalities of identifying radiocaesium contamination hot-spots.

Authors: N.A. Beresford, Catherine L. Barnett, Brenda J. Howard, Jan Poskitt and J.Dighton
Organisation: Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands, Cumbria, LA11 6JU.
Report: TFS project T07051e1/ MAFF Project No. N740

3.5.3 Local data sets

Radioactivity in the environment : A summary and radiological assessment of the Environment Agency's monitoring programmes

Report for 1997

This is an annual report of independent monitoring of radioactivity in the environment, undertaken to support the Agency's role in enforcing the Radioactive Substances Act 1993. The report presents the data from monitoring programmes and provides a commentary on their radiological significance. It includes assessments of radiation exposure by members of the public for compliance with the annual dose limit recommended by the International Commission on Radiological Protection.

In 1997, the programme included the monitoring of 527 environmental samples, collected mainly in the vicinity of certain nuclear sites. The 1997 programme concentrated on sampling environmental materials such as water and associated sediments from ponds, lakes, streams, rivers and inter-tidal beaches, in order to assess the exposure of members of the public to radiation from non-food related pathways.

Over 140 locations were monitored during 1997, with nearly 300 individual results reported. Monitoring of contact beta/gamma debris was carried out at the most recent strand line on the beach or river bank. This is in addition to the measurement of gamma radiation absorbed dose rate in air at one metre above ground level.

Analysis was conducted by Tracerco at its Billingham laboratory. Total alpha and total beta activities were measured, and in many cases this was supplemented by a range of other analyses including gamma-ray spectrometry, alpha-spectrometry. Specific radionuclides monitored included plutonium, americium, thorium, uranium, curium, neptunium, sulphur-35, techetium-99, strontium-90, tritium and uranium.

Sediments were sampled in the vicinity of Sellafield, BNFL Capenhurst, BNFL Springfields, Harwell, UKAEA Winfrith, Amersham International (Amersham), AWE Aldermaston, British Steel Sinter plants. Results are presented for each site, indicating that, in general, exposures remained similar to those in previous years.

Contact Details:
Organisation: Environment Agency
National Compliance Assessment Service
Lancaster.
Contact: Dr. Paul Leinster, Director of Environmental Protection

An airborne and vehicular gamma survey of Greenham Common, Newbury District and surrounding areas

This study was commissioned by Newbury District Council and Basingstoke & Deane Borough Council in response to public concern over the possibility of radioactive contamination in the areas and accidents involving radioactive material.

The investigation comprised an airborne gamma ray survey and a vehicular survey conducted in 1996. The airborne survey involved the recording of a sequence of gamma ray spectra, positional information and ground clearance data to quantify levels of individual radionuclides and the gamma ray dose rate. The vehicular survey collected gamma spectra across part of the Greenham Common site. Calibration was performed using core samples analysed by high resolution spectrometry to provide traceability to international reference materials.

Results indicate that Newbury District and surrounding areas represent an area with low environmental radioactivity compared with national and European averages.

Contact Details:

Authors: D.C.W. Sanderson, J.D. Allyson, A.J.Cresswell and P.McConville
Organisation: SURRC, Scottish Enterprise Technology Park, Rankine Avenue, East kilbride, Glasgow, G75 0GF.

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 1,800 food samples and 3,900 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

3.5.4 Literature Review

Table 3.12 Summary of published information on land contamination by radionuclides throughout England

Location	Title	Summary	Reference
Wirral and Lancashire	Radionuclides in coastal and estuarine sediments from Wirral and Lancashire.	Radionuclide level in sediments measured are compared with values on the coast. Down-profile variations determined, and used to assess net accumulation rates.	(Bonnet, 1988)
Sellafield	Relationships between radionuclide content and textural properties in Irish Sea inter-tidal sediments.	Surface inter-tidal sediments collected along coast, particle size and radionuclide activity determined. Results indicated that Cs-137 and Am-241 were associated with fine grained sediment.	(Clifton, 1997)
Irish Sea	Radionuclides in tide-washed pastures on the Irish Sea coast in England and Wales and their transfer to food products	Paper provides a review of available data on radionuclide concentrations in various environmental compartments, including examples of radionuclide activity concentrations recorded in sediments, soils and vegetation from tide-washed pastures.	(Howard et al., 1996)
Irish Sea	Anthropogenic radionuclides in tide-washed pastures bordering the Irish Sea coast of England and Wales	Paper presents the findings of a survey of activity concentrations of Cs-137, Pu-238, Pu-239,240, and Am-241 in root mat and vegetation samples collected from tide-washed pastures in 17 estuaries along the eastern Irish Sea.	(Sanchez et al., 1998)
Site specific, England and Wales	Radionuclides around nuclear sites in England and Wales.	Radionuclide concentrations determined in soils and grasses collected from areas near 18 sites in England and Wales. No obvious correlations with frequency of wind direction. Generally, highest concentrations were found for Cs-137. Increases in Cs-137 and Pu-239,240 soil inventory within 500m of boundary fences.	(Sanchez, 1996a)
SW England	Relationship between indoor and soil gas radon in SW England.	Study examined the indoor Rn-222 concentrations in 252 buildings. Mean indoor concentration found to be 261	(Varley and Flowers1994)

Location	Title	Summary	Reference
		Bq/m3, and soil gas 64.19kBq/m3. Significant increase in expected indoor concentration above 100 kBq/m3.	
SW England	Preliminary report on the radioactivity of the Godolphin area	Details radioactive occurrences found during radiometric surveying of the Godolphin area	(Beer, et al 1955)
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)
SW England	Radon and Thoron in soil gas traverses, South Hams, Devon	Formerly a confidential report now open file status	(Cameron, 1989)
Sellafield	Emissions from Sellafield and activities in soil	Paper reviews recent data on emissions from the Sellafield site and activities in soil, and compares levels with archive data. Particular reference to the emissions of irradiated uranium oxide from the Windscale piles, the releasses in the 1957 accident, and the aerial emissions from the re-processing plant.	(Chamberlain, 1996)
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)
South West England	Radon in the surface waters of south-west England and its bearing on uranium distribution, fault fracture systems and human health	Analysed stream sediments and waters for U and Rn concentration. Found high correlation between high radon levels and uranium enriched granites	(Heath, 1991).
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 et al, 1999)
England Scotland 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)
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 October- 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)

Note: This table represents a summary of information sources identified as being of direct relevance this work. A number of other references related to investigations of radioactivity at a more local scale, or those covering a similar area to those described above are given in the Annex.

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) and the Environment Agency (Sewage Sludge Register).

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 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 Buisness 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 2,500 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. The DETR Mineral Resource Planning Map series is currently only available for a limited number of counties, but will eventually cover England and Wales. 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: Dr Tim Colman, 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, a range of commercial organisations including oil and construction companies also donates records and reference material.

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 nation-wide 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: Department of the Environment, 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 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 the Agency. 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) Aspinwall and Co Ltd., 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

Registered landfill sites

The Environment Agency provides digital data on the location of registered landfill sites. The data are updated every three months. In the majority of cases information is held as polygons depicting the spatial extent of landfill sites. Alternatively data is held as point data. The data set is currently undergoing further development.

Contact: MR D. Owen, National Centre for Environmental Data and Surveillance, Environment Agency, River House, Lower Bristol Road, Twerton, Bath BA2 9ES. Tel: 01225 444066 Fax: 01225 469939

Register of landfill sites (pre-1972)

During 1972 to 1974, a national survey of landfill sites was performed on behalf of the Department of the Environment. Data recorded for each site included a brief history of the site, site map, local geology, types of waste disposed of and a brief risk assessment of the sites potential to pollute surface and/or groundwater resources.

A summary of data is held digitally on the British Geological Surveys Geoscience Data Index (GDI) geo-referenced with British National Grid coordinates. More extensive paper records are available for each site on request.

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

3.10 Land-use information

3.10.1 National data sets

IPCIS

The Environment Agency provides digital data on current authorisations, IPC applications, Radioactive substances authorisations, water industry act referrals and consents for discharges to land, water and air. Data can be supplied as Excel spreadsheet or text files. The data is updated monthly, is considered to be of good quality by the Agency and is available for England and Wales.

Contact: Mr N. Veitch, National Centre for Environmental Data and Surveillance,
Environment Agency, River House, Lower Bristol Road, Twerton, Bath BA2 9ES. Tel: 01225 4440666. Fax:01225 469939.

The Derelict Land Survey of England 1993

The Derelict Land Survey 1993 forms the most recent nationwide report of derelict land in England. Previous surveys were conducted in 1974, 1982 and 1988. The survey was carried out by local authorities with the guidance and assistance of the Department of the Environment.

Local Authorities were asked to provide information on the total area of each of nine types of derelict land existing as at 1 April 1993, as well as the amount reclaimed in each year, and the use of the land after reclamation. Other details provided included the amount of derelict land which was considered by Local Authorities to justify reclamation, and any site specific information such as grid references and location maps.

The survey was published by the Department of the Environment as two volumes. Volume 1 provides a summary of the survey findings, while Volume 2 includes a detailed breakdown of all Local Authority responses.

Contact Details: HMSO Publications
Publisher: The Stationery Office

The National Brownfield Sites Project

This is a two year study of issues relevant to 'brownfield' sites, initially defined by the project board as *'land or premises which has previously been developed and may be vacant, partially occupied, derelict, contaminated or in some other way not in a satisfactory condition for immediate use'*. Scheduled for completion in May 2000, the project aims to investigate issues such as the current practice and availability of information, types of brownfield land, locational patterns and factors affecting remediation and redevelopment.

It is planned that the project will draw on a variety of sources of information including phase 1 of NLUD, academic studies and landowner and land agent data. The study includes the development of pilot schemes within target areas in England and Wales, in order to test the project typology for the classification of brownfield sites. Planned target areas are listed in Table 3.13:

Table 3.13 Target Areas planned for the Brownfield Sites Project (as of June 1999)

Target area level	Base mapping scale	Target area
Sub-Regional	1:50,000	North Staffordshire Merseyside South Yorkshire
District	1:10,000	Tyne & Wear (South of the Tyne) Swansea
Individual Sites	1:1,250	East Staffordshire Portsmouth Wolverhampton Bishops Stortford Oadby & Wigston Nantwich

Contact Details:
Further information may be obtained from Victoria Joy, Project Manager, Urban Mines Ltd, PO Box 89, Parry Lane, Bradford, West Yorkshire, BD4 8TW. Tel: 01274 755 326/327 Fax: 01274 755 040, Email: urbanmines@dial.pipex.com,
WWW: http://urbanmines.org.uk/urbanmines/

The Land Utilisation Survey

The Land Utilisation Survey was first carried out in the 1930s by Dudley Stamp, and maps were published at a scale of 1:63,360 scale. In 1960, the second survey was initiated. Results to date have been published as 1:25,000 scale maps. Each map covers an area of 10 by 20 km using the Ordnance Survey 1:25,000 topographic base. 64 land use categories are recognised within 14 groups. The field survey was originally conducted at a scale of 1:10,560 - later metricated to 1:10,000 - and copies of field slips are available as photographic slides.

Data is available as hardcopy published maps and handbooks e.g. Land use survey handbook: an explanation of the Second Land Use Survey of Britain on the scale of 1:25,000 / by Alice Coleman. - 5th ed. London: Land Use Survey, King's College, 1968. - 32p

Maps are available for consultation at the Library of the Institute for Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE17 2LS

Alternatively contact: The Director, Kings College, Strand, London, WC2.
Tel: 020 8244 6733; email: libraryenquiry@kcl.ac.uk;
WWW: http://www.ulu.ucl.ac.uk/

The National Land Use Database (NLUD)

The National Land Use Database (NLUD) Survey is being developed in partnership between the DETR, Ordnance Survey, English Partnerships (now Regional Development Agencies) and the Local Government Management Board. The first phase will involve local authorities in England providing information on previously developed land or brownfield sites, which are available for development. Future NLUD phases will extend the database to all uses of land and maintain it as a national resource.

Contact: Mr J. Boulby, English Partnerships, No 3 the Park, Lodge Lane, Newton-lee-Willows, Merseyside, WA12 0JQ. Tel: 01942 296900 Fax: 01942 296927

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

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)	Beryllium (total)
pH	Boron (total)
Cadmium (Total)	Boron (available)
Chromium (Total)	Cobalt (available)
Copper (Total)	Molybdenum (total)
Nickel (Total)	Phosphorus (total)
Lead (Total)	Selenium (total)
Zinc (Total)	Silver (total)
Arsenic (Total)	Tin (total)
Mercury (Total)	Thallium (total)
Total sulphide	Tungsten (total)
Phenols (Total monohydric)	Vanadium (total)
Cyanide (Total)	Total polycyclic aromatic hydrocarbons (PAH)
Antimony (Total)	Loss on ignition
Barium (total)	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 (LARRMACC)

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. For example, landowners such as BGplc, English, Welsh and Scottish Railway Ltd, and other national bodies which administer land, such as the Royal Navy. 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 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 Environment Agency in an electronic format as part of the sludge register.

Major civil engineering projects commonly collate and manage land quality information for example the Channel Tunnel Rail Link (CTRL) consortium manages land quality information relating to sites along the planned route. 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

A number of companies specialise in supplying environmental and historic land use data. Information supplied by such companies is derived from existing public domain data sources, including Environment Agency and local authority registers. 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.

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.

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
	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

Data source	Dataset title	Data type
	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
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 Environment Agency and Local Authority datasets:

Table 4.2 Data sets used by ICC site search

Data Source	Dataset	Standard Search Radius
Environment 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. Standard charge for a search of Environment Agency and Local Authority databases is £250 per property.

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 (Lake District, Pennines and South West England). 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 and as described in the Wolfson Geochemical Atlas. 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 Soil Geochemical Atlas (McGrath and Loveland, 1992) also discusses 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 at a more local scale 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. The North Pennines have been identified as being susceptible to acid deposition. This 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 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. The G-BASE programme has extensively characterised a number of urban centres in the Midlands in recent years. A broader national picture can be built up by allying this information with local authority data sets. Extensive studies have been carried out in both urban and rural environments. Studies in London, South West England, Yorkshire and Tyneside are documented as well as in the Midlands and highlight mining-related and anthropogenic/industrial contaminant hot-spots. The productivity of land in some coastal areas of Kent and Essex has been impaired by high salinity. 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 indicate 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. However, it should be noted that landfills, despite being seen as gross sources of pollution, often contain a lower concentration of hazardous inorganic substances than sites of naturally occurring mineralisation. Extensive nationwide 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 (e.g. 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 England. 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
130,423	17,430	24,550	500	13.5	19	0.5	33

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. 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. Surveys have since 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. However, 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.

A limited survey of PCBs within urban and rural locations (Badsha and Eduljee, 1986) found levels comparable with other industrialised countries, with significantly elevated concentrations found in urban samples compared with those from rural localities. Similar background levels were reported in a rural survey by Creaser et al (1986). The majority of samples analysed in the latter survey contained PCB at concentrations below 20μg kg^{-1} samples. The median of this reduced data set was considered to be more representative of background levels in soils than the mean value, as the mean result is strongly influenced by a small number of high levels observed.

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, HMIP (one of the predecessors of 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 54 sites located on a 50km grid across England. In order to accurately define background levels, samples containing 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 statistical definitions of 'background' have been used in other national and regional UK surveys, enabling intercomparison of survey results. Surveys have indicated that PCDDs, PCDFs and PCBs are ubiquitous at trace levels 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, both in order to establish baseline levels of these compounds (eg. Fernandes et al, 1994) and as part of exposure assessments of existing potential sources (eg. Stenshouse and Badsha, 1990, Abbot et al, 1997).

Table 5.2 Typical background values of organic contaminants in soils in England based on published data

Contaminants	Location	Reference	Type	No. of samples	Minimum	'Background' level	'Background' criteria
PAH	Eng land, Wales, Scotland	(Cousins et al, 1997)	Rural	46	20 -7400μg/kg	460μg/kg	Median of ΣPAH
PCB	Manchester, Southampton, London	(Badsha and Eduljee, 1986)	Rural Urban	12 11	1.0-23μg/kg 11-141μg/kg	8 62	Mean of ΣPCB
PCB	Central-Southern England	(Creaser and Fernandes, 1986)	Rural	95	2.3- 444μg/kg	6.8μg/kg	Mean of reduced data set
PCB	England, Wales, S. Scotland	(HMIP, 1989)	Rural	100*	1.7- 32μg/kg	6.1μg/kg	Median ΣPCB of reduced data set (+-2.5 std dev)
PCB	NW England	(Alcock et al., 1993)	Rural/ Urban	39	14- 669μg/kg	28μg/kg	Mean of reduced data set.
PCB	England, Wales, Scotland	(Lead et al., 1997)	Rural	46*	0.5- 20μg/kg	4μg/kg	Mean of ΣPCB
PCDD, PCDF	England, Wales, S.Scotland	(HMIP, 1989)	Rural/ Urban Urban	78* 13	51-2602 ng kg^{-1} 19- 1220 ng kg^{-1} 226-8890 ng kg^{-1} 470-1400 ng kg^{-1}	237ngkg^{-1} (ΣPCDD) 95ngkg^{-1} (ΣPCDF) - -	Median of reduced data sets (+-2.5std dev) - -
PCDD, PCDF	England, Wales, S Scotland	(Cox and Creaser, 1995)	Urban	28*	374-104800 ng kg^{-1} 546-1887ng kg^{-1}	637 ng kg^{-1} (ΣPCDD) 328ng kg^{-1} (ΣPCDF)	Median of reduced data sets (+-2.5 std dev)

* Total data set- includes samples collected outside England

Only one large-scale survey of PAH concentrations in UK soils has been undertaken to date (Cousins et al, 1997). 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 England are summarised in Table 5.3.

The analysis of these soils was not isomer-specific, and hence I-TEQ values were not calculated. 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. Stenshouse 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. Results of PCDD/PCDF studies generally show a progressive increase in concentrations throughout this century, while concentrations of PCBs showed a distinct peak during the 1960s, reflecting maximum production rates, followed by a gradual decline.

Table 5.3 Summary of national, regional and temporal surveys of organic compounds in soils undertaken in England

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	✔
(Jones et al., 1989)	PAH	Harpenden, Hertfordshire	1846-1986	1	✔	NA	✔
(Creaser and Fernandes, 1986)	PCB	Midlands, England	1985	95	✘	NA	✔
(Alcock et al., 1993)	PCB	Hertfordshire, Midlands, England	1944-1990	5	✔	NA	✔
(Lead et al., 1997)	PCB	England, Wales, Scotland	NR	46	✔	NA	✔
(HMIP, 1989)	PCDD, PCDF	England, Wales, southern Scotland	1986-7	78	✔	✘	✔
(Cox and Creaser, 1995)	PCDD, PCDF	England, Wales, southern Scotland	1988	28**	✔	✔	✔
	PCB			98	✔	NA	✔
(Alcock et al., 1998)	PCDD, PCDF	Harpenden, Hertfordshire	1881-1992	1	✔	✔	✔
(Kjeller et al., 1989)	PCDD, PCDF	Harpenden, Hertfordshire	1846-1986	1	✔	✘	✔

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

5.1.3 Radionuclides

The monitoring of radiation levels and radioactivity has been undertaken to determine the distribution of natural and anthropogenic radionuclides in the environment, and assess the risks to which the human population may be exposed. Surveys have also been undertaken to identify uranium ore-bodies, as high levels of background gamma-radioactivity are associated with uranium mineralisation. 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 England is summarised in Table 5.4.

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 a number conducted within upland areas of West Cumbria affected by the Chernobyl accident, historic discharges from Windscale and Sellafield (Sanderson et al, 1996), and a national high resolution gamma survey is in the process of being undertaken by the British Geological Survey.

The monitoring of radionuclides in environmental samples collected in the vicinity of nuclear establishments in England is routinely performed by MAFF and the Environment Agency. Results of these monitoring programmes are published annually by the Environment Agency, MAFF and SEPA, 1997, including radionuclide specific analyses of soil and inter-tidal sediment samples in the vicinity of nuclear sites, as well as at a limited number of industrial and 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). Soil surveys have since been undertaken to monitor radioactivity levels in a number of affected areas in the UK, including West Cumbria (Beresford, 1990). More localised surveys have been performed to investigate levels of radioactivity in soils near to nuclear facilities (e.g. Sanchez, 1996a). Little information on radionuclide inventories is available for the majority of coastal areas, although detailed surveys have been undertaken along the eastern Irish Sea (eg. Howard et al, 1996, 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 each 5km^2 of England. 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.

Table 5.4 Summary of survey techniques used to obtain information on radioactivity levels in England.

Scale	Aerial radioactivity survey	External dose survey	Environmental sampling
National	Natural levels of Uranium in Britain	Great Britain (NRPB) Northern Ireland (DoE (NI))	'Post Chernobyl Radiation Monitoring' (ITE)
Regional	Cumbria Chapelcross SW Scotland SW England Ayrshire	Radon soil gas survey	Cumbria SW England (Radon) SW Scotland N Scotland Irish Sea
Local	Greenham Common, Newbury Berkshire Sizewell		Ribble Estuary Solway Firth Esk Estuary Morecombe Bay Sellafield Sizewell
		Agency Monitoring Programme (Radioactivity in the Environment)	********
		MAFF & SEPA Monitoring Programme (RIFE)	
		Local Authority Monitoring (LARRMACC)	

The monitoring of direct gamma ray dose rates throughout Great Britain has also been undertaken by the NRPB, while the Environment Agency 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.

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

Table 5.5 Number of consultees holding land quality information on a range of determinands

Parameter	UK only[1]	UK + England[2]
Inorganic	14	71
Organic	10	61
Radionuclides	**6**	**25**
Pathogens	3	14
Munitions	2	17
Environmental Quality Indicators	7	36

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

5.2.2 Sample media and impacts

Table 5.6 below shows that the majority of land quality data held by information providers relates to made ground, topsoil and both surface and groundwater. These data are used to assess a broad range of impacts, with human-health risks, water pollution and damage to materials and buildings being the most significant.

Table 5.6 Details of sample media and impacts to which land quality information relates

Sample media	Number	Impacts	Number
Made ground	61	Soil fertility	23
Top soil	44	Groundwater pollution	39
Stream/River Sediment	12	Ecological harm	32
Drift geology	22	Surface water pollution	41
Solid geology	23	Air quality	28
Surface water	31	Human health risk	55
Groundwater	55	Damage to built environment	36
		Socio-economic	9

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 systems.

5.2.4 Data categorisation

Data from site investigations undertaken by consultants on behalf of local councils is typically categorised and stored with the associated planning application. By contrast, research institutes often categorise land quality information on the basis of land use (or land cover) type using a GIS. Few details are available concerning categorisation 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 surveys (e.g. Soil Survey of England and Wales) 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 intercomparison 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 harmonisation. 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 the Agency 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 ITE and the NERC Data Strategy Group) and the Agency 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 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.

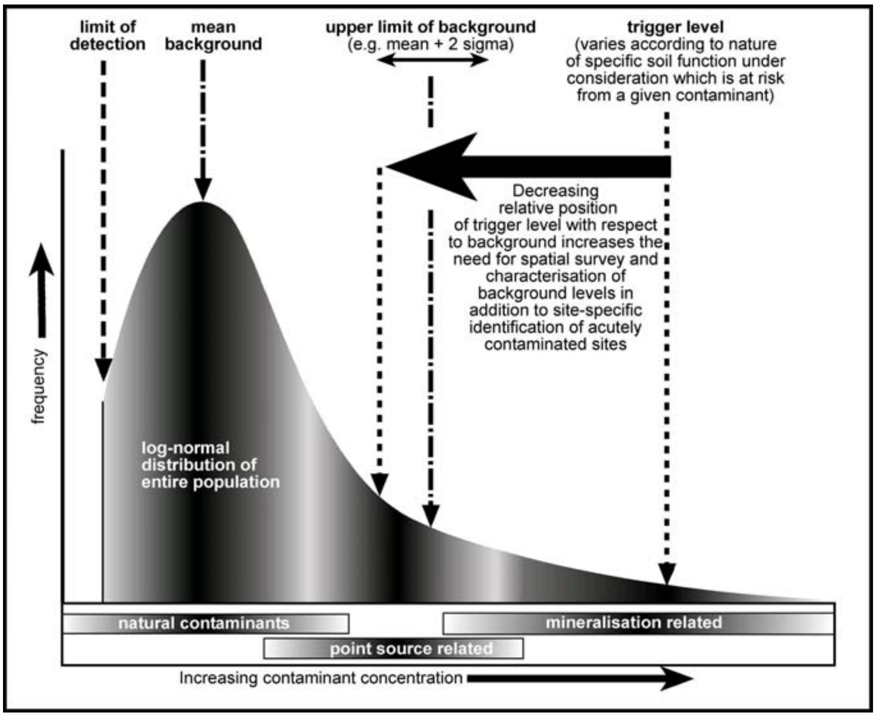

Figure 5.1: Diagram showing a typical (log-normal) distribution of a potentially harmful element or species in a single spatial survey dataset. The diagram indicates the differing nature of components of the distribution illustrating sources of the contaminant in question. A definition of background 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 (eg map of coalfields, map showing MRP extent; see Fig 5.2 and 5.3). 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.

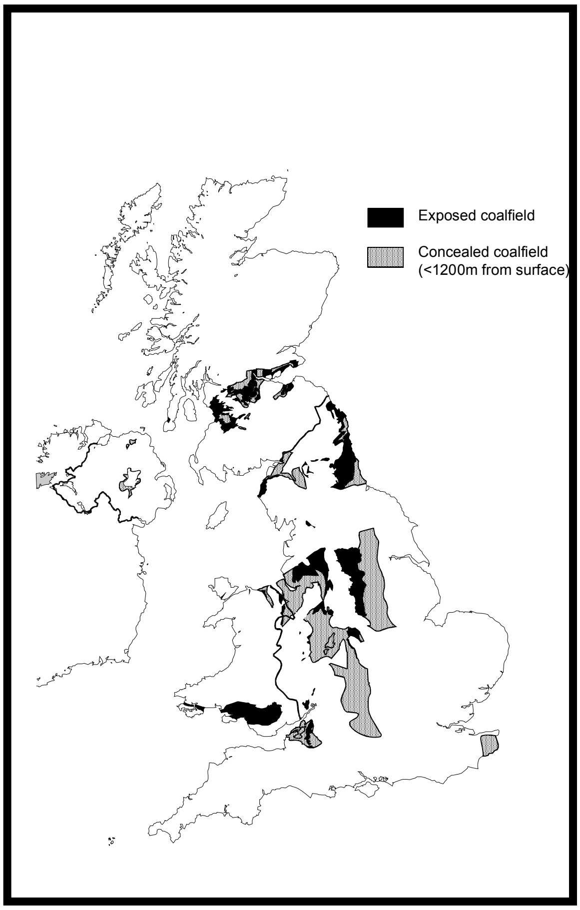

Figure 5.2. Map depicting the extent of exposed and concealed coalfields in the UK where the presence of elevated levels of trace elements map be influenced by the presence of elevated levels of potentially toxic trace elements associated with coal. NB. This map does not indicate areas of glacial drift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

Background and trigger levels: the relationship and its implications

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 a level at which to require action. However, this demand may be offset in 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 may differ from one contaminant substance to another. For example trigger levels for As may be much closer to mean background than for Chromium. 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 delineating areas of excessive contamination is paramount regardless of trigger level and as such characterisation and risk assessment is typically best achieved on the site specific scale. A need for pinpointing acute contamination is paramount regardless of trigger level and as such, characterisation is typically achieved on the site-specific scale. However, if levels are close to background, the need for more detailed surveys at the local and site specific scale and upwards is magnified.

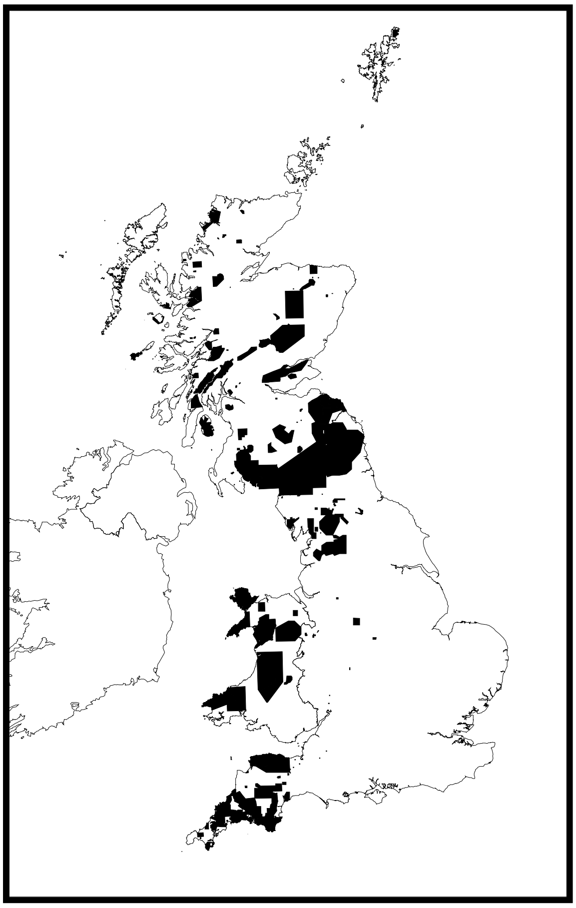

Figure 5.3. Map indicating areas of the UK investigated in the course of mineral exploration programmes. These areas may consequently be associated with the presence of elevated levels of potentially toxic trace elements resulting from natural mineralisation. NB it should be noted that this map does 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 the Agency.

6. CONCLUSIONS AND RECOMMENDATION

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 either as regional survey data from soils and/or stream sediments.

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 England 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 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.

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, 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 persistence of 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.
- Guidance is needed regarding 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

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…

---

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

Appendix B. Detailed information for G-BASE atlas areas

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.

Atlas: Lake District and Adjacent Areas
Sampling Period: summer 1978-1980
Resolution: 1 sample per 1.6 sq km
Media (number sites sampled): stream sediment (6,200), stream waters (2,585), heavy mineral panned concentrates (6,200)
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 (3339 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: North-east England
Sampling Period: summer 1986-1988
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (4,306), stream waters (2,153), heavy mineral panned concentrates (4,306). Soils: Due to the absence of surface drainage channels in the area underlain by chalk in the Yorkshire Wolds, soil samples were collected from 502 sites at a sample density of 1 per 1 km^2. Over other areas of poor drainage density over the vales of York and Pickering, soils were also collected at a density of 1 per 2 sq km.

Soils were collected on a grid basis, one from every 1 km national grid square over the chalk and from every second grid square in other areas. Soils were collected at a standard depth of 30 – 40 cm with a hand auger.
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 were analysed by acid attack (ammonium persulphate with 75% hydrochloric acid) followed by solvent extraction AAS in all samples; 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, all except Sb and As in soil and for pH, conductivity, bicarbonate, fluoride and U in water.

Atlas: Parts of North-West England and North Wales
Sampling Period: summer 1988-1990
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (5,203), stream waters (3,000), heavy mineral panned concentrates (5,203). Soils: Due to the absence of surface drainage channels in some of the lowland areas of Lancashire and Cheshire, soil samples were collected from 2064 sites at a sample density of 1 per 2 sq km. Soils were collected on a grid basis, one from every second 1 km national grid square. Soils were collected at a standard depth of 30 – 40 cm with a hand auger.
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 were analysed X-ray fluoresence (XRF) in all samples; 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 soil and for pH, conductivity, bicarbonate, fluoride and U in water.

Atlas: Wales, the Welsh Borders and West Midlands
Sampling Period: summer 1990-1994
Resolution: 1 sample per 1.5 sq km
Media (number sites sampled): stream sediment (19,164), stream waters (13,500), heavy mineral panned concentrates (19,164). Soils: Due to the absence of surface drainage channels in some of the lowland areas of the West Midlands, soil samples were collected from 2000 sites at a sample density of 1 per 2 sq km. Soils were collected on a grid basis, one from every second 1 km national grid square. At each site At each site two individual soil samples were collected one at 10-20 cm and another at 35-45 cm below ground level with a hand auger.
Sample Preparation: stream sediments and 35-45 cm soil sample < 150 micron fraction ground until 95 % was < 53 micron using an agate ball mill; surface soils (10-20 cm) were oven dried, sieved to –2mm and ground until 95% was less than 53μm using an agate planetary ball mill.

Determinands (methods): ; Mg, P, K, Ca, Ti, Mn, Fe, V, Cr, Co, Ba, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Y, Zr, Nb, Mo, Pb, Bi, Th, U, Ag, Cd, Sn, Sb, Cs, La, Ce (XRF); Sb and As were analysed X-ray fluoresence (XRF) in all samples; Soil pH determined on all subsoil samples in a slurry of 0.01 M $CaCl_2$ (10 g air-dried soil to 25 ml 0.01 M $CaCl_2$).
Atlas content: Data from this phase of the G-BASE programme has now been collated and error controlled. An atlas including interpolated geochemical maps and accompanying text for surface waters in this region is currently being written and will be published in 2000, a similar atlas for stream sediment and soil will also be published in 2000.

Atlas: Humber Trent
Sampling Period: summer 1994-1996
Resolution: drainage sites - 1 sample per 2 sq km soil sites - 1 sample per 2 sq km
Media (number sites sampled): stream sediment (13,000), stream waters (13,000), heavy mineral panned concentrates (13,000). Soils: Due to the absence of surface drainage channels in some of the lowland areas of the west midlands, soil samples were collected from 2064 sites at a sample density of 1 per 2 sq km. Soils were collected on a grid basis, one from every second 1 km national grid square. At each site At each site two individual soil samples were collected one at 10-20 cm and another at 35-45 cm below ground level with a hand auger.
Sample Preparation: stream sediments and 35-45 cm soil sample < 150 micron fraction ground until 95 % was < 53 micron in agate ball mill; surface soils (10-20 cm) were oven dried, sieved to –2mm and ground until 95% was less than 53µm an agate planetary ball mill.
Determinands (methods): ; Mg, P, K, Ca, Ti, Mn, Fe, V, Cr, Co, Ba, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Y, Zr, Nb, Mo, Pb, Bi, Th, U, Ag, Cd, Sn, Sb, Cs, La, Ce (XRF); Sb and As were analysed X-ray fluoresence (XRF) in all samples; Soil pH determined on all subsoil samples in a slurry of 0.01 M $CaCl_2$ (10 g air-dried soil to 25 ml 0.01 M $CaCl_2$).
Atlas content: Data from this phase of the G-BASE programme has now been collated and being error controlled. A data release date of late 1999 is expected with an expected Atlas publication date of 2001.

Atlas: East Midlands
Sampling Period: summer 1996-2000
Resolution: drainage sites - 1 sample per 2 sq km soil sites - 1 sample per 2 sq km
A geochemical survey of the East Midlands is ongoing. The survey is scheduled to collect samples at approximately 13,500 sites with an average sample density of 1 site per 2 sq km for both soil and drainage sites. Sampling in the area is due to be completed in 2000 and has followed methodologies undertaken during the geochemical survey of Humber Trent. It is anticipated that chemical analysis will be completed by midway through 2001 and data should be available for consultation soon afterwards.

Appendix C. Additional information

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
Ribble Estuary	A Survey of Radioactivity in the Ribble Estuary. Part 1. Activity Concentrations and Estuarine Dynamics.	Mudge, S.M., Assinder, D.J., and Bourne, G.S.	1994	Environment Series No.2.			HMIP
Esk Estuary, Cumbria.	Fixation of Cs-137 by soils and sediments in the Esk estuary, Cumbria, UK.	Davies, K.S. and Shaw, G.	1993	Science of the Total Environment	132	71-92	
Ribble Estuary	Environmental Radioactivity of the Ribble Estuary and Wyre Estuary, Lancashire.	Kelly, M., Rowe, J.E. and Bradshaw, K.	1991	Technical Report R300.			Institute of Environmental and Biological Sciences, Lancaster.
West Cumbria	Radioactivity in environmental samples taken in the Sellafield, Esk and Morecombe Bay areas of west Cumbria.	Curtis, E.J.C., Popplewell, D.S. and Ham, G.J.	1991	Science of the Total Environment	105	211-231	
	A survey of radioactive caesium in soils in Cumbria and north Lancashire. Comparison of accumulations pre- and post-Chernobyl.	Cawse, P.A. and Baker, S.J.	1990				UK AEA
West Cumbria	Chemical associations of radionuclides in West Cumbrian soils.	Livens, A. and Baxter, M.S.	1988	Journal of Environmental Radioactivity	7	75-86	
West Cumbria	Particle size and radionuclide levels in some West Cumbrian soils.	Livens, A. and Baxter, M.S.	1988	Science of the Total Environment	70	1-17	

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
NW England	Studies of Environmental Radioactivity in Cumbria. Part 8: Plutonium and Americum in the Intertidal Sands of North-West England.	Eakins, J.D., Morgan, A., Baston, G.M.N., Pratley, F.A., Yarnold, L.P., and Burton, P.J.	1988	AERE-R-12061			UK Atomic Energy Authority, HMSO, London.
Cumbria	Chernobyl fallout in three areas of upland pasture in west Cumbria.	Horrill, A.D. and Howard, D.M.	1990	Journal of Radiological Protection	11	249-257	
Cumbria	The influence of grassland management on the radionuclide inventory of soils in west Cumbria, UK.	Horrill, A.D and Mudge, S.	1990	Journal of Environmental Radioactivity	12	143-165	
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

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
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)					
Site specific, England and Wales	Survey of radionuclides around nuclear establishments in England and Wales.	(Horrill, 1994)					
Site specific, England and Wales	Survey of radionuclides around nuclear establishments in England and Wales. Final report.	Horrill, A.D., Sanchex, A. and Singleton, N.D.	1994	MAFF			
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)					

Location	Title	Author	Year	Journal Or Report	Vol	Pages	Organisation
	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 implications for radionuclide levels in food products from these areas.	(Howard et al., 1996)					
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	