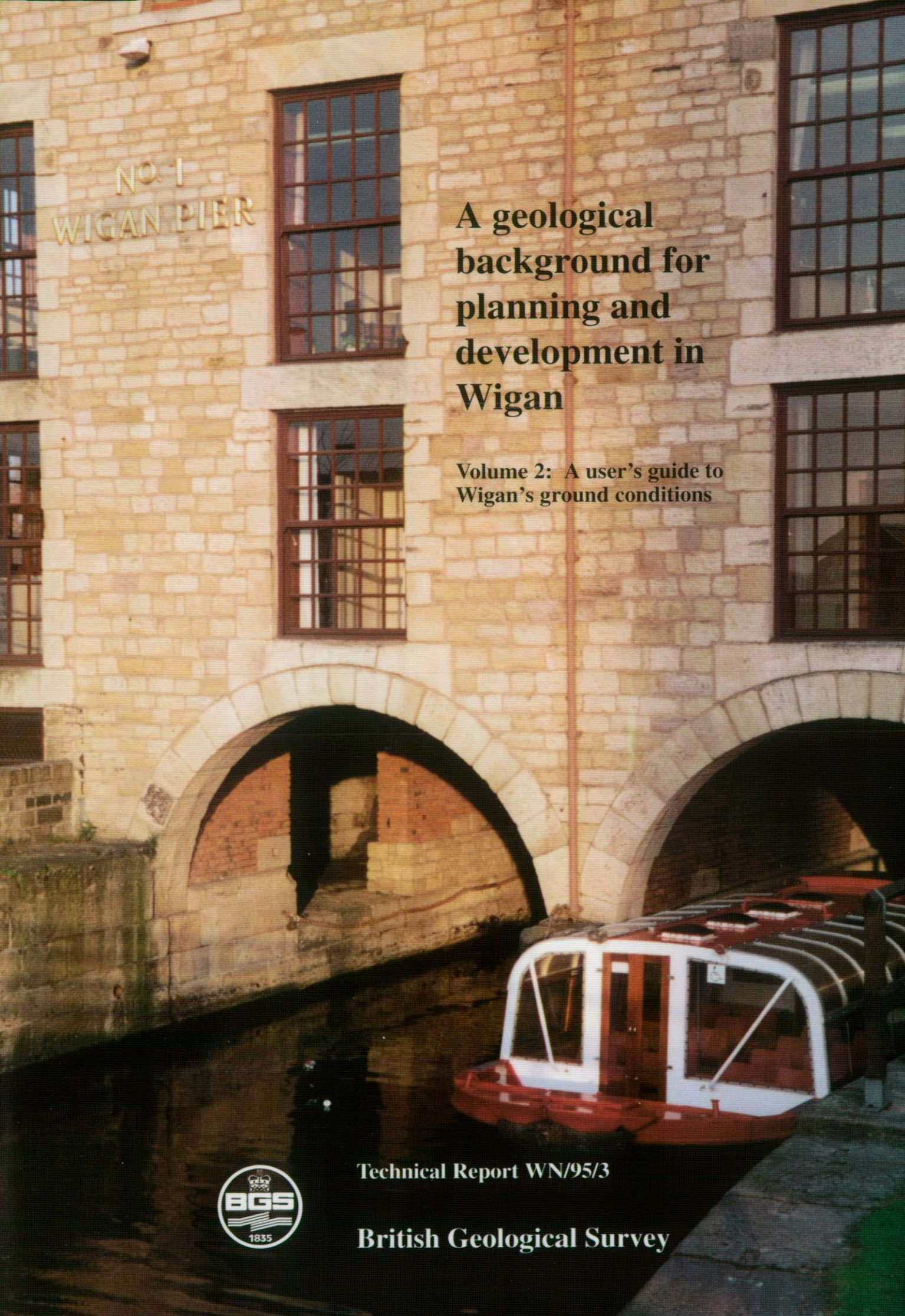

A geological background for planning and development in Wigan

Volume 2: A user's guide to Wigan's ground conditions

Technical Report WN/95/3

British Geological Survey

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BRITISH GEOLOGICAL SURVEY
In association with
Roger Tym and Partners

TECHNICAL REPORT WN/95/3

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Volume 2: A user's guide to Wigan's ground conditions

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Maps and diagrams used in this report are based on Ordnance Survey mapping.

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Keyworth, Nottingham British Geological Survey

BRITISH GEOLOGICAL SURVEY

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Contents

EXECUTIVE SUMMARY

1. This is the second volume of a two volume report resulting from a Department of the Environment brief to provide concise, accessible data on the geology of the Wigan area and to derive from this the implications for planning and development in the area. The study commenced in September 1992 and was completed in June 1995. Its findings are published in two volumes:

- Volume 1: **'A geological foundation for planning'** concerns technical matters and describes the geological data collected and presents them in a comprehensive and structured format.
- Volume 2: **'A user's guide to Wigan's ground conditions'** seeks to apply the geological data described in the technical volume to the workings of the local planning system and to consider their implications for future planning and land use.

2. The study area for this project is that of the Metropolitan Borough of Wigan, comprising about 200 square kilometres and a population of just over 300 000. This area has a long history of human occupation, of mining activity and of industrial development. These factors have all been related to, and have often been directly dependent upon, the local geology as outlined in **Chapter 2** of this Volume.

3. Geology, or ground conditions in their widest sense, interact with the local planning system in several ways. Ground conditions can increase development costs; they can be the underlying basis of areas of attractive landscape and environment which the planning system seeks to protect; they can include valuable minerals whose future possible exploitation should not be sterilised by permitting development on the surface.

4. These apparently straightforward interactions are, in reality, at least partly dependent upon the different perspectives of various interest groups. The public planning sector, developers/landowners, and groups with a specific interest in environmental conservation do not always view the relative importance and consequences of ground conditions in the same light. An individual site may be an important environmental resource for one group, a valuable mineral resource for another group, or an area for economic regeneration and new jobs by a third group.

5. The views of representatives of each of these groups in the Wigan area were sought at an early stage of this study as summarised in **Chapter 3**. Although there was divergence of opinion in some areas, there was common agreement that:

- Data on ground conditions in Wigan were not easily available, incomplete or not reliable, and not publicly available (or perceived as being so). There was general agreement that improved and more accessible data were needed.
- Certain ground conditions were particularly important in the area, namely **mined ground** (with implications of possible subsidence), **landfill sites** (often on the site of previous mineral extraction), and **derelict land** (usually the result of industrial processes).

6. Within the context of these differing perspectives, the specific ground conditions applying in the Wigan area are detailed in **Chapters 4–8** of this volume and Maps 1–9 of this report. These are presented with area-wide or general ground conditions first, following through to more detailed site-specific conditions, as follows:

- groundwater protection
- contaminated land and rehabilitation
- landfill, leachates and gases
- mineral resources and subsidence
- flooding, slope stability, subsoil and ease of excavation

7. In each of these sections, this report follows a common format. First we examine the significance of a specific ground condition in the Wigan area. This is followed by an outline of the key indicators which can be used to evaluate the impact of this condition. The locations where the ground condition might be found and suggested appropriate action to be undertaken are then covered. Finally, each section concludes with suggested reading material and a list of initial contacts for further local information.

8. The latter parts of this volume, **Chapters 9 and 10**, seek to draw together Wigan's individual ground conditions and to outline how in combination these conditions will, could or should affect future planning decisions for development, redevelopment and conservation. These effects are only one of a large number of 'material considerations' in the planning process in Wigan. As such they are analysed in the wider context of the planning and economic factors which operate in the local area. This analysis is considered in terms of:

- the current extent of derelict land in Wigan
- the means of and proposals for remediation of such land
- the impact of adverse ground conditions on development costs
- the relationship between ground conditions, economic development policies and potential grant aid

9. Finally, **Chapter 11**, summarises the five applied geological factors or ground conditions which are considered to be particularly significant in the Wigan area. These are highlighted in combination on Map 10 in order to present a consolidated representation of applied geological resources and constraints. These key factors are summarised in the following five paragraphs.

10. **Shallow mining as a potential undermining hazard** Coal has been mined in the Wigan area for hundreds of years and much early mining, for which records are absent or only partially available, was at shallow depths. This has caused subsidence and the potential for some future subsidence remains. This could affect both existing and new development. The shallow mining in the past would have taken place in the northern two-thirds of the borough which can be subdivided into areas where old workings may occur but for which no evidence has been found and areas where past mining has been proven. In either case the potential for subsidence is present.

11. **Land which may be contaminated** This comprises land where the presence of substances, usually in the soil and usually deriving from industrial activity or landfilling, are at such concentrations that they may cause harm to humans, animals, vegetation or structures. Contamination is not generally an absolute deterrent to development or conservation proposals, since remedial measures are possible. However, the Wigan area has areas of contaminated and potentially contaminated land which must be taken into account by the planning system. Much previously contaminated land in Wigan has now been reclaimed and the presence of contamination is best checked by on-site survey. This report shows areas where there is a known potential for contamination, either from past or present potentially contaminative industrial uses or from landfill sites.

12. **The potential for groundwater contamination** All groundwater is a vital resource and needs protection. Any proposed development which might put this resource at risk requires careful consideration. The Sherwood Sandstone Group rocks below the southern part of the Wigan area is part of a larger aquifer, extending further to the south and providing a major source of public water supply in the North-West. The principal recharge area within this water catchment zone includes rock at outcrop and below permeable superficial deposits. Both it and existing water abstraction points have a high potential vulnerability to pollution of groundwater. These features thus represent both major resources and significant constraints to development.

13. **Mineral resources** The Wigan area still has, despite a long history of mineral extraction, existing and potential mineral resources in the form of coal, sand and gravel, and sandstone. The value of these resources has and will continue to vary according to supply and demand. A deposit which is currently not economic to exploit may become so, and vice versa. Such resources could be sterilised by development or conservation proposals and the relative merits of any individual case will need consideration. Peat in the south-east part of the area is also a resource, but in terms of its environmental contribution rather than its commercial value.

14. **Geological faults** The Wigan area includes a large number of geological faults or fractures. Some may still be a focus for earth movements if their stability were disturbed by excavation. But more significantly, some faults may act as passageways for fluids such as leachates, gases such as methane, or (if rising groundwater flooded mine workings) contaminated water. Such passageways could lead to 'downstream' surface or groundwater contamination. As such, planning and conservation proposals should be evaluated in the light of their relationship to local geological faulting.

15. The areas influenced by each of the above factors are indicated on Map 10. The map seeks to demonstrate, at a broad scale, the key interactions between local ground conditions (the geological environment) and the use and conservation of land (the planning environment). Planning decisions are based on an extensive number of criteria, particularly government policy and the content of Wigan's Unitary Development Plan. Ground conditions are thus only one of a large number of inputs to planning decisions, but they remain a significant input in Wigan — both to the preparation of local planning policies and to decisions on specific development and conservation proposals.

1 Introduction

AIMS AND OBJECTIVES

1.1 The data described in this report were obtained during a three year research contract Reference PECD 7/1/438, commissioned by the Department of the Environment in 1992. The work was carried out by the British Geological Survey (BGS) in collaboration with Roger Tym and Partners (RTP). The BGS carried out the geological aspects and thematic map production and RTP were responsible for the planning aspects.

1.2 The aim of the research was to provide concise, accessible advice on the relevance of geological conditions to strategic land use planning in the Wigan area, which would also provide a regional context for site investigations.

1.3 The broad objectives of the work were:

- to establish the range of available earth science data and to bring these together in a comprehensive, concise format;
- to produce a set of applied geological maps depicting particular issues or themes relevant to land use planning in the Wigan area;
- to produce a derived summary map of the main planning considerations applicable to Wigan.

The results of the work are set out in a report which comprises two volumes. Volume 1 'A geological foundation for planning' is a technical report and contains a series of nine maps showing geological information:

1. Distribution of boreholes pits and site investigations
2. Bedrock geology
3. Superficial geology
4. Hydrogeology
5. Mineral resources
6. Distribution of made and worked ground
7. Previous and present industrial uses
8. Engineering geology
9. Shallow mining

Volume 2 'A user's guide to Wigan's ground conditions' is a planning based report and includes a summary map showing the main geological planning considerations applicable to Wigan.

STATEMENT OF LIMITATIONS

The use of this report

1.5 This work is based on existing geological maps, site investigation reports, mine plans and other reports which were collected by, or made available to, the project. Except for a small, field sampling programme for methane, radon and carbon dioxide no new data were determined. It must be stressed that the information provided on the thematic maps and in the technical and planning reports is interpretive, of variable quality and is distributed unevenly.

1.6 Other data may exist, which were not available to the project, that would add to the information shown on the maps and some of the geological information shown on the map is known to require resurvey and updating. Where possible those areas in need of revision are indicated. It is possible that there are relevant features in the area such as old shallow mining or past industrial use for which no record was made at the time or for which records have been lost.

1.7 Consequently the maps and reports should only be used as a guide for general planning purposes and pre-site investigation desk studies. They cannot be used as a substitute for site specific investigation but should be regarded as a reference source providing a regional context and guide to the design of the necessary site investigation procedures for the site of interest. Each map has only a concise descriptive key and it is strongly recommended that they should be used in conjunction with the reports which contain more detailed descriptions and indicate the limitations of the information portrayed. The report and associated database may be used as a guide to more detailed sources of information such as the collection of non confidential boreholes and other data which comprise the British Geological Survey, National Geological Records Centre data collection. These include 1:10 000/10 560 geological standards, open file reports and the original field slips from the geological survey of the area.

1.8 Attention is also drawn to other sources of information and advice which should be consulted, such as the National Rivers Authority and the Coal Authority, in terms of water, mining and other specific interests.

Data sources and database

1.9 The project was restricted to the collection and use of existing data with the exception of a small, data gathering, field exercise to determine the methane, carbon dioxide and radon gas potentials of the geological deposits in the Wigan Metropolitan Area. Confidential data were used in making regional interpretations but in such a way that none of the site specific data were revealed in the reports or maps. The principal data sources used were:

1.10 *British Geological Survey*

Geological maps at 1:10 560 and 1:50 000 scale, geological field slips, hydrogeological records, library holdings (serials and books), archive material, 1200 borehole records and 25 site investigation reports were identified in the BGS data collection relevant to the Wigan project area

were. These have been added to in the course of the project with records and data from the following sources.

1.11 *Wigan Metropolitan Borough*

Wigan Metropolitan Borough made available to the project a large number of site investigation reports, information on contaminated land and other data.

1.12 *British Coal — deep mining*

Thirty seven seam plots at a scale of 1:25 000 comprising working outlines for individual seams and a mine entry plot at a scale of 1:25 000.

1.13 *British Coal — open cast*

Open cast completion plans with details of seams and lithology were obtained. An extensive collection of data about sites which have been prospected but not worked was already held in the BGS but the information was of variable detail.

1.14 *Air photographs*

A complete stereo air photo cover of the Wigan Metropolitan Area, comprising 592, 9″ × 9″, black and white, panchromatic photographs at a scale of 1:6000, flown in 1992 was purchased. Additional cover was available at the Greater Manchester Geological Unit (GMGU) who also held complete sets of air photos in black and white from the 1960s and 1980, some cover in the east from the 1940s and a complete set of colour prints flown in 1989/90.

1.15 *Wigan College of Technology/Salford Mining Museum*

A collection of material relating to the local geology had been gathered by the Wigan College of Technology including the collection of mine plans deposited there by the pre-1947 mining companies operating in the area had been transferred to the Mining Museum at Salford.

1.16 *Greater Manchester Geological Unit*

A large amount of data was made available by the GMGU. Details are as follows:

1. Air photographs.
2. Prepared minerals local plan for Greater Manchester.
3. Minerals workings survey of 1982 and 1988 in A4 ring binders, with plans. This shows all known disused and extant quarries/pits and their state of restoration.
4. Landfill gas study for the Wigan area. Listing of landfill sites and gas production potential and 1:25 000 map (confidential).
5. Mines and Quarries Inspectorate. Known mines and shafts shown on 1:10 000 maps with accompanying reports.
6. Planning applications for waste disposal/landfill reports indexed by 1:10 000 map.
7. Landfill sites — maps and reports predating statutory obligation of 1970s dating back to the 1940s.
8. Applications for mineral workings. 1:10 000 maps and reports.
9. Results of shallow drilling for minerals undertaken by the Greater Manchester Council.

1.17 *North West Water*

Sixty-five site investigation reports within the Wigan area of interest were made available to the project by North West Water.

1.18 *National Rivers Authority*

The National Rivers Authority supplied information on mine drainage, basic aquifer properties, hydrogeology of the Coal Measures, flashes and information on water quality.

1.19 *Civil engineering consultants*

Several civil engineering consultants who are active in the Wigan area allowed the project to use information from site investigation reports which they held.

DATABASE

1.20 A database of the information collected during the project has been set up using D base 3+. The database is designed to be flexible, evolving as the data are entered and the need for refinement is identified. This has been linked to Intergraph Microstation for spatial display of vector and raster data thus enabling on screen analysis. A database user's guide is included in Volume 1 of this report as Appendix I. This contains details of the structure and guidance on the use of the database. Copies of the database are lodged with the DoE, BGS and Wigan Metropolitan Borough Council.

2 Characteristics of the study area

LOCATION

2.1 The Metropolitan Borough of Wigan lies between Liverpool, 25 km to the south-west and Manchester, 27 km to the east-south-east. It was formed in 1974 from the amalgamation of Wigan, Leigh and a number of small industrial and rural communities which surround them. Its area is about 200 square kilometres and population is of about 306 000. During the course of the Applied Geological Mapping Project, on the 1st of April 1994, minor adjustments were made to the boundaries of the Metropolitan Borough. These changes have been indicated on the boundaries of the thematic maps which accompany this report.

TOPOGRAPHY

2.2 Topographically Wigan is generally an area of gently undulating scenery. To the south, along the A580(T) and around Chat Moss in the south-east, the land is relatively flat with an elevation of around 20 to 40 m above sea level. The land becomes more undulating to the north and reaches elevations of about 120 to 150 m above sea level around Haigh and Aspull. Steep slopes are generally uncommon but occur locally, such as the banks of the River Douglas which crosses the Borough from north-west to south-east. In much of the area the topography has been altered artificially. In the urban and industrial areas there are large areas of made ground, disturbed ground and excavation. In other areas, which have been undermined, the land has been lowered in elevation. This has, in some areas, caused the formation of extensive flooded areas called flashes. In contrast areas such as Chat Moss have been drained, improved and brought into agriculture or worked for peat.

INDUSTRIAL HISTORY

2.3 Wigan has a long history which goes back at least to the Roman occupation of Britain when it was the location of the garrison of Coccium. However, little is known of the early development of Wigan other than by inference from archaeological remains and from rare documentary evidence which has survived from that period. Documentary records are increasingly available from the time of the Norman Conquest onward and it appears that by the start of the twelfth century Wigan was established as a small but busy town. An account in the seventeenth century refers to a 'Charter of incorporation' dating from the year 1100, now lost, which makes Wigan Lancashire's oldest borough. During the Medieval period Wigan prospered and was the location of craft workshops such as those of blacksmiths, wagoners, masons and tanners. It was also the site of the earliest expression of its later, major industries that would bring both wealth and dereliction to Wigan; the smelting and fabrication of pewter, the processing of wool, flax and cotton into textiles and the extraction of coal from shallow surface workings.

2.4 The eighteenth century found Wigan as a significant town at a major road junction and with an expanded industrial base. Metal working had grown to include iron founding, smithing, pewter ware and the manufacture of clocks. Mining had progressed to underground workings from shallow, drift mines with outputs from some mines running at a few thousand tons per annum at the end of the seventeenth century and by the middle of the eighteenth century deeper mining from shafts was commonplace. The mining industry continued to develop, extracting coal from greater depth by means of increased mechanisation which enabled mines to be pumped dry and coal to be hauled cheaply and efficiently. The industry reached its peak at the end of the nineteenth and early twentieth centuries and then waned as seams were worked out and economic circumstances developed to its disadvantage leaving only opencast operations for coal extraction at the present time.

2.5 The need for tools and machinery in the coal industry caused the existing metal working industry to grow and change. Pewter working and bell casting were left behind and the heavy iron and steel manufacturing capability grew rapidly. The development of steam power was particularly significant to the industrial growth of the area. It supplied the stationary engines to drive winding gear, power tools and railway locomotives for hauling coal within the colliery and further afield.

2.6 The development of the coal industry was dependant on a bulk transport system. This need was met initially by the Douglas Navigation and later by the Leeds and Liverpool Canal via its spur to the Douglas at Tarleton. Later still access to the Duke of Bridgewater's canal and the Midland's canal system was realised by the construction of a branch to Leigh.

2.7 The development of a cheap bulk carrying system helped the Wigan textile industry to expand by allowing the import of wool and cotton from the port at Liverpool for processing in the factories in Wigan and subsequently the carriage of the finished goods to markets at home and abroad. However, the mechanisation of the factories was hampered by a lack of suitable water power which had been used by other Lancashire, textile towns. The local availability of stationary steam engines which could drive factory machinery solved the problem and by the early nineteenth century steam driven factories were leading a dramatic increase in textile output, which was, by this time, composed almost entirely of cotton goods.

2.8 Towards the end of the nineteenth century the Wigan industrial base was starting to be overtaken by those of Manchester and Liverpool who had taken greater advantage of the more rapid bulk carrying capacity offered by the expanding railway network. Later Manchester gained a further advantage by the construction of the Manchester Ship Canal which enabled imports and exports to be handled in the heart of the city.

2.9 The general decline of British heavy industry through the twentieth century left Wigan without a heavy iron and steel industry or deep mining for coal, the last pit closed in 1992. The textile industry is still present, though much reduced and has been joined by many new industries based on modern technologies. The changes of the present century have caused the end of many old polluting and despoiling processes which have left much derelict land in the Borough. This problem has been addressed, with success, since the 1950s and it continues to have a high priority in local affairs.

LAND USE

2.10 Although the Wigan Metropolitan Borough is an important industrial and urban area some two thirds of its area is open land, much of it designated as Green Belt. Wigan enjoys the benefit of a number of large country parks, nature reserves, country paths and amenity open spaces. The Haigh and the Pennington Flash Country Parks which comprise 100 and 450 hectares respectively are of particular note. Elsewhere in the Borough there are over 100 hectares of ancient woodland and many other areas of importance to wildlife. Some of these areas are of natural origin but others are the result of industrial processes which have created new habitats suitable for colonisation by animals and plants whose natural environment is normally only found outside the Wigan area. These new ecologies may form valuable additions to the local environment.

2.11 Agriculture is not an activity of major significance in the area and the crops grown may vary according to local economic considerations and the farming policies of the European Community. The agricultural activity is therefore best considered in terms of the soils present and the crops which they are capable of supporting.

2.12 The agricultural soils of the Wigan area are often thin and of poor quality. They are shown on the Soil Survey of England and Wales 1: 50 000 sheet 108 'Soils of the Liverpool District' and 1:250 000 sheet 3 'Soils of Midland and Western England'. They comprise mainly Brickfield series but include lesser areas of Ormskirk, Newport, Clifton, Rivington, Salop, Sollom, Wick and Salwick series. Large areas of an urban or industrial nature are shown as 'disturbed soils' or 'unsurveyed'. More details are given in Chapter 5 of Volume 1 of this report.

GEOLOGY

2.13 In the Wigan area the bedrock is composed of rocks deposited during two distinct periods of geological time. The oldest are Upper Carboniferous rocks of about 320–300 million years age which outcrop over the northern part of the area and comprise mainly sandstone, mudstone and coal. In the southern part of the area these rocks are overlain by younger, Permo-Triassic rocks of about 280–250 million years of age. These comprise mainly weaker sandstone and some mudstone.

2.14 The Upper Carboniferous rocks were deposited mainly in marine conditions, within a large subsiding basin. At the land sea interface large delta complexes formed. Coarse-grained sediments (sandstones) were laid down where the deltas were active and finer-grained sediments (mudstones) were deposited where conditions were quieter. Periodically the land emerged and peaty swamps covered by dense forests of primitive vegetation developed. These in time were buried and, after compaction and lithification, the peat turned to coal. This process occurred repeatedly giving rise to a cyclical sequence of sandstone, mudstone and coal.

2.15 Towards the end of this period the phases of emergence above sea level and peat development became more frequent and lasted longer. This resulted in complicated patterns of coal seam development and complex relationships between, the different lithologies thus reflecting the varied conditions in a large delta complex.

2.16 In the Late Carboniferous (about 290 million years ago) the land was uplifted and a long period of erosion continued into early Permian time (about 280 million years ago) by which time a great thickness of the Carboniferous strata had been removed.

2.17 In the early Permian time, widespread regional subsidence occurred and sand was deposited, in a desert, or near desert, environment, which later became the Collyhurst Sandstone. Subsidence increased and the area was flooded by the sea in which mud was deposited, which after lithification became the Manchester Marl. The land subsequently rose above the sea and desert conditions resumed with the deposition of more sand which was to become the Sherwood Sandstone Group.

2.18 Bedrock formations younger than the Sherwood Sandstone are not present in the area. Any younger rocks which may have been deposited have been removed in the millions of years of deposition and erosion which have taken place since then which have resulted in the present bedrock surface.

2.19 Details of the rocks which form the bedrock and their structure are given in Chapter 8 of Volume 1: 'A geological foundation for planning' of this report and the disposition of the rocks at the surface and below recently deposited superficial material is shown on Map 2.

2.20 Much of the bedrock surface of the area is covered by, geologically, very young unlithified material called superficial deposits or drift. These deposits were mainly deposited on the bedrock surface during the last period of glaciation or by the processes which have acted since its end, approximately 14 000 years ago. The material which formed directly by the action of glaciers is generally a sandy, silty, stony clay of variable lithology and is called placement till (formerly called boulder clay). It is generally relatively dense and stiff as a result of its being compacted by the weight of the ice above it. As the ice melted other materials of various compositions were deposited such as melt out till, laminated glacial lake sediments and outwash sand and gravel these are generally less dense and softer than the placement till since they have not been compressed by overlying material. The most recent natural deposits in the area are fine, wind blown sands found in the west of the Borough, peat which forms the mosses and the alluvial material deposited by the rivers and streams which currently drain the area.

2.21 The deposition of superficial deposits has caused the present day topography to be generally more subdued than

the underlying rockhead surface. Approximately half the Borough is covered by deposits less than 5 m thick, but infilled channels in bedrock locally attain thicknesses exceeding 50 m.

2.22 Details of the recent geological history of the area and the deposits formed by the processes operating during that time are given in Chapter 8 of Volume 1 of this report and the disposition of the deposits are shown on Map 3.

2.23 The rocks which form the Wigan Coalfield have a long history of deformation as a result of movement of the earths 'crustal plates'. Rocks may be deformed in two ways depending on the nature of their lithology and the conditions under which the deforming stress is applied. When subjected to compression they may deform plastically and become bent or folded in order to accommodated the stress. Associated with the compression, tensional forces are also generated and rocks may behave in a brittle fashion resulting in fracturing and movement along the breaks. These planes of movement are called geological faults. The net result is a complex three dimensional pattern of folded and fractured rock far removed from the original relatively simple disposition of the rocks when they were originally formed. Folding and faulting are not geologically active processes in the Wigan area at the present time. However, faults may be reactivated artificially and they have in the past been activated by subsidence due to mining.

2.24 Details of the geological structure of the area are given in Chapter 7 of Volume 1 of this report and the position of major faults are shown on Map 2. The next chapters of this volume outline the planning and development issues upon which the geology of the Wigan area has a bearing. Chapters 4 to 9 consider specific ground conditions and their importance to planning and development.

3 Planning and development issues

3.1 The characteristics and geology of the Wigan area as described in the preceding chapter form the physical background upon which the local planning and development system operates (see also Chapters 5 to 15 of Volume 1 of this report). In this chapter we look at:

- the impacts which ground conditions have upon the planning system
- the varying perspectives of different groups in the planning system as to which ground conditions are the most significant.

GROUND CONDITIONS AND THE PLANNING SYSTEM

3.2 In Wigan, as elsewhere, the statutory planning system seeks to achieve a balance between:

(a) providing an adequate supply of land to meet society's changing requirements, and

(b) seeking to protect and enhance the natural and built environments from development which would be harmful.

3.3 This pursuit of balance is encapsulated in Government policy advice (PPG1, paragraph 2) which states that 'the town and country planning system is designed to regulate the development and use of land in the public interest'. The relationship between applied geology, or ground conditions in their widest sense, and the statutory planning system expresses itself in several ways as outlined below:

- by increasing development costs
- by creating a high-quality environment
- avoiding development on land which overlaps minerals
- by attracting grant aid

Increase in development costs

3.4 Low bearing capacity soil, underground cavities, poor drainage, undermining, slopes, contaminated land and similar negative ground condition impacts on proposed development can all, in principle, be overcome — but at a cost. Whether the cost can be borne by a scheme will, in open market conditions, depend upon the anticipated residual value of that scheme. This in turn will be influenced by the availability and viability of alternative sites which the planning system may, or may not, make available.

3.5 By restricting potential land supply, the planning system tends to increase the value of land which has the benefit of permission for development. This increase in value can, and commonly does, contribute towards site remediation though not necessarily at 100 per cent. Thus, for example, the use of the planning system in Wigan to promote the redevelopment of old industrial areas by (amongst other factors) restricting new industrial development on greenfield sites, probably has the general effect of increasing both industrial site values and industrial development costs, though not necessarily by equal amounts.

3.6 Thus ground conditions are a direct input to the statutory planning system. This system can be utilized to focus development and redevelopment onto some sites with difficult ground conditions which the development industry might otherwise avoid or regard as a low priority. But endeavours to use new development to remove contamination or to improve derelict sites have their limitations. Some development, and particularly inward investment bringing new jobs, is not tied to a particular site and can relatively easily be located in adjacent areas with different ground conditions and with different planning regimes.

Creation of a high-quality natural environment

3.7 Wigan Metropolitan Borough Council encompasses five Sites of Special Scientific Interest (SSSIs), a nature reserve at Borsdane Wood (between Hindley and Aspull) and 85 designated 'sites of biological importance' spread across the Borough. They owe much of their value to their underlying ground conditions which have enabled a range of flora and fauna to flourish. In some cases, such as the peat deposits at Chat Moss, it is relatively undisturbed ground conditions which contribute to the natural environment. But often it is the legacy of mining and other industrial operations which have, in places fortuitously, led to the establishment of new natural habitats which the planning system now seeks to protect. Examples include water-filled shallow depressions (flashes) due to mining subsidence and the colonisation of spoil heaps.

Avoiding development of land which overlays minerals

3.8 Some mineral resources can be sterilized and their possible future extraction made uneconomic by development on the ground surface. This is particularly true of sand and gravel deposits. Development may be proposed which would physically overlie what could otherwise be a surface or underground extractive site, or be located too close to possible future extraction in terms of noise or additional heavy traffic.

3.9 The planning system can respond to these possibilities by protecting land from development, although in this respect the initiative usually comes from the private sector. Thus, it is accepted that for housing and commercial development the planning system will assess and quantify future needs and will then seek to allocate and phase new sites accordingly by way of development plans. But for mineral resources and proposed extraction, whilst the planning system retains control, it is not generally active in site selection. In Wigan, as elsewhere, the public sector planners regard the'areas of search' approach in

development plans is as too open-ended. As a result, the initial site selection for possible mineral workings is usually in the hands of commercial operators.

Attraction of grant aid

3.10 The effect of increased development costs due to adverse ground conditions in Wigan may be offset, on certain sites, by the attraction of grant aid from central government or from the European Community. More precisely, the additional costs remain but their burden is carried by national or European Community taxpayers and not by the local Wigan economy. The structuring and availability of such grant aid has varied over time and is currently based in UK on the Single Regeneration Budget as funded by the Department of the Environment and made available via Regional Government Offices.

3.11 The prime purpose of such aid is to help achieve economic regeneration and its focus has largely been, and will probably remain on, derelict land. To the extent that Wigan still has areas of derelict land, despite an impressive record of improvement over the past 30 years, grant aid can be sought. But this mechanism has distinct drawbacks:

- It will not usually alleviate increased development costs imposed by other adverse ground conditions such as flooding or compressible soils.
- Grant aid is often not available for a specific project or will not meet the full cost of countering adverse ground conditions.
- The procedural mechanisms of securing grant aid and uncertainty as to the outcome of any application for aid may deter some potential developers, though this is less likely to affect firms with experience in the north-west.

DIFFERENT PERSPECTIVES ON GROUND CONDITION IMPACTS

3.12 Some of the impacts of adverse ground conditions upon planning and development, as outlined above, fall relatively equally on the various groups involved in planning, development and conservation in the Wigan area. During the current study it became apparent that there was a widely shared view, irrespective of sectional interest, that some data on ground conditions in Wigan were:

- not easily accessible to interested parties; or
- not publicly available (or perceived by some as not being so); or
- incomplete or not reliable.

3.13 It is hoped that the Technical Report of this study will significantly contribute towards improvement in these areas. The range and extent of the Technical Report's geological information should represent an initial starting point for many enquirers.

3.14 Beyond these issues of data availability, access and sensitivity, there is understandably a divergence of interest between various groups as to which ground conditions are particularly important and as to how they should influence the future planning and development of Wigan. Three broad groups with an interest in local ground conditions have been distinguished as follows:

- Those with a public sector responsibility to have regard for planning and development across the whole Wigan area.
- Those with a commercial interest in developing or redeveloping specific sites and/or buildings — primarily developers and landowners.
- Those with a specific interest in environmental conservation — primarily conservationist groups with an active and specific interest in the Wigan area.

3.15 There is obviously some degree of overlap between these three groups but they do represent different perspectives and preferences as to whether, where, when and how development should proceed. The public sector planners seek regeneration and new jobs (though not at the expense of the environment), they seek improved and better integrated ground condition data, and they have some concern that any emphasis on Wigan's adverse ground conditions might unnecessarily deter inward investment.

3.16 Secondly, private sector commercial interests are profit-driven and seek a planning regime with increased certainty as to site risks and allowable uses. This sector will deliberately radiate a positive or negative view depending at least partly upon differing negotiating stances. Thus a developer may positively promote a scheme to the public sector, whether the latter are acting as regulators or potential partners (or both). But simultaneously the developer may present a negative stance towards the owner of the land required for the scheme so as to seek a lower price for land acquisition.

3.17 Thirdly, environmental conservationists, though a more fragmented group, seek to protect and enhance specific parts of the built or natural environment. This diverse group generally has concerns that some proposed improvement schemes may in fact be ultimately damaging; e.g. new public access may be detrimental to wildlife.

3.18 Consultations were made with these three groups at an early stage in the study — namely with public sector interests, with private sector commercial interests, and with environmental conservation interests. The responses from these groups are summarised in paragraphs 3.19 to 3.31 below.

Public sector perspectives

3.19 Wigan MBC's Unitary Development Plan (UDP), in its Deposit stage at the time of writing, summarises the local planning authority's primary objectives for Wigan. Overall the UDP seeks to improve Wigan's economy, environment, infrastructure and the quality of life for residents. Man has had a profound impact on the natural environment and on ground conditions throughout Wigan's long industrial history. This background was responsible in helping to form past perceptions that parts of Wigan were fraught with ground condition problems. Such perceptions are now very largely historic, ill-informed and held only by a small number of organisations based outside the North West. Nevertheless, earlier industrial development has left its mark and Wigan's planners are endeavouring to alter

any residual perceptions by reshaping both planning policy and by enabling positive changes to the natural and built environments.

3.20 The ground condition problems which are considered to be of most importance by Wigan's public-sector planners are as follows:

Derelict land — This is commonly defined as land so damaged by industrial or other development that it is incapable of beneficial use without treatment. Of particular relevance in Wigan is the extent to which contamination, usually from industrial processes, can increase the stock of derelict land. Derelict land is a prime, though not the only, target of grant aid in the Wigan area as outlined above in paragraph 3.11.

Landfill — This has a major impact on (re)development in terms of sites with low or uneven bearing capacity, and the potential for gaseous emissions.

Coal mining — Whilst deep coal mining has now ceased, there remain the residual effects of this past mining activity including surface digging, small quarries, tunnels, shafts, cavities and gaseous emissions.

Subsidence — Disused shallow and deep mines and disused landfill sites affect the ground stability of a number of existing and potential development sites.

Fault lines — Their location and the possibility of movement is a factor to be acknowledged in preparing development plans.

3.21 There is some degree of overlap in the above issues in that the legacy of coal mining has, in places, a bearing on dereliction and subsidence. Nevertheless, the study team's understanding of the public sector position is that coal mining's legacy, as a whole, is a distinct and important issue.

3.22 Both (existing) landfill and (future) tipping are regarded as key issues by the public sector in Wigan. More generally, the key planning and development issues raised by Wigan's planners placed a strong emphasis on issues relating to improving the local economy, in particular job creation. Wigan's previous negative image, to the extent that it existed at all, has been almost entirely demonstrated as being inappropriate. But some concern as to possible misconceptions remain, despite the fact that grant aid can neutralise some of the adverse financial impact of poor ground conditions.

Developers' and landowners' perspectives

3.23 Commercial developers seek to engage in activities whereby land and/or buildings are developed so as to secure a profitable financial return. In order to help achieve this objective, developers are concerned with maximising certainty and minimising risk. Intending developers can account for known ground conditions by adjusting budget estimates. But a lack of information on possible adverse ground conditions reduces certainty, increases risk, and may lead to premature abandonment of a project.

3.24 The ground conditions identified by developers as being of most importance in the Wigan area are:

Derelict land — In particular, land which has been contaminated by industrial activity or other development that is incapable of beneficial use without treatment

Mined ground — Specifically there is concern with shallow mines and the impact of potential land subsidence on new development.

Landfill — In particular, land stability and the potential impact of gas emissions from former waste disposal sites.

3.25 As with issues identified by the public sector, there is some degree of overlap between the three ground conditions itemised above but each is often regarded as a distinct issue. Nevertheless, and even when grouped together, ground conditions as a whole are generally not regarded by developers as being of prime importance in the context of determining whether a specific project proceeds towards implementation. Thus developers place a greater weight on more commercially driven issues such as supply and demand, the proximity and accessibility of significant road infrastructure and the availability of a suitable labour force.

3.26 Many schemes are site-specific. Thus a particular site for a major scheme will be well located for the intended use and have good infrastructure connections. As such, ground conditions will usually be of secondary importance. In these circumstances, developers will often tend to treat sites with apparently unfavourable ground conditions as viable due to the relatively low cost of site treatment compared with the anticipated high rate of return on the investment. Conversely, smaller lower-cost schemes such as housing infill may not be economic because ground treatment costs are high relative to the selling price. Yet even in these circumstances, grant aid can modify the developer's financial equation by making difficult sites more attractive and/or supporting smaller scale uses as parts of larger schemes.

3.27 Thus the great majority of schemes by developers are not unduly hampered by adverse ground conditions. Local developers in particular are usually aware of likely ground conditions, know where and how to seek further applied geological information and have experience of likely remediation costs. This may give them a competitive edge and will often reduce the risk of a given proposed scheme. At national level, developers may not have operated in the Wigan area, but they will have experience of adverse ground conditions and will be aware of the need to seek detailed advice. The possible weak link for any developer or initiator of a major scheme may be the securing of substantial finance. Thus some London-based or other outside financiers may have some reluctance to fund a scheme with perceived difficult ground conditions. If neither funding nor grant aid can be secured, then any site which is financially not viable, will be by-passed by developers thus leaving owners with potentially costly liability and Wigan MBC with reduced planning flexibility.

3.28 Developers tend to seek added value on a site-by-site basis, with development potential and costs forming their key criteria. In parallel, Wigan MBC places a strong emphasis on the need to continue urban renewal and dere-

lict land reclamation schemes in order to achieve environmental improvement and, where applicable, to bring forward developable land. The activities of developers and of Wigan MBC overlap, but are not the same. The Council seeks general environmental improvement and the removal of eyesores; developers seek site-specific profit. These interests often, but not always, operate in parallel. One result, however, is that most of the easiest options in terms of land reclamation and development potential have been, or are being, achieved; whilst developers tend to leave the more difficult sites for later consideration.

Environmental conservation perspective

3.29 The phrases 'conservation' and 'conservationist' are used here to denote reference not to more narrowly defined built environment issues but to the wider ranging area of nature and resource conservation. There is a large number of conservationist groups with an active interest in the Wigan area. These groups operate at local, regional or national level. Their primary objective is the protection of specific parts of the natural and built environments within the area. Conservationist interests recognise that much of the Wigan environment is compromised by man-made ground conditions, and also recognise that existing problems can be further exacerbated through development of affected land. On the other hand many recent reclamation schemes have enhanced the environment and development on damaged sites can have a beneficial effect.

3.30 Like many northern towns with a long industrial history, Wigan today has to deal with many historic, man-made, ground condition problems. There are a wide range of ground conditions which are potentially of interest and/or concern to conservationist interests. Amongst the ground conditions upon which conservationist interests expressed interest are the following:

Derelict land — Such land can cause environmental problems in its present state or when remediation proceeds. Both wildlife (which has made such sites their habitat) and water quality (once reasonably stable contaminants have been mobilised) may be at risk.

Landfill sites — Existing landfill sites can be potentially hazardous to both wildlife and water resources, although where filling has ceased some sites may provide an additional conservation resource.

Groundwater — This is one source of water supply in the Wigan area and protection of its quality from possible contamination or pollution is vital.

Mining — Opencast and underground mineral extraction can incur environmental risks including pollution, and the loss of habitats and flora.

Peat extraction — Peat is a scarce resource and both it and the rare Mosslands its supports should be protected.

Flood-prone land — Development on such land can reduce flow of water or flooding capacity and thus potentially increase risk of damage or contamination of land, property or water supplies.

Subsidence — This creates land that may be liable to flooding, thereby altering the environmental balance.

3.31 The fundamental planning and development issue which is significant to conservation interests is the perceived, and often real, conflict between economic development and the environment. Conservationists argue that continued development in Wigan may, in places, exacerbate or create adverse ground condition problems. For example, the clearing up of historic contaminated land sites can turn a relatively stable situation into a volatile one whereby groundwater may be put at risk of contamination. Conservationists are also concerned to ensure that the problems caused in the past are not repeated today.

Evaluation of ground conditions

3.32 Just as the 'planning system' encompasses a wide range of different interests, different groups and organisations evaluate ground condition information from different perspectives. But although the perspectives of the three broad groups outlined in paragraphs 3.19–3.31 above are different, they do have some common points. Derelict land, landfill sites and (potential) subsidence were mentioned by all groups as important planning issues in the Wigan area. These and other aspects of ground conditions are at least partly interdependent. Each ground condition interacts with the planning system in a variety of ways, often directly but at times more subtly.

3.33 Specific ground conditions are considered in detail in the following sections of this report. Rather than considering each ground condition as a 'resource' or as a 'constraint' (many are of course both), this report attempts to group the elements of applied geology into a framework related to the planning system. the following sections thus consider ground conditions in relation to:

- the protection of natural resources (section 4)
- contaminated and rehabilitated land (section 5)
- landfill sites and associated issues of leachate and gases (section 6)
- minerals planning and related environmental issues (section 7)
- other general ground conditions (section 8)

3.34 Chapters 4 to 10 of this report seek to provide an overall assessment of the relationship between ground conditions and the planning system in Wigan they examine:

- the issues which have a direct bearing on the location of new development
- the link between ground conditions and economic development strategies seeking to encourage inward investment
- the key geological considerations in planning and development.

The key geological factors in planning and development are summarized on Map 10 which is described in Chapter 11 of this report.

4 Protection of natural resources

4.1 Protection of natural resources and the need for new development need not always represent conflicting objectives. The reclamation of much derelict land in Wigan has enabled development and environmental improvement to proceed in tandem. However, the pressure to designate development land as set against greater public awareness of the environment has increasingly led to conflict.

4.2 Wigan's Unitary Development Plan (UDP) affords a high level of protection against development in many areas. The statutory and/or UDP designations of green belt, Sites of Special Scientific Interest, nature reserves and sites of biological importance greatly restrict possibilities of damaging development, though even in areas such as green, belt pollution can occur, for example, as a result of agricultural activities such as slurry spreading which do not require planning permission. Development in the countryside beyond these designated areas has varying direct and indirect effects on natural resources and the environment.

4.3 The focus of this chapter is the use of the planning system to protect natural resources, rather than the improvement of resources such as derelict land which may already be contaminated. In this regard it is important to distinguish between derelict land and contamination. **Derelict land** is generally defined as being land so damaged by industrial or other development that it is incapable of beneficial use without treatment. Derelict land is covered in detail in Chapter 9. **Contamination** is less easily defined than derelict land. It stands for the pollution of a resource by a damaging agent. The latter may be in solid, liquid, gaseous or radioactive form. The extent to which a pollutant is perceived as contaminating a resource depends at least partly on society's use (existing and potential) of that resource and of the value (commercial or environmental) attached to it. Groundwater is a major natural resource which is potentially liable to contamination. Two aspects of groundwater protection are considered in this chapter, namely:

- the risks of groundwater contamination
- the movement of the groundwater table

RISKS OF GROUNDWATER CONTAMINATION

The significance of possible groundwater contamination

4.4 Groundwater is one of the most important components of the hydrological cycle. It is also a major and vital resource for human domestic consumption and for industrial/commercial use. Contamination of groundwater may be overcome by additional treatment but this is costly and, if reasonable precautions are taken in the first place, should not be necessary. Despite its importance, groundwater protection has not generally received adequate attention until relatively recently.

4.5 Groundwater flow and the transport of pollutants are not easily observed or measured, and are generally very slow. However the general scale and persistence of groundwater pollution is now becoming appreciated because of its impact on potable water supplies and because of the excessive cost and technical difficulties of remedial actions to restore groundwater quality. Polices are being developed by the National Rivers Authority (NRA) and are outlined in paragraph 4.26 below.

4.6 The pollution of groundwater is increasingly being recognised to be of crucial importance. Once polluted, groundwater could remain so for decades. Leachates from landfills, for example, may contaminate both surface and groundwater, and the development of sites where contaminants may have previously been immobilised or isolated may cause their release. Breaches in buried tanks and pipework may release contaminated water and liquids into the ground. The disturbance and subsequent washing of fine particles is a common problem when rehabilitating land despoiled by metalliferous mining or processing. These are all potential risks in the Wigan area.

4.7 The effect of a contaminated site on groundwater quality will be more subtle than that on surface waters, and groundwater problems can be extremely complex. Materials leaching from the base of a site will percolate downwards and will eventually enter the water table, although physical, chemical and biological processes acting within the unsaturated zone, coupled with the dilution, dispersion and other processes within the saturated aquifer can reduce the effect of the contaminants.

4.8 The NRA classifies surface waters into four broad bands using various biochemical criteria; see Table 1 below. The quality of surface water in the Wigan area is linked to the legacy of industry and mining. Many of the surface waters are polluted and support little aquatic life and local rivers and canals are generally classified as containing water of 'poor' or 'bad' quality. An exception is

Table 1 Water quality classification.

Class	Description
1. Good	Water of high quality suitable for potable supply abstrations; game or other high class fisheries; high amenity value
2. Fair	Waters suitable for potable supply after advanced treatment; supporting reasonably good coarse fisheries; moderate amenity value
3. Poor	Waters which are polluted to an extent that fish are absent or only sporadically present; may be used for low grade industrial abstraction purposes; considerable potential for further use if cleaned up
4. Bad	Waters which are grossly polluted and likely to cause a nuisance

the River Douglas and smaller tributaries of the two river networks which are considered 'fair'.

4.9 The two main aquifers are the Sherwood Sandstone and the sandstone units within the Carboniferous Coal Measures. The **Sherwood Sandstone** is currently the most exploited aquifer in the Wigan area. It provides much of the local municipal water supply and abstractions in the Wigan area for public supply deliver a significant proportion of that supply to areas outside the Borough. This groundwater has been exploited for over a century because of favourable aquifer properties and good quality water. Borehole yields are normally high and the aquifer is generally unconfined. Tests at Kenyon Junction show that about 70 per cent of the flow into the borehole was from fractures rather then permeability. At greater depths, however, the contribution of flow from fractures decreases. Therefore, for most practical purposes, the aquifer is considered to be restricted to the upper 200 m. The area is dissected by faults and the fracturing associated with these faults can increase the permeability of the sandstone; see Chapter 9 of Volume 1 of this report for further details.

4.10 The **sandstone units within the Coal Measures** form the second main aquifer in the Wigan area. This aquifer is complex and multi-layered, and has been changed considerably by past mining activities. These changes have been due not only to the construction of shafts and galleries, but also by the effects of subsidence. Subsidence will have created vertical fractures cutting across and connecting previously separate aquifer horizons. Groundwater storage and transport through the associated sandstone horizons are largely dependent upon fractures in the otherwise weakly permeable sandstones. Boreholes and well yields may decline in response to long-term pumping, since there is only limited recharge to the sandstones. These issues are covered in more detail in Chapter 9 of Volume 1 of this report.

4.11 The bulk of the superficial deposits are till, which is clay-rich in the Wigan area. Till is generally impermeable but lenses of glacial sands and gravels can give modest groundwater supplies to shallow wells, and have been used mainly for domestic and agricultural use. Made ground, often consisting of mining waste can also contain groundwater where it overlies low permeability till, for example at Ince Moss. There are also considerable thicknesses of water filled peat deposits in the Chat Moss area where surface drainage ditches are required to maintain water levels below the ground surface.

4.12 It is the excess rainfall of winter months which provides the main recharge to the aquifer. However where, as in most of Wigan, the relatively impermeable drift deposits are thick then there will be a lot of water run-off, instead of major recharging to the aquifer. There are two main recharge areas — one being along the south-west local authority boundary to the south-west of Ashton-in-Makerfield and through upward leakage from the deep lying Collyhurst Sandstone, and this can be induced particularly along fault lines.

4.13 Groundwater within the Sherwood Sandstone is generally of good drinking quality. A 1981 study by Birmingham University also concluded that the age of fresh waters within the aquifer was less than 2000 years old. However deep sources of saline water have been detected, and the construction of deep boreholes could puncture this layer and allow upward migration of the saline water. Also, if there is leakage of water laterally from the Coal Measures or vertically from the Collyhurst Sandstone, the mixing of groundwaters can lower the quality of the native groundwater.

4.14 Groundwater within the Coal Measures is generally of much poorer quality than that found within the Sherwood Sandstone. The water is moderately hard, with very high or high concentrations of sulphates, irons and trace metals. All the deep coal mines in the Wigan area are closed. This may lead to rising water-levels within the Coal Measures and the potential threat of highly acidic and mineralised groundwaters polluting rivers and streams. The legacy of mining has also produced eccentric and convoluted subsurface drainage patterns, allowing mixing between various sandstone units. Deep coal mining has left an extensive legacy of abandoned workings in an unknown state of collapse. Those workings which had not collapsed on abandonment may be assumed to be degrading steadily.

4.15 Switching off the water pumps of abandoned mines allows water to re-enter the workings. This can produce very acidic mine waters with high concentrations of sulphate, ferric hydroxides, iron and other dissolved metals. If these mine waters enter an aquifer used for water supply, the groundwater would be made useless for potable supply and would be a potential environmental hazard. However, if the mine waters were to reach the surface, greater environmental damage can occur.

Key indicators for groundwater contamination

4.16 With a good knowledge of the conditions of both surface and groundwaters in the Wigan area, development can take place which can maximise the use of these precious resources.

4.17 Groundwater pollution can have either point or diffuse sources.

- **Point sources**: These arise at defined locations giving rise to plumes of polluted groundwater which move in the direction of the groundwater flow. Examples can include leachate from municipal or industrial landfill sites, farm slurry tanks, silage, leaking fuel stores, chemical tanks, sewage treatment lagoons, mining waste tips, sludge lagoons and accidental spillage.
- **Diffuse sources**: In contrast, groundwater pollution from diffuse sources can cause pollution more or less homogeneously over large areas such as from agricultural applications of fertiliser or pesticides. Leaking sewers in an area such as Wigan, with its growth during the industrial revolution, might provide a diffuse source of pollution. In some urban situations, a large number of small point sources may combine to produce diffuse pollution.

4.18 A site investigation which will include borehole drilling, materials sampling and analysis, and on-site testing will enable the nature of the aquifer to be determined. It also enables an understanding of the flux and rate of liquids leaching from the base of the site. However, it is essential that any site investigation of a potentially contaminated site be designed and executed so as to avoid

the creation of a migratory pathway down which `perched' contaminants might move into hitherto uncontaminated strata. Investigative boreholes or trial pits, commonly used as part of the investigation of an actual or suspected contaminated site, are often themselves the greatest risk to an underlying aquifer. This is due to the inclination of site investigators to keep digging down beyond the base of the (suspected) contaminated layer in order to find out 'what is underneath'.

4.19 Assessment of the aqueous environment, or water environmental assessment, requires consideration of the following for both surface water and groundwater:

- quality and variability
- flowpaths and direction — both natural and man-made
- special constraints, such as the morphology of watercourses and aquifers
- flow rates and variability, including hydraulic constraints and aquifer characteristics
- water levels and variability, including flooding and piezometric levels
- inputs — e.g. from watercourses, rainfall, natural and man-made discharges from or within the study area
- outputs — e.g. evapotranspiration losses, natural and man-made discharges and abstractions from or within the study area

4.20 In this context, the term 'natural and man-made discharges' includes any exchange of water between surface and groundwater systems — e.g. via losses or gains from watercourse beds, via springs or risings, or via sinks. Assessment of all the above factors should be considered in both a background (environmental) context as well as at a site-specific level. Also, it is usually appropriate to establish how representative the values obtained for any specific parameter are in the short term compared with a period of several decades or more. This may be particularly important where a 'natural' condition has been long suppressed by an artificial influence (such as abstraction or impoundment of water by others) which may be withdrawn without warning.

Locations where possible groundwater contamination might be important

4.21 As noted above, the **major aquifer** in the Wigan area is the Sherwood Sandstone which contains high quality groundwater in the south of the area. Whilst most of this aquifer is overlain by drift deposits, there are localised areas of sandstone outcrop. These occur primarily in the Golborne area and also at Bedford Moss/Chat Moss. In these areas the drift cover is thin or permeable and the underlying aquifer is vulnerable to pollution by industrial or agricultural practices.

4.22 There is also a **minor aquifer** formed by Coal Measures sandstones in the northern part of the Wigan area. Groundwater movement in this aquifer is affected by former coal workings and it provides, via faulted boundaries, some recharge to the Sherwood Sandstone aquifer to the south. Major outcrop areas, where cover is thin and this minor aquifer is vulnerable to pollution, are spread around the northern part of Wigan Borough particularly in the area between Wigan town centre and Longshaw to the south-west, and near both Standish and Tyldesley. However, groundwater vulnerability in the Coal Measures is complicated and very site-specific and any individual proposed development needs consideration on its own particular merits.

4.23 The great importance of groundwater to Wigan means that development in areas where the aquifer is vulnerable to contamination must be closely monitored. The main aquifer covers the Cheshire basin to the south, thus representing a major regional water resource. This resource pays no regard to local authority boundaries and thus the statutory planning system within Wigan has a far-reaching responsibility for any development proposals which could possibly lead to groundwater contamination.

4.24 Deep sources of saline waters have been detected within the Sherwood Sandstone. The construction of deep boreholes could puncture confining layers and allow upward migration of these saline waters. Depending on the localised geological structure, excessive pumping could likewise draw saline waters upwards and pumping thus potentially contaminating groundwater supply.

Appropriate action on the risks of groundwater contamination

4.25 Wigan Metropolitan Borough Council has stated its intention in the draft Unitary Development Plan not to permit development which is likely to result in unacceptable levels of pollution in watercourses and groundwater (Policy EN3). There are three key elements to consider in this regard:

- groundwater protection policy
- aquifer protection
- source protection

4.26 In parallel with existing and emerging planning policies deriving from Wigan MBC and the Department of the Environment, the NRA has published a groundwater protection policy. This employs the assessment and mapping of aquifer vulnerability and the designation of protection zones around sources. The NRA has a statutory duty to monitor and protect the quality of groundwater and to conserve its use for water resources. The NRA policy seeks, in principle, to strike a balance between total prohibition of any activity which would degrade the groundwater resource on the one hand and completely unrestrained development on the other. Its broad objectives are:

- To prevent excessive exploitation and resulting reduction in the long-term availability of groundwater resources. This can be accompanied by lowering of the water table, allowing inflow of water of inferior quality and other undesirable or unpredicted environmental effects.
- To prevent the deterioration in groundwater quality as a result of contamination from the land surface.

4.27 The NRA's groundwater protection policy is still undergoing refinement. It divides the Permo-Triassic aquifer into zones based on vulnerability to pollution.

Specific developments or activities may be inappropriate in certain zones. These zones may be subject to revision by the NRA without notice in the event of changing abstraction or improved hydrogeological modelling. Further advice on the location or vulnerability of groundwater sources and protection zones should be sought from the NRA.

4.28 Reading material on the risks of groundwater contamination

- *Policy and Practice for the Protection of Groundwater*, NRA, 1992, especially the North West Regional Appendix. ISBN 1 873160 37 2. £15.
- *Summary Groundwater Vulnerability Map with Explanatory Notes, Wigan MBC*, NRA North West Region, 1993.
- *Groundwater Vulnerability 1:100 000 Maps: Sheet 10: Central Lancashire*, NRA, due March 1996. *Sheet 16: West Cheshire*, NRA, 1994. ISBN 0 11 885832 7. £9.95.
- *Catchment Management Planning Guidelines*, NRA, 1993.
- *River Douglas Catchment Management Plan*, consultation report, NRA North West Region, 1993.
- *Abandoned Mines and the Water Environment*, Water Quality Series No. 14, NRA, 1994. ISBN 0 11 886520 X. £7.95.
- *Contaminated Land and the Water Environment*, Water Quality Series No. 15, NRA, 1994. ISBN 0 11 886521 8. £7.95.
- *Source Protection Zone Maps*, under preparation by the NRA.
- *A Geological Background for Planning and Development in Wigan*, published by British Geological Survey, 1995.
- *Waste Management Licensing Regulations 1994*, SI No 1056, HMSO. This provides details of the new waste management licensing scheme, including waste oils and groundwater.
- *Environmental Protection Act 1990*, HMSO.
- *Water Resources Act 1991* (especially Section 85).
- *Digest of environmental protection and water statistics*, HMSO. ISBN 0 11 752939 7.
- *National Rivers Authority's reports* on monitoring of local rivers and canals. (Most recent survey in 1990).

4.29 Initial contacts for primary information on groundwater

- National Rivers Authority, Groundwater Section, PO Box 12, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG. Tel. 01925-653999 ext. 2532.
- North West Water Ltd, Stephens Way, Goose Green, Wigan, WN3 6PJ. Tel. 01942-244241.
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- National Geosciences Record Centre, Keyworth, Nottingham NG12 5GG. Tel. 0115-9363100
- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- The NRA free telephone 'Hotline' for reporting pollution incidents is 0800-807060.

MOVEMENT OF THE GROUNDWATER TABLE

The significance of movements of the groundwater table

4.30 Groundwater abstraction directly affects water levels. Its presence can deplete water resources, often at some distance to the point of abstraction. Conversely, after a long period of abstraction, its cessation can cause pollution if the rising groundwater table floods mineworkings, mineral workings or waste deposits where the water may come into contact with contaminant minerals or substances.

4.31 Before the Industrial Revolution, the quantities of groundwater abstracted would have been extremely limited. The water table would have generally been a subdued version of the ground topography. Recharge would have entered the aquifer in areas where drift was absent, thin or composed of permeable materials. Groundwater flow would have provided the base flows of rivers and streams.

4.32 The Industrial Revolution caused a rapid increase in groundwater utilisation, particularly for industrial and public supply purposes. The need to work coal below the water table required the removal of water from the workings and this was able to meet most of the required increase in supply. As mine workings extended ever deeper, shafts and horizontal galleries, together with vertical fracturing caused by subsidence, largely destroyed the original multi-layered nature of the Coal Measures aquifer and caused a significant lowering of the water table. The available information is shown on Map 4 (Hydrogeology).

4.33 Whilst the Coal Measures supplied most of the local water needs, the water levels in the Sherwood Sandstone were affected by excessive abstraction elsewhere in South Lancashire and were gradually declining. Deep coal mining in the northern part of the Wigan area ceased some 20–30 years ago allowing water levels to rise In contrast, in parts of the southern area, mining and pumping continued until closure in the early 1990s; only then did water levels start to rise in that area.

4.34 Around the 1960s, when mine water pumping was at a maximum, groundwater levels in the Coal Measures strata were depressed to their lowest levels and it is highly probable that water flowed from the Sherwood Sandstone to the Coal Measures.

4.35 When the coal mines in the Wigan area were closed, pumping ceased and abstraction from the Coal Measures for public supply also declined rapidly. It is probable that water levels within the Coal Measures rose rapidly but were unable to return to the original levels due to enhanced drainage through the mining disrupted strata. Simultaneously, increased abstraction from the Sherwood Sandstone to the south caused a considerable lowering of the

water table within it, and created significant groundwater downdraw around major public supply pumping stations.

4.36 After the mid-1960s there was a significant increase in public supply abstraction; in 1993 the total annual licensed abstraction was over 13M cubic metres. With the cessation of mine dewatering following the final deep mine closures in the early 1990s, water levels may be rising locally in the Coal Measures strata. The history of groundwater changes and the consequences of the end of mining are described in Chapter 9 of Volume 1 of this report.

Key indicators for groundwater table movements

4.37 The direction of groundwater flow within the Sherwood Sandstone is dominated by abstraction patterns. At the present time, water movement is generally towards the depression created by the abstractions between Leigh and Golborne. Towards Ashton-in-Makerfield water levels are rising but further east water levels have achieved some degree of balance with a possible slight downward trend. However, any alteration of abstraction patterns will result in changing water-levels. Detail of current abstraction patterns are given in Chapter 9 of Volume 1 of this report.

Locations where movement of the groundwater table might be important

4.38 As outlined above, the Sherwood Sandstone is the main aquifer. Any movement of the groundwater table in these strata is thus important in that it could, technically, have a bearing on the cost of exploiting this resource. Groundwater table movement may also be important within the Coal Measures, but here movements are more difficult to predict as they depend upon whether mine or other dewatering works have stopped or when they are likely to stop.

4.39 The hydrogeological properties of the main geological units in the Wigan area are shown in Table 2 below. This shows the hydrogeological characteristics of each of the aquifers.

Appropriate action on movements of the groundwater table

4.40 Some movement of the groundwater table will occur naturally. But proposed developments may affect its level and as such they will normally require notification to, and possibly permission from, the NRA. Intending developers may be best advised to contact the NRA at an early stage. In addition, the NRA is a statutory consultee of the planning authority (Wigan MBC) for planning applications. The NRA also has a direct regulatory role and the statutory powers to take remedial action as appropriate.

4.41 The great reduction in mine pumping over the past 30 years and the consequent rise in groundwater levels in that part of Wigan with underlying Coal Measures has already been referred to above. There are currently no known deep mine dewatering abstractions since the closure of the last deep pit in 1993/94. Post-privatisation mining proposals may be relevant but at present these are unknown. In other parts of the UK the cessation of mine pumping has led to the flooding of deep basements and/or potential problems due to reducing foundation bearing capacities. There is insufficient evidence as to whether this will happen in Wigan. It is a site-specific issue and any developments incorporating deep basements which are proposed in low-lying areas should be supported by analysis of existing groundwater levels and of recent movements.

4.42 For areas of **rising groundwater levels**, appropriate action might include:

- Appropriate engineering design for new development. If groundwater may rise after construction, such engineering may be based on making below-ground structures water-tight and flotation-resistant.

Table 2 Hydrogeological units and characteristics.

Hydrogeological unit	Character	Hydrogeological characteristics
Superficial: sand and gravel	minor aquifer	Minor aquifers within superficial deposits giving shallow perched water tables or increasing recharge to underlying aquifers
Superficial: till	aquitard/aquiclude	Covering much of the area, inhibiting recharge and in places confining the underlying aquifers.
Sherwood Sandstone	major aquifer	This aquifer has a high permeability. Groundwater flow is through both fractures and pore spaces, and is generally restricted to the top 200 m.
Manchester Marl	aquitard/aquiclude	A low permeability layer confining the Collyhurst Sandstone and inhibiting hydraulic contact between the Collyhurst and Sherwood Sandstones.
Collyhurst Sandstone	minor aquifer	A thin, friable sandstone of high permeability not generally exploited due to its deep confinement and thin outcrop.
Coal Measures	aquifer	Sandstones within the Coal Measures can be locally important aquifers. They are generally well cemented and groundwater flow is through fractures. Numerous faults dissect the sandstone units into small blocks. Mine workings if present may provide highly transmissive conduits for groundwater not naturally present in strata, including those normally regarded as impermeable.

- Construction of remedial, drainage or dewatering works to protect existing structures.

4.43 For areas subject to possible **falling groundwater levels**, appropriate action might include:

- Remedial works to prevent 'loss' of water.
- Restriction or revocation of abstraction licences issued by the NRA.
- Restriction of over-abstraction or of drainage works by the serving of a NRA Conservation Notice.

4.44 **Reading material on movements of the groundwater table**

- *Policy and Practice for the Protection of Groundwater*, NRA, 1992, especially the North West Regional Appendix. ISBN 1 873160 37 2. £15.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Water Resources Act 1991*, HMSO. ISBN 0 10 545791 4. £18.15.
- *Environmental Protection Act 1990*, HMSO. ISBN 0 10 544390 5. £14.45.
- *Water Industry Act 1991*, HMSO. £16.65.
- NRA documentation

Initial contacts for primary information on groundwater movement

4.45 Her Majesty's Inspectorate of Pollution (HMIP), established in 1987 as part of the Department of the Environment, has statutory responsibility under the Environmental Protection Act 1990. These powers will normally encompass the lateral spread of leachates and gases, at least where due to recent and current industrial processes. At the time of writing it is the Government's intention to create a new, independent Environmental Protection Agency for England and Wales, bringing together the responsibilities of HMIP, the NRA and the waste regulation functions of local government.

4.46

- National Rivers Authority, Groundwater Section, PO Box 12, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG. Tel. 01925-653999 ext. 2532.
- North West Water Ltd, Stephens Way, Goose Green, Wigan, WN3 6PJ. Tel. 01942-244241.
- British Coal Enterprise Ltd, Grosvenor House, Agecroft Road, Pendlebury, Manchester, M27 8UW. Tel. 0161-743 9449
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991

5 Contaminated and rehabilitated land

5.1 The long industrial legacy of the Wigan area has resulted in the creation of contaminated land, though much of this has been restored or reclaimed over the past 40 years. Reclamation programmes have covered both contaminated sites and non-contaminated but nevertheless despoiled sites. In addition, national regeneration has taken place on both contaminated land and on other despoiled areas. This section thus deals with the partially linked issues of:

- contaminated land
- the rehabilitation of despoiled areas

CONTAMINATED LAND

The significance of contaminated land

5.2 The term 'contaminated land' refers to the presence of substances on a site, usually in the soil, in concentrations which could cause harm (directly or indirectly) to humans, animals, vegetation or structures. Areas of made and worked ground in the Wigan area are shown on Map 6. Not all such sites are, in fact, contaminated. Assessment of any individual site will invariably require a specific study and, as applicable, site investigation.

5.3 The new Environmental Protection Bill, currently under debate in Parliament, provides, for the first time, a statutory definition of contaminated land. This covers any land, including closed landfill sites, which harms, or is likely to harm, living organisms or ecological systems, or pollutes controlled waters such as rivers and groundwater. In effect 'harm' includes harm to property due to the consequent damaging effects to man. Statutory responsibilities for control of contaminated land will, if the Bill is passed, rest with a new Environmental Protection Agency as outlined in paragraph 4.45 above.

5.4 In Wigan as elsewhere the pressures to retain green belt land and open land, and the emphasis placed upon inner city regeneration and urban renewal, generates an increasing need to redevelop land which was formally used for industry, mining, waste disposal and other potentially contaminating uses. A good example would be a former town gas production site which is now available for redevelopment as a result of the nationalisation of the gas industry and the switch from town gas to natural gas.

5.5 This reuse of sites reduces the land-take needed from undeveloped sites and it usually represents an improvement in physical or visual amenity. Such reuse in Wigan has included industrial, commercial and public open space uses.

5.6 Land contamination impacts on the planning system in two broad ways as follows:

- For proposed development requiring planning permission, contamination is a **material planning consideration** which needs to be taken into account by both the statutory planning process and by developers in initial project feasibility assessments.
- The town and country planning system and other regulatory systems will normally make a **statutory response to existing contamination**.

5.7 With regard to statutory responses, the planning system (and building regulations) can seek to tackle contamination by specifying remediation of a site when development proposals are made for that site, and by possibly rezoning contaminated sites for higher end uses and then exercising control via conditions. Neither of these mechanisms is comprehensive, and the latter might be seen as a 'reward' to polluters. The alternative is use of the Environmental Protection Act 1990, usually via HMIP.

5.8 Who, or what, may be at risk from contamination will vary depending upon the past/present and proposed use of the land. Private housing, with gardens, is often the most sensitive area. For example, where land contamination from heavy metals (e.g. lead, cadmium and mercury) is intended for housing the following may be affected:

- residents (especially young children who may eat contaminated soil)
- consumers of home-grown produce
- gardeners, who will have prolonged contact with soil

Key indicators for contaminated land

5.9 The current and past uses of land will usually provide an indication as to whether a site might be contaminated. Numerous present and past land uses have the potential to contaminate sites. These include, though not necessarily in order of potential danger, the following:

- application of sewage sludge to agricultural land
- chemical and pharmaceutical industries
- colliery tips
- electrical goods manufacturing, e.g. use of solvents and metals
- filled dock basins, canals and dockyards
- fly-tipping, cable-burning and bonfires
- gas works
- iron and steel works
- metal treatment and finishing
- mining and extractive industries
- oil refining and storage
- paint and dyestuff industries
- railway land, especially large sidings and depots

- scrap yards and fragmentation plants
- sewage works and farms
- timber treatment
- waste disposal activities (hazardous and non-hazardous industrial and household wastes)

5.10 The following table summarises the types of contaminant which might be found in some sites in the Wigan area.

5.11 A preliminary check should be initiated at the very beginning of a project, bearing in mind the history of the site, and the possible type and effect of contaminants. It should also be borne in mind that some contaminants will, or might be, mobile. Thus contamination can migrate from adjacent or other lands via sub-surface gas migration or via contaminated groundwater; for the latter, refer to Chapter 4 above. The study of mobility of contaminants is a relatively new field and expert site-specific advice may be essential.

5.12 Associated with the problem of contamination may be one of fire. This may be propagated underground if material of a suitable calorific value is present together with an ignition source and a sufficient supply of oxygen. Examples include ground containing coal or coal dust, oils or domestic waste. Bonfires on the surface may be sufficient to start an underground fire which is then difficult to extinguish. Signs of such a fire may be emission of steam, warm patches of ground or settlement.

Locations where land contamination might be important

5.13 The investigation of contamination will often require on-site boreholes or trial pits, but an initial review of historical information will usually provide an idea of what to look for and where to look. The areas of known or suspected land contamination in the Wigan area are shown on Map 7 (Previous and Present Industrial Uses). Generally they are within or close to urban areas and settlements. Sites which are actively operated at the present are differentiated from closed sites.

5.14 In addition to these areas of known or possible contamination, people or animals can be affected where water pipes pass through contaminated land, e.g. soils containing phenolic compounds or other organics which are able to migrate through plastic water pipes and taint water at extremely low concentrations. Where chlorinated water supplies are affected this may produce chlorinated phenols with enhanced toxicities and a perceived poorer taste. On the other hand, flexible piping may be desirable in ground which might be subject to instability. Thus there could be a conflict of requirements on any one particular site and, again, decisions need to be taken on the basis of site-specific information.

5.15 An associated risk is that of unacceptable odour. These may be associated with the release of toxic or flammable gases from landfills and may also be a problem in land contamination with organic substances, such as coal tars. Although odour problems are not necessarily associated with a particularly hazardous situation, the nuisance imposed can often be difficult to control and may have a profound effect on public perception and the choice of end use for the site.

5.16 Contaminated land also affects new development and redevelopment, including commercial schemes such as office buildings and car parks. Compared to residential use, such commercial uses tend to be less sensitive to particular contaminants. Thus there are possible risks for this type of development, e.g. the risk of releasing contaminants during site works prior to redevelopment; the susceptibility of concrete to attack from sulphate; the migration of toxic or explosive gases into buildings; the effects of organic contaminants on water supply. The type and degree of contamination may limit the future use of the land, or remedial measures may be necessary before the land can be developed safely for a proposed use.

Appropriate action on land contamination

5.17 The proposed Environmental Protection Agency (see paragraph 4.45 above) will exercise contaminated land powers as currently laid out in the Environmental Protection Act 1990. In this regard, there are three main stages in managing the proposed development of a contaminated site:

- identification
- assessment of hazard and investigation
- remedy

5.18 Identification of contaminated land is to remain a function of Wigan MBC. The Government review of

Table 3 Types of contaminant which may occur in the Wigan area.

Contaminants	Hazards
Heavy metals, phenols, coal tars, cyanide	Toxicity to humans or animals by ingestion of soil (particularly children) or home grown produce
Oils, tars, phenols, asbestos	Toxicity to humans or animals by direct contact
Hydrogen sulphide and other gases	Toxicity to humans by way of inhalation
Phenols, oils, coal tars, sulphates, sulphide and chlorides	Attack on services, e.g. plastic pipes, or building materials, e.g. concrete
Landfill gas, flammable or combustible materials	Risk of explosion or fire
Zinc, copper, nickel, sulphates	Phyto-toxicity (substances harmful to plant growth)

contaminated land (Framework for Contaminated Land, November 1994) proposes that:

- Boroughs and districts be required to identify contaminated land and closed landfill sites in their areas.
- The authorities prepare registers of contaminated land as required by Section 143 of the Environmental Protection Act 1990.
- The definition of contaminated land be revised (see paragraph 5.3 above) so that information is recorded only on actual (and not suspected) contamination, and is only recorded if it is 'significant'.
- These registers will specify the action needed to remedy any contamination present.
- The primary responsibility for contamination is based on the 'polluter pays' principle.
- Liability for such remediation will fall first on the polluter, but will pass to new owners when any property is transferred.
- The proposed Environmental Protection Agency will provide a framework of guidance for remediation, based on the 'suitable for use' approach.

5.19 For the assessment and investigation of (possible) contamination hazards, a detailed knowledge of the specific site is critical. In this regard, sources of site information include:

- Maps, e.g. Ordnance Survey (current and historical) — these often indicate former uses which are prone to creating contaminated land; Geological Survey maps and town plans
- Statutory authorities e.g. local authorities, Health and Safety Executive, HM Inspector of Pollution
- Utility and infrastructure companies, e.g. British Gas, British Rail
- Trade information from directories, trade associations, etc.
- Photographic records, including aerial photographs
- Technical data from published literature
- Anecdotal information, e.g. from libraries, newspapers
- Meteorological and hydrological records

5.20 There is a great deal of ground condition information available for the Wigan area as encompassed by Volume 1 of this report. Interpretation and analysis of this information will provide an indication of the likely nature of contamination. Knowledge of the nature of contaminating materials, the layout and the history of the site and the local environmental conditions will enable the most appropriate investigation and treatment strategies to be undertaken. This in turn will lead the planning authority, prospective developers and other interested parties to consideration of two issues as outlined below, namely:

- the **planning process** by which adequate information and proposed remediation should be considered by the statutory planning system, and
- The **practical solutions** for resolving the problem of contamination.

5.21 **Planning process** Where it is known or strongly suspected, that a site is contaminated, a site investigation will normally be required by Wigan MBC, as the local planning authority, before any planning application is determined. If the submitted information is insufficient, then the intending developer will normally be required to provide additional information. Should remedial action be required to safeguard future users/occupiers or existing adjacent users/occupiers, then planning permission may be granted subject to conditions specifying the measures to be carried out. If the proposal is considered unsatisfactory, planning permission may be refused on grounds relating to contamination.

5.22 When a development proposal is in the form of an outline application, the applicant may seek to regard siting or means of access as a 'reserved matter'. If such a proposal is made on a site which is (or is considered to be) contaminated, it would normally be prudent for Wigan MBC, as the planning authority, to ensure that any consent is conditioned or tied to a legal agreement. This will ensure that appropriate remedial actions and/or safety requirements will be undertaken by the developer.

5.23 Where there is only a suspicion of contamination, site investigation and assessment may be made a condition of the granting of planning permission. If the problem cannot be solved by imposing a planning condition, it may be possible to allow the development to proceed by the local planning authority and developer entering into a voluntary legal agreement under Section 106 of the Town and Country Planning Act 1990. The agreement will specify the remedial action which will be taken on the site.

5.24 **Practical solutions** In Wigan, as elsewhere in UK, the reclamation of contaminated sites has generally been achieved by one of several methods:

- 'diluting' the contaminated materials with clean fill so as to reduce the concentration of contaminants
- treating the contaminated material, either in-situ or elsewhere, so as to remove or reduce the source of contamination
- leaving the contaminated materials on the site untreated, and simply covering them with a capping material
- removing the contaminated materials for disposal by landfill, either off-site (at a waste disposal facility) or on-site (often in a controlled 'cell')

5.25 These are fairly basic approaches but they have customarily been adopted, often as the least expensive option available. However, practice is certain to change due to factors such as a wider general environmental awareness, the harmonising of European Community legislation, and changing UK waste disposal legislation. For these and other reasons, interest is increasing in *in situ* treatment aimed at minimising the need for substantial materials handling operations and off-site disposal.

Reading material on contaminated land

5.26 Any review of literature on possible contamination should include historical data, if available, on past uses and

processes including mining history. If possible the history of a site should be researched back to its original or 'green-field' status, though this will not always be practical in an area such as Wigan with its extensive and lengthy industrial heritage. Reading sources include:

- Ordnance Survey maps, both current and historic
- aerial and other photographs
- *Pollution Potential of Contaminated Sites: A Review*, draft consultation report, R&D Note 181, NRA, 1993.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *Planning and Pollution Control, PPG23*, July 1994, DoE.
- *Contaminated Land,* DoE/Welsh Office, consultation paper, March 1994.
- *Framework for contaminated land,* HMSO, Nov. 1994
- *Paying for our Past,* DoE.
- *Guidance on preliminary site inspection of contaminated land.* 1994. DoE, HMSO.
- *Sampling strategies for contaminated land.* 1994. DoE, HMSO.
- *Information systems for land contamination.* 1994. DoE, HMSO.
- *A framework for assessing the impact of contaminated land on groundwater and surface water.* 1994. DoE, HMSO.
- *Documentary research on contaminated sites* 1994. DoE, HMSO.
- *Site investigation in construction*, 1993, Part 1 — Without site investigation ground in a hazard. Part 2 — Planning procurement and quality management. Part 3 — Specification for ground investigation. Part 4 — Guidelines for the safe investigation by drilling of landfills and contaminated land. Published by Thomas Telford.
- *Environmental Information Regulations 1992*, SI 1992/3240, HMSO. This requires local authorities to make available any information they hold relating to the environment.
- *Building Regulations 1971*, (SI 1991/2768). This specifically addresses the need to properly consider potential hazards caused by substances on or in the ground. However this does not apply to areas beyond the extent of the particular building under consideration.
- *Buildings Act 1984*, HMSO. Section 29 enables the local planning authority to reject plans, where it is proposed to build on ground which is filled with faecal or offensive animal or vegetable matter or which has such matter deposited upon it.
- *Various guidance notes* from the Interdepartmental Committee of the Redevelopment of Contaminated Land (ICRCL), DoE. These notes cover specific aspects of problem sites including landfills, gasworks, sewage works and scrap yards. A full list can be obtained from the Department of the Environment.
- *Environmental Protection Act 1990.*
- *Town and Country Planning (Assessment of Environmental Effects) Regulations 1988.*

Initial contacts for primary information on land contamination

5.27 On a general basis, the following should be consulted:

- Greater Manchester Waste Regulation Authority, Blackfriars House, 6th Floor, Parsonage, Manchester, M3 2JA. Tel. 0161-832 2776
- Greater Manchester Geological Unit, University of Manchester, Oxford Road, Manchester, M13 9PL. Tel. 0161-275 2314
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- National Rivers Authority, PO Box 12, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG. Tel. 01925-653999

5.28 On a site-specific basis, additional consultation should take place with:

- former and current occupiers and users
- local archives and local newspaper proprietors

REHABILITATION OF DESPOILED AREAS

The significance of rehabilitation

5.29 Rehabilitation of despoiled areas may take place naturally and/or be encouraged by man. Man-made reclamation is very recent in historic terms and has essentially occurred only in the last 75 years. Such intervention has taken place both for commercial re-use of the land and to accelerate 'natural' reclamation. As much of Wigan's industrial heritage pre-dates this period, some by several centuries, extensive reclamation of despoiled areas has taken place naturally.

5.30 Rehabilitation, whether natural, man-made or both, is important for a number of reasons:

- it may make the ground safe for development;
- it reduces erosion, helps slope stabilisation, and reduces blockages in watercourses;
- it often provides a valuable and new refuge for wildlife;
- it improves the visual image of the site and the surrounding area;
- it avoids the spread of dust and detritus by wind.

Key indicators for the rehabilitation of despoiled areas

5.31 Given the length of time over which some areas have experienced rehabilitation in Wigan, identification of such areas is often not possible from a superficial inspection.

Indeed, some such areas are to all intents and purposes in their 'natural' state at present. Nevertheless, at least three clues are sometimes present:

- Steep slopes (whether natural, excavated or tips) may be potentially unstable and will not vegetate of their own accord. Regrading of such slopes may be necessary for revegetation or aesthetic reasons, but in any event the resulting landform should be physically stable.
- There may be visual evidence of man-made re-contouring.
- Badly or recently contaminated sites will frequently not support the range of flora that might otherwise be expected and again give rise to a reasonable suspicion that an area has suffered some degree of environmental damage which has not (yet) been overcome by natural or man-made rehabilitation.

Locations where the rehabilitation of despoiled areas might be important

5.32 Despoiled areas are thus one of the results of human modification of the natural environment. Where such areas include steep slopes, geotechnical assessment will often be necessary before any form of intervention, still less development, is proposed. In the Borough of Wigan the natural environment has been modified by:

- the addition (by tipping) of materials, thus producing **made ground**, and
- the removal (by excavation) of the natural ground, thus producing **worked ground**.

5.33 The locations of these areas in Wigan are shown in Map 6 (Made and Worked Ground). The extent to which these areas have been rehabilitated varies not only between sites but also with time. Natural rehabilitation is a slow process, although it can be accelerated by man's intervention. Investigation on a site-by-site basis is thus necessary in order to ascertain the current 'natural' state of any specific site.

Appropriate action for the rehabilitation of despoiled areas

5.34 Wigan has a long history of both natural and man-made rehabilitation of what in the past was a very extensive range and number of despoiled areas. Map 6 shows a large number of sites comprising made and/or worked ground. It is not suggested that all or even many of these are currently despoiled; as stated above site-specific inspections are required. Many sites have been reclaimed by human action, particularly over the past 40 years. From a conservation perspective, this is invariably beneficial though it is often natural rehabilitation which provides for a more interesting end result.

5.35 From the perspective of Wigan's objective to continue to promote inward investment, it is those remaining unimproved sites which are most visible and particularly those on or near the main road network which will benefit from early rehabilitation.

5.36 **Reading material on the rehabilitation of despoiled areas**

- *Nature Conservation in Wigan: A Strategy*, Wigan MBC Planning Department, 1991.
- *PPG9: Nature Conservation*, Department of the Environment, 1994.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.

5.37 **Initial contacts for primary information on the rehabilitation of despoiled areas**

- Institute of Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE17 2LS. Tel. 01487-3381
- English Nature, Northminster House, Peterborough PE1 1UA. Tel. 01733-340345
- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- Wigan Groundwork Trust. Tel. 01942-270770
- Red Rose Community Forest Centre. Tel. 0161-875-0010
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100

6 Landfill, leachates and gases

66.1 Landfill and waste disposal are on-going processes. Map 6 shows the current extent of made ground and landfill sites in the Wigan area. In addition to these existing sites, some of which are taking additional fill, there is also the need to plan for new landfill sites to accommodate further needs.

6.2 Some, though by no means all, of the sites shown on Map 6 have been potentially prone to the lateral spread of leachates and/or gases, often arising from uncontrolled landfilling in the past. Thus, this chapter of the report considers:

- existing landfill sites
- the prospects for new landfill sites
- the lateral spread of leachates and gas

EXISTING LANDFILL SITE

The significance of existing landfill sites

6.3 Landfill is currently the cheapest and most common waste disposal method in Britain. It accounts for approximately 90 per cent of domestic wastes and over 80 per cent of hazardous wastes. But changing attitudes and particularly the 1990 Environmental Protection Act mean that costs are expected to increase substantially.

6.4 There are two broad types of landfill site: uncontained sites and contained sites. The broad difference relates to the philosophy of control of the leachate generated within the deposited wastes. Leachate is the liquor produced within a landfill from the products of biodegradation of the wastes and dissolution of the waste components. Infiltrating rainwater adds to the volume of these liquors. If the site penetrates the surface of the underlying ground water table, leachate may contribute to pollution. Substantial volumes of leachate can be produced which are frequently highly polluting. For either type of landfill site there is a risk that any interference with an existing site could cause contamination of the ground and/or of groundwater.

Key indicators for existing landfill sites

6.5 The first issue to check is the nature of the fill material as this will help to determine whether or not problems are likely to be encountered. Thus a site filled only with non-biodegradable material such as builders' hardcore will not present problems with regard to gas generation or leachate production, though it might increase the cost of foundations for any future building project. But many landfill sites have either no record or an incomplete record of the actual materials deposited, and even supposedly non-biodegradable material such as hardcore often contains wood. It is thus usually best to assume, until proved otherwise, that any landfill site has a potential to produce contaminants.

6.6 **Uncontained sites** Some of these sites are uncontained because it was assumed, rightly or wrongly at their time of opening, that they would have no potential contaminants to be contained. For the remainder a 'dilute and disperse' principle is adopted, relying heavily on attenuating mechanisms. These mechanisms are complex natural processes which are presumed to reduce the polluting characteristics of the leachate. There is concern as to how effective this system is in effectively controlling pollution of groundwaters. Great care is required in the assessment of the attenuating potential of the strata surrounding the site and of the groundwater regime, since if the leachate comes into contact with groundwater it may have the potential to cause contamination. If the groundwater is an aquifer from which water is abstracted for drinking, then contamination is likely to cause serious problems.

6.7 **Contained sites** These are based on the principle of isolating the wastes from the environment until such time as they are no longer polluting. A criticism of this approach is that it is essentially long-term storage. Containment can be achieved either by taking advantage of natural resources such as low permeability strata or, artificially, by using either clay or manmade liner (eg high density polyethylene) to cover the sides and base of the site. This philosophy implies the need for active management of leachate and landfill gas. It is vital to ensure that leachate is not released to pollute the surface or groundwaters. Landfill gas will often need to be vented. Such management of leachate and landfill gases will probably have to continue long after the site has ceased to accept wastes, possibly for 20 years or more. On completion the containment site will need to be capped effectively to prevent rain or surface waters from entering, saturating the wastes and causing leachates to overflow. This capping must be carefully designed so as not to cause a build-up of landfill gases.

Appropriate action on existing landfill sites

6.8 The extension, and indeed continued operation, of existing sites will need critical evaluation against predetermined hydrogeological criteria which are crucial to good landfill practice. This is particularly the case if there are uncontrolled landfill sites which have received domestic waste within the past 10–15 years (and possibly longer), or if any sites have been operated on the dilute and disperse principle.

6.9 It is not possible to prioritize individual landfill sites without detailed examination on a case-by-case basis. However, evidence of underground structures and tanks, waste pits, made ground (i.e. artificial ground where ground level is raised by man's activities and not due to natural cause), and old drain runs should be sought and investigated as appropriate.

6.10 **Reading material on existing landfill sites**

- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.

- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Environmental Protection Act 1990 (Commencement No 15) Order 1994*, SI No 1096, HMSO. This brought into force the waste management licensing provisions of the 1990 Act.
- *Circular 11/94, Waste Management Licensing: The Framework Directive on Waste.* ISBN 0 11 752975 3, HMSO.
- *Waste Management Paper 4: Licensing of Waste Management Facilities.* ISBN 0 11 752525 0, HMSO.
- *Waste Management Paper 26A: Landfill Completion,* ISBN 0 11 752807 2, HMSO.
- *Control of Pollution Act 1974* (part 1).
- *Environmental Protection Act 1990* (part 2). In particular, S50 places a duty on waste regulation authorities to draw up waste disposal plans.
- *A Consultation Paper on Waste Disposal under an Environmental Agency*, Aug 1992, DoE.
- *EC Proposed Landfill Directive* (originally published, OJ C190 22.7.91)
- *Directive on Protection of Groundwater Against Pollution Caused by Dangerous Substances*, (80/68/EEC) (OJ L20 26.1.80). This makes it an offence to allow indirect discharge of certain classes of compounds directly into groundwater. This includes mineral oils, which are frequently found in leachate in significant concentrations.
- *Handbook on the design of tips and related structures.* March 1991. ISBN 0 11 752539 1, HMSO.

6.11 Initial contacts for primary information on existing landfill sites

- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-44991
- Greater Manchester Waste Regulation Authority, Blackfriars House, 6th Floor, Parsonage, Manchester, M3 2JA. Tel. 0161-832 2776
- Greater Manchester Geological Unit, University of Manchester, Oxford Road, Manchester, M13 9PL. Tel. 0161-275 2314
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100

PROSPECTS FOR NEW LANDFILL SITES

The significance of new landfill sites

6.12 There is growing pressure, reflected in government policy guidelines, to achieve the goal of sustainable development. This will continue to have a direct bearing on packaging and waste generally. Nevertheless, the UK's reliance on landfill to dispose of the majority of domestic and industrial waste is likely to continue in the short and probably the medium term. This need translates itself into an on-going search for new landfill sites, both nationally and in Wigan.

6.13 Landfill is typically located in a suitable void, which meets a range of geological and other conditions. But such voids were most often mineral-extraction quarries, rather than sites which were specifically selected on the basis, for example, of predetermined hydrogeological criteria which are crucial to good landfill practice.

6.14 In the Wigan area most of the former, substantial mineral workings have already been infilled, often though not always with waste. There may be potential for utilising void spaces associated with future opencast coal mines, although this possibility needs to be treated with caution as many of the sites are not suitable for a variety of planning and environmental reasons.

6.15 A growing number of UK sites are exploiting above-ground filling, and it is conceivable that, in the future, novel engineering solutions may be employed to achieve filling above ground on greenfield sites (undeveloped land).

Appropriate action on new landfill sites

6.16 Suitable rock types and the groundwater regime are the two key factors to be considered when looking for possible new landfill sites. Impermeable, unfractured rocks, in an area where there is no through flow of groundwater are required. The ability to absorb pollutants is also a desirable property. Care in assessing the permeability, attenuating potential and groundwater regime of the strata surrounding a potential site is vital, since if leachate comes into widespread contact with groundwater it may have the potential to cause contamination.

6.17 The choice of any potential new landfill sites will need to be rigorously evaluated against the predetermined hydrogeological criteria which are crucial to good landfill practice. In principle, any future landfill site should be located on substantial clay deposits and away from vulnerable groundwater recharge areas as identified in Chapter 4. However, even in areas with a thick till deposit, the localised presence within the till of varying sand and gravel deposits may make any proposed landfill site less suitable or indeed completely inappropriate. The deposition of sand and gravel in the till is not sufficiently well known to support any less generalised comment as to where new landfill sites would be most appropriate. Detailed geological data on a site-by-site basis will thus be necessary to fully support any such proposals.

6.18 Reading material on new landfill sites

- *Landfill Sites: Development Control*, Circular 17/89, DoE.
- *PPG23: Planning and Pollution Control*, DoE, 1994.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Environmental Protection Act 1990 (Commencement No 15) Order 1994*, SI No 1096, HMSO. This brought into force the waste management licensing provisions of the 1990 Act.
- *Planning (Hazardous Substances) Regulations 1992*, SI No. 656, HMSO.

- *Waste management — the duty of care — a code of practice.* December 1991. ISBN 0-11-752557-X, HMSO.

6.19 Initial contacts for primary information on future landfill sites

- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-44991
- Greater Manchester Waste Regulation Authority, Blackfriars House, 6th Floor, Parsonage, Manchester, M3 2JA. Tel. 0161-832 2776
- Greater Manchester Geological Unit, University of Manchester, Oxford Road, Manchester, M13 9PL. Tel. 0161-275 2314
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100

LATERAL SPREAD OF LEACHATES AND GASES

The significance of leachate and gas movement

6.20 Her Majesty's Inspectorate of Pollution (HMIP), established in 1987 as part of the Department of the Environment, has a range of statutory responsibilities under the Environmental Protection Act 1990. These powers will normally encompass the lateral spread of leachates and gases, at least where this is due to recent or current industrial processes. At the time of writing it is the Government's intention to create a new, independent Environment Agency for England and Wales, bringing together the responsibilities of HMIP, the NRA and the waste regulation functions of local government.

6.21 There is frequently no direct control of leachate migration in dilute and disperse landfill sites. In contained sites, however there must be active leachate control to prevent its escape from the site and the possibility of serious environmental pollution.

6.22 A very significant group of gaseous contaminants derives from the degradation of the organic component of wastes in landfills and is known as landfill gas (LFG). Wherever degradable organic matter is present there is the potential for gas generation. The main products of decomposition of degradable organics, in the absence of oxygen, are methane and carbon dioxide, although other gases such as hydrogen, hydrogen sulphide and trace organic vapours can also be present. Carbon monoxide may be present as a result of underground fires.

6.23 The rate and extent of gas generation depends upon a number of interactive factors within the landfill and its surroundings. Methane and carbon dioxide impede plant growth when present in soil through depletion of oxygen levels. Trace components of landfill gas may be acutely toxic to plants at low concentration.

6.24 In some areas of the UK the naturally occurring radioactive gas radon can be a hazard to health. Significant levels of radon may be encountered above faulted, fractured or permeable strata, but there is no evidence that this is a problem in Wigan.

6.25 However, the release of natural methane (mine gas) at the surface has long been, and remains, a potential problem in Wigan. Problems do not end with the cessation of mining or of pumping since gas continues to be emitted from remaining coal and associated strata and may migrate through mine voids. It is possible that the cessation of pumping may lead to the displacement of methane towards the surface, but site specific work would be needed to prove whether or not this will be a problem.

Key indicators for the lateral spread of leachates and gases

6.26 The potential for gas to migrate from a site depends upon several factors:

- pressure caused by gas production or settlement where significant material has degraded
- changes to atmospheric pressure
- gas concentration gradients
- gas permeability in the fill, capping layer and surrounding strata
- changes in the water level in the ground

To assess whether or not gas will be a hazard to a development of a site, the following are important:

- existing composition and pressure of gas within the site boundary
- extent of gas migration from the site
- potential for organic materials for future degradation and subsequent gas production
- volume of gas in the soil atmosphere
- potential pathways for migration — i.e. permeable zones; collapsed strata; old mine workings

Locations where the possible spread of leachates or gases might be important

6.27 Leachates can pollute surface water and groundwater causing contaminated land and the death of vegetation. They generally originate from old landfill sites and spoil tips (highly mineralised water can also arise from mine workings). Revised practice and government guidance should avoid this problem in the case of recently approved new landfill sites.

6.28 Gases may migrate into unprotected buildings. Potentially hazardous gases include carbon dioxide, methane and radon. Carbon dioxide may accumulate in basements with a risk of asphyxiation. Methane may accumulate in enclosed spaces with a potential hazard for explosion.

6.29 Radon may be emitted from certain source rocks and long term exposure can increase the risk of cancer if it migrates from the ground into poorly ventilated living spaces. A small number of soil gas measurements have been made in the course of this study and these suggest that radon emissions are not likely to pose a problem in most of the Wigan area. Significant amounts of radon have been found in the soil only near geological faults and it could be prudent to make measurements of radon levels inside buildings which are above or close to faults to determine whether any accumulation has occurred. More information

is given in the National Radiological Protection Board's publication *The Householder's Guide to Radon.*

Appropriate action on the possible spread of leachates or gases

6.30 The basis for any action with regard to the potential spread of leachates or gases is to collect sufficient data, by desk study and site investigation, to prepare and implement an agreed environmental strategy. Action for both leachates and gases is summarised below.

6.31 With regard to leachates in contained landfill sites, there must be active leachate control to prevent its escape from the site and the possibility of serious environmental pollution. This can be achieved by off-site disposal or by physical, chemical, or biological treatment. Increasingly restrictive conditions are being applied to NRA and HMIP consents for off-site disposal, especially with respect to heavy metal concentrations. Another important consideration is where the local water undertaking is selling sewage sludge for application to agricultural land. In this case the accumulation of potential harmful elements in the sludge could be a problem.

6.32 Physical, chemical and biological treatments are frequently used to pre-treat leachate prior to disposal. The extraction of leachate and respraying back onto the landfill (or a nearby suitably vegetated surface close by) is also used as a control mechanism but it is not without problems. Odours and spray-drift can cause a serious nuisance, though there is no evidence of this in the Wigan area. Nevertheless this method of control can damage soil structure and vegetation, and result in a build-up of heavy metals in soils and vegetation. The potential long-term effects of this low cost method have not been established.

6.33 Permanent gas sampling units should be installed, in the ground, to determine the site conditions with regard to landfill gas. The three main phases of waste decomposition result in landfill gas generation of variable composition; the first phase (aerobic) is relatively short and produces mainly carbon dioxide. The second phase (anaerobic) generates hydrogen and carbon dioxide and can last for many years if conditions are not helpful. The third stage is also anaerobic and causes the generation of a mixture of carbon dioxide and methane.

6.34 The major hazard associated with landfill gas is the flammable nature of methane and its potential to form an explosive mixture with air. There are also highly odorous compounds in trace quantities. It will usually take many years for the gas generation from a landfill site to cease. This has important implications with respect to the development of closed landfill sites or land adjacent to them. Gas may be passively vented, or dealt with by controlled degassing. The latter is now a common solution and can lead to the use of landfill gas for beneficial purposes. Thus the domestic landfill site at Billinge Hill Quarry has been designed so as to control and collect methane with the possibility of then using it to generate electricity.

6.35 Both landfill gas and coal mine methane are particular hazards if they accumulate in confined spaces such as poorly ventilated buildings, conduits and tunnels. Some of these buildings and structures are outside planning control as they may be permitted development under the General Development Order.

6.36 **Reading material on leachates and gases**

- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995
- *PPG23: Planning and Pollution Control*, DoE, 1994.
- *Amended Proposal for a Council Directive on Packaging and Packaging Waste* [OJ C285 21/10/93 — COM(93)416)], proposed EC Directive OJ C263 12/10/92.
- *Waste Management Paper No 27: The Control of Landfill Gas*, DoE, January 1989). This is a technical memorandum on the monitoring and control of landfill gas. It is a key document in considering any redevelopment proposals adjacent to operational landfills or adjacent to or upon restored landfills.

6.37 **Initial contacts for primary information on leachates and gases**

- Manchester Waste Regulation Authority, Blackfriars House, 6th Floor, Parsonage, Manchester, M3 2JA. Tel. 0161-832 2776
- Her Majesty's Inspectorate of Pollution, Romney House, 43 Marsham Street, London, SW1P 3PY. Tel. 0171-276 8061
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- National Radiological Protection Board, Chilton, Didcot, Oxon, OX11 0RQ. Tel. 01235 831 600.
- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- Coal Authority, 200 Lichfield Lane, Berryhill, Mansfield, Nottingham, NG18 4RG. Tel. 01623-427162
- Institute of Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE17 2LS. Tel. 01487-3381

7 Minerals and environmental planning

7.1 Minerals in Wigan represent both a resource for the future and a legacy from the past. Available resources include sand, sandstone and coal all of which need to be considered for possible protection. In addition to mineral resources, there is a legacy of subsidence from past coal mining. This is both extensive and, in places, intensive and has a direct bearing on existing and proposed development. This section considers the issues of:

- mineral resources
- mining subsidence

MINERAL RESOURCES

The significance of mineral resources

7.2 The key mineral resources in the Wigan area include coal, sand, sandstone, clay and peat. As outlined in Chapter 2 these minerals have been of great value to the local community and indeed to the UK as a whole. They have determined much of Wigan's past economic and physical development, continue to exercise a major influence today and will do so in the future. Map 5 (Mineral Resources) indicates the extent of mineral resources in the area.

Key indicators for mineral resources

7.3 *Coal*

Whilst coal was a major mineral resource in Wigan for several hundred years, there is now no longer any deep coal mining and only three opencast coal sites were in operation during the course of this study. Any future extraction of coal is likely to be by opencasting. Map 5 (Mineral Resources) shows the extent of potential coal resources which could be mined in the future, if economic circumstances and environmental constraints permit. These extend under about two-thirds of the Wigan area and future mining of coal in parts of the area is under active consideration by several prospective minerals operators. The economics of such mining will vary with demand, geological factors such as overburden thickness and local conditions. However, guidance on the likely, maximum extent of the resource will assist in the assessment of the implications of any development which will inhibit, or prevent, access to the resource.

7.4 *Clay*

Local clays from till deposits (boulder clay) and from Coal Measures shales have been used for brick-making in the past, but there are, currently no active, brickclay workings in Wigan. This is due partly to changing technology, partly for the need for certainty of quality, and partly to the thick overburden of superficial deposits over large areas which would preclude working. It is unlikely that current clay deposits would be able to support any local brickwork operations in the future. Currently, the only active clay extraction is at Crankwood, near Abram, where very small amounts of till are worked in a site adjacent to the Leeds and Liverpool canal for use as a 'puddling clay' by The British Waterways Board.

7.5 *Glass sand*

Part of the extreme west of the Wigan area, near Billinge, is covered with wind-blown sand, known locally as Shirdley Hill Sand and typically one metre thick. This deposit has been extensively worked in the past for glass-making. However, the thinness of deposits, consequent high working costs and availability of glass sand from other sources, means that it is unlikely that the Shirdley Hill Sand will be used as a source of glass sand in the future. Its unusual particle-size distribution makes it unsuitable for other applications and has no other commercial value.

7.6 *Sand and gravel deposits*

There are deposits of sand and gravel, and of sand, associated with the till and late glacial drainage. These are fairly widespread and have been an important aggregate resource in the area north of Standish, where most of the recent operations have been located. They are usually suitable for use in mortar and asphalt and, after washing, for use as the fine aggregate in concrete but are at the fine end of the specified range. The only current extraction is at Worthington.

7.7 Whilst the glacial sand deposits tend to form extensive areas of fairly level or undulating, well-drained land (which often have formed attractive sites for towns and villages), they can be covered by significant thicknesses of till, or deeply buried within till. Such concealed deposits are not easily found and their extent, thickness and overburden ratios are not known. It is possible, however that they may provide worthwhile sites for future working. On the basis of the limited information available, the area of Late Glacial Flood Gravels shown on the geological map to the south of Leigh are considered to be fine grained. They are not thought to be a significant resource of sand and gravel.

7.8 *Sandstone*

Triassic sandstones (usually red sandstones) form the flat land of the south Lancashire Plain, and occur in the southern part of the Wigan district. They have low crushing strength and are overlain by thick deposits of till, although occasionally the overburden is sufficiently thin to provide extraction sites. These sandstones are currently worked both at Bold Heath and Croft (both outside Wigan district), but the crushed rock is friable and easily disintegrates. It is too weak for use as concrete aggregate or as roadstone, nor does it conform with any of the British Standard specifications. Generally, the sandstones are unsuitable for commercial uses. However a new working is under development south-east of Leigh, which is expected to produce a sand for mortar and asphalt.

7.9 The stronger Carboniferous sandstones from the Millstone Grit and Lower Coal Measures have traditionally

been a source of building stone and flagstone in Lancashire. During the last 50 years these markets have declined and sandstone is now mainly used for the production of crushed rock. Generally, Lancashire's Carboniferous sandstones are too weak and susceptible to frost damage for use as roadstone or concrete aggregate but it is possible that unweathered sandstone could be used as construction fill. Resources in the Wigan area are small, and currently there are no workings for sandstone. However, the extraction of sand from weathered Sherwood Sandstone has recently been licensed to the south-east of Leigh.

7.10 *Peat*

Lowland Peat deposits occur in Chat Moss in the extreme south-eastern part of the district. These deposits have been worked extensively in the past for horticultural purposes. Most of the current workings are in adjacent parts of Salford District, with only two workings within Wigan Borough. The Wigan UDP has a strong policy presumption against new peat workings.

Locations where the extent and type of mineral resources might be important

7.11 Map 5 (Mineral Resources) shows the large extent of coal bearing measures and sandstones which collectively cover much of the Wigan area. However, with the possible exceptions of coal and sand and gravel, there are no major, currently viable mineral resources in the Wigan area. No economic resources of outstanding worth have been identified and in most cases better, or more economically viable, resources are located outside the district. Peat is an important mineral resource in parts of the southeast, but its importance lies not in its value of extraction but in terms of its contributions to a unique, if disturbed, local ecological systems.

Appropriate action on mineral resources

7.12 Since the statutory planning system is concerned with the use and development of land, the nature of the actual ground must be of importance. The possible sterilisation of mineral resources is a potential issue and occasionally it is possible to lease land required for future mineral extraction for other 'short-term' purposes. The length of term is one for negotiation with the owners. It may be possible to agree to substantial alternative development of land which is of value as a mineral resource with the agreement that the land is to be made available for mineral extraction at an agreed future date.

7.13 Such environmental effects may also relate to earth resources or to the nature of the ground. Increasingly there are efforts to make 'sustainability' a practical tool rather than an ideal, and policy presumption against further peat workings is fully in line with such efforts.

7.14 **Reading material on mineral resources**

- *Greater Manchester Minerals Local Plan*, Greater Manchester Council, 1986.
- *Mineral industry guidance notes* IPR 3/1-3/6, HMIP/HMSO (1992).
- *Large-scale geological maps* held by British Geological Survey.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Statutory Planning Register* held by Wigan MBC.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *Memoirs of the Geological Survey of Great Britain, Wigan District*, 1938, HMSO.
- *Mineral Planning Guidance Notes* (MPGN series), all by the Department of the Environment:
  - MPG1 General considerations and the development plan system, 1993.
  - MPG2 Applications permissions and conditions, 1988.
  - MPG3 Coal mining and colliery spoil disposal, 1994.
  - MPG4 The review of mineral working sites, 1988.
  - MPG5 Minerals planning and the General Development Order, 1988.
  - MPG6 Guidelines for aggregate provision in England and Wales, 1994.
  - MPG7 The reclamation of mineral workings, 1989.
  - MPG12 Treatment of disused mine openings and availability of information on mined ground, 1994.
- *The Mosslands Strategy*, City of Salford and Wigan MBC, 1989.
- *Draft MPG: Guidelines for Peat Provision in England*, DoE, 1994.
- *Peat Extraction and Related Matters*, Working Group Report, DoE, 1994.
- *Out of the Mire: A Future for Lowland Peat Bogs*, Royal Society for the Protection of Birds, 1993.
- *Sustainable Development: The UK Strategy*, Government White Paper, DoE, 1990.

7.15 **Initial contacts for primary information on the extent and type of mineral resources**

- Wigan Metropolitan Borough Council, Minerals Section. Tel. 01942-244991
- Greater Manchester Geological Unit, University of Manchester, Oxford Road, Manchester, M13 9PL. Tel. 0161-275 2314
- British Geological Survey, Keyworth, Nottingham, NG12 5GG. Tel. 0115-936 3100
- Coal Authority, 200 Lichfield Lane, Berryhill, Mansfield, Notts. NG18 4RG. Tel. 01623-427162
- RJB Mining plc, Harworth Park, Blythe Road, Harworth, Doncaster, South Yorkshire DN11 8DB.

MINING SUBSIDENCE

The significance of mining subsidence

7.16 The process of mining coal creates a void where coal and associated rocks have been removed. It is the subsequent behaviour of this void and the strata which overlie it, which determines whether or not the ground requires

special treatment before development can take place. Information about the presence, or absence, of mineworkings and also about post-excavation changes to any voids is of major concern to those involved with planning and development.

7.17 In modern total extraction mining, shortly after working, the void left after coal extraction will fill by downward displacement of the overlying strata causing subsidence at the surface. In cases of old 'partial extraction' the collapse may be long delayed and locally may require special remedial or preventative measures. However, throughout much of the Wigan area, the subsidence associated with total extraction has taken place with a resultant decrease in the ground level. The 'Flashes' in the area are examples of water-filled subsidence hollows. Numerous methods have evolved for the prediction of the subsidence which occurs at the time of mining, but none can be applied with absolute certainty, particularly where multi-seam working has taken place.

7.18 Where deep mining has taken place beneath a site it should be assumed that subsidence will have taken place and that this subsidence might be up to the maximum total thickness of the coal extracted. This assumption extends to the area of the concealed coalfield where coal has been mined beneath Permo-Triassic rocks. A study for the British Waterways Board showed that the subsidence beneath the Leigh branch of the Leeds and Liverpool Canal, where some 100 m of Permo-Triassic rocks overlies Coal Measures, greatly exceeded predictions and continued for several years after mining ceased. In order to maintain water level the canal has been raised to accommodate the subsidence and is now on embankments of about 9 m high. An estimate of the total thickness of coal extracted from 11 seams beneath the canal is in the order of 10 m. A recent study in the Northumberland coalfield has shown a similar correlation between subsidence and total thickness of multiple seams worked.

Key indicators for mining subsidence

7.19 The methods used in ancient mining commonly removed only portions of the coal so that the remaining coal could provide support to the mine roof, the cavities remained open (partial extraction) and collapse did not take place at the surface. Access to these workings was by vertical shafts or horizontal and inclined tunnels (adits). Because the means of access had to be kept open during the life of the working and to afford safe passage they were usually well supported by timber or brick. Therefore, they will remain open and may remain a hazard long after abandonment of the workings and their collapse. Further details are given in Chapter 11 of Volume 1 of this report. Workings were generally at relatively shallow depths owing to limitations in technology and equipment. Few plans or records exist, and those that do may be in some way deficient for much of the ancient mining.

7.20 It is open or partially collapsed workings which are most likely to require special treatment during development. Consequently this study has placed particular emphasis on shallow mine workings, defined here as within 30 m of the present day ground surface. Changes in the groundwater table can affect possible subsidence.

Locations where mining subsidence might be important

7.21 Based upon the geological structure defined by fault blocks, areas have been allocated to three general categories relating to the likelihood of shallow mining:

- Areas where no coal seams are believed to occur within 30 m of the surface. Shallow mining is unlikely.
- Areas where coal is believed to occur within 30 m of the surface, but the study found no evidence for seams to have been worked locally within the fault block although they are known to have been mined elsewhere in the Borough.
- Areas where coal is believed to occur within 30 m of the surface and the study found evidence for seams to have been worked within the fault block.

These areas are shown on Map 10, Major planning considerations.

Appropriate action on mining subsidence

7.22 Government policy on unstable land is outlined in PPG14: 'Development on Unstable Land' (1990). This guidance advises developers and local authorities that the effects of ground instability are a material consideration and should be taken into account both when determining planning applications and when preparing and revising development plans. Mining subsidence is clearly a potential source of ground instability. In addition the operation of the building regulations by Wigan MBC requires that any hazard from ground movements due to subsidence must be taken into account in designing and building structures.

7.23 Supplementary guidance to PPG14 is provided by the Department of the Environment's publication 'Treatment of disused mine openings and availability of information on mined ground' (MPG12, 1994). These guidelines review the problems and methods of dealing with disused mine openings, and outline the liabilities which may arise. Specific guidance is given on the role and operation of the planning system in relation to these problems in terms of the effect on land use, the need for control, and, as with PPG14, the impact on planning decisions and development plans.

7.24 More generally, reference should be made to the 'Review of Mining Instability in Great Britain' by Arup Geotechnics (1990). This demonstrates that the problems and opportunities presented by abandoned mines affect almost every part of Great Britain. The review compiles a wide range of data, shows that mining subsidence is widespread, and stresses the need for it to be comprehensively addressed by developers and planners.

7.25 However, the identification of mineworkings does not preclude development, nor necessarily imply that extensive and/or expensive remedial measures must be undertaken. Similarly the presence of existing buildings on or near a site does not mean that the area is free from mineworkings which might affect subsequent development. Where action needs to be taken there are circumstances in which the excavation and sale of the coal remaining in ancient workings beneath a site can assist in

financing development costs. Where plans do not exist and old workings have been identified an estimation of layout and likely condition can be made, based on the methods likely to have been used at the estimated time of mining.

7.26 The following points should be considered when workings are known or suspected:

- the amount of coal extracted from each seam, the dimension of pillars left in-situ
- the pattern of mine roadways, their number and size
- the nature and extent of roof support packing
- the pattern of strata movement at the time of working
- the nature of connections with nearby workings
- the layout and condition of soughs (drainage adits)
- the likelihood of non-coal material having been excavated and, if so, what and where

7.27 **Reading material on mining subsidence**

- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *PPG14: Development on Unstable Land*, DoE, 1990.
- *MPG12: Treatment of Disused Mine Openings and Availability of Information on Mined Ground*, DoE, 1994.
- *Review of Mining Instability in Great Britain*, Arup Geotechnics, 1990.

7.28 **Initial contacts for primary information on mining subsidence**

- Coal Authority, 200 Lichfield Lane, Berryhill, Mansfield, Notts. NG18 4RG. Tel. 01623-427162
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- Wigan Metropolitan Borough Council, Minerals Section. Tel. 01942-244991

8 Other general ground condition factors

8.1 Chapters 4–7 consider the interaction between some of the major ground conditions present in the Wigan area and the planning system. There are a number of other conditions which can be important, in terms of either location and/or time, these being:

- flooding and possible flooding
- slope stability
- subsoil and its suitability for development
- the ease of excavation

FLOODING

The significance of flooding

8.2 Wigan is drained by two river networks: the River Douglas and its tributaries drain the north-east, whilst the south and east are drained by tributaries of the Mersey. The River Douglas flows southward through the centre of Wigan before turning sharply in a north-westerly direction to pass through Shevington. The catchment boundary between the River Douglas and the Mersey tributary of Glaze Brook (which itself is created by Moss Brook and Pennington Brook) is ill-defined where there is no topographical divide, particularly around Ince Moss. The construction of artificial features such as drains or spoil heaps near the divide, or modification of the topography by landscaping, could alter the precise position of the catchment boundary. Therefore, any catchment boundary marked on a map should be considered as an approximation.

8.3 The Leeds and Liverpool Canal cuts across the Wigan area. The main route of the canal follows roughly that of the River Douglas. The Bridgewater Canal cuts east–west to join the Leeds and Liverpool canal in the centre of Leigh near Bedford Basin.

8.4 There is only one river gauging station within the study area (on the River Douglas) and the river hydrology is complex. Abstractions from the river for industrial, agricultural and municipal uses and also industrial discharges to the river provide short-term fluctuations to the hygrograph and give a 'spiky' appearance.

8.5 Chat Moss was originally a large area of marshland. Thick peat deposits and till impeded natural drainage and confined the underlying Sherwood Sandstone aquifer rendering it, in some places, artesian. However, the value of the land for farming led to the construction of an extensive drainage network. Large drainage ditches flow into tributaries of Glaze Brook.

8.6 Past mining activities have affected the surface drainage pattern. In places, subsidence caused by mining has produce large shallow depressions. Their subsequent infilling by water has produced large lakes, locally known as *flashes*. As a result Wigan MBC has for a number of years carried out extensive drainage works and improvements.

Key indicators for flooding

8.7 Planning and development need to take account of both the likelihood of extreme heavy rainfall and of prolonged periods of lesser but steady rain. Either event can result in flooding and/or localised land instability. Incidences of flooding are most likely to occur in floodplain areas (see Map 4, Hydrogeology) in the spring.

Locations where flooding might be important

8.8 The areas most at risk from flooding are along the banks of the River Douglas. Extreme rainfall events can increase the volume of water sufficiently to cause flooding. Consequently several flood defence schemes are in place along the length of the river. The areas marked on Map 4 (Hydrogeology) as being at risk from flooding are defined as the area of maximum known flooding, or the areas defended by a flood defence scheme, whichever is the greater. Therefore it is possible that some areas marked as being at risk from flooding might have been made less vulnerable by improved defence.

Appropriate action on possible flooding

8.9 There are numerous responses to the risk of possible flooding. These include:

- Exercising planning control over land uses and development so as to avoid flood-prone areas and to build elsewhere.
- Leaving land unbuilt so as to accommodate periodic floodwater.
- Technical responses such as improved drainage and, if feasible, reducing run-off.
- Building responses such as revised designs for bridges or buildings.

8.10 Such actions, even if fully implemented, tend to mitigate the hazard of flooding rather than remove it. The planning system cannot assume that it is safe to develop land simply because such responses have been made. Any comprehensive attempt to reduce the risk from flooding should be based on an analysis of long-term data on flooding patterns.

8.11 Insofar as possible flooding or the threat of flooding may arise from movements of the groundwater table, refer to suggested action as outlined in Chapter 4 above.

8.12 **Reading material on possible flooding**

- *River Douglas Catchment Management Plan*, consultation report, NRA North West Region, 1993.

- *Development and Flood Risk*, Circular 30/92, DoE.
- *A Geological Background for Development and Planning in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *Review of Erosion, Deposition and Flooding in Great Britain*, DoE, published May 1995.

8.13 **Initial contacts for primary information on possible flooding**

- National Rivers Authority, Groundwater Section, PO Box 12, Richard Fairclough House, Knutsford Road, Warrington, WA4 1HG. Tel. 01925-653999 ext. 2532
- North West Water Ltd, Stephens Way, Goose Green, Wigan, WN3 6PJ. Tel. 01942-244241
- British Geological Survey, Keyworth, Nottingham, NG12 5GG. Tel. 0115-936 3100
- Wigan Metropolitan Borough, Engineering Department. Tel. 01942-244991

SLOPE STABILITY

The significance of slope stability

8.14 Property and public safety can be put at serious risk where there is slope instability, particularly during very wet weather. However, apart from a few instances of minor landslipping on the eastern bank of the Douglas, no definite evidence of natural slope instability has been found in the Wigan area. Nevertheless, made or worked ground (see Map 6) may include steep and potentially unstable slopes. These areas include tips, embankments, cuttings and quarries. In such cases, geotechnical assessment will often be needed prior to any proposals for landscaping or development; see preceding comments on rehabilitation of despoiled areas (Section 5).

Key indicators for slope stability

8.15 Despite the lack of natural instability, natural slopes in engineering soil may become unstable if they are undercut, top-loaded or saturated by the introduction of large volumes of water. The implications for slope stability in excavation on cut faces in Wigan are summarised in Table 4.

Table 4 Geology and slope stability.

Engineering unit	Geology unit	Slope stability
Rocks		
'Strong' sandstone	Coal Measures sandstone	Subject to discontinuity spacing and orientation relative to face. Determine on site specific basis. Steep faces generally stable with some rock fall possible.
'Weak' sandstone	Collyhurst Sandstone Sherwood Sandstone Pebble Beds	Subject to discontinuity spacing and orientation relative to face. Determine on site-specific basis. Steep faces generally stable. Protect from surface water run-off. May weather rapidly.
'Strong' mudstone	Coal Measures mudstone	Dependent on degree of weathering and the groundwater regime. Cuttings and embankments cut at 1:2 to 1:4, depending upon height and lithology should be stable in the long term.
'Weak' mudstone	Manchester Marl	Not known.
Soils		
Mixed cohesive/non-cohesive stiff/dense	Till (Boulder Clay)	Dependent on local groundwater regime and local lithology. Thick homogenous clayey till usually stable.
Mixed cohesive/non-cohesive soft/loose	Laminated clay alluvium	Not applicable (see Excavations).
Non-cohesive fine	Shirdley Hill Sand	Not applicable.
Non-cohesive coarse	Glacial Sand/Gravel and Outwash Gravel	Dependent upon lithology and groundwater regime. Generally stable.
Organic	Peat	Not applicable.
Highly variable mixed	Made ground fill	Not applicable.

8.16 The accuracy of the divisions between engineering units in the above table is constrained by (a) their being based on mapping undertaken for geological, rather than engineering geological or geotechnic purposes, and (b) the lack of geotechnical data.

Locations where slope stability might be important

8.17 Map 8 (Engineering Geology) shows the distribution of rock and soil types. An initial appreciation of likely land conditions can be gained by an on-site viewing of the exposed rock and soil.

8.18 **Reading material on slope stability**

- *PPG14: Development on Unstable Land, DoE*, 1990.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Technical review of the stability and hydrogeology of mineral workings.* Geoffrey Walton Practice, HMSO.
- *Handbook on the hydrogeology and stability of excavated slopes in quarries.*Geoffrey Walton Practice, HMSO.
- *Handbook on the design of tips and related structures,* Geoffrey Walton Practice, HMSO.
- *Landslides and planning. Draft Annexe to PPG 14. DoE* 1995, HMSO.
- *British Standard 5930.*
- *BRE Digest 318* SI for low rise buildings.
- *BRE Digest 322* SI for low rise buildings.
- *BRE Digest 348* SI for low rise buildings.
- *BRE Digest 274* SI for low rise buildings.
- *BRE Digest 275* Fill Part 1 classification and load carrying characteristics.
- *BRE Digest 275* Fill Part 2 site investigation ground improvement and foundation design.
- *Site investigation in Construction*, 1993. Parts 1–4, published by Thomas Telford.

8.19 **Initial contacts for primary information on slope stability**

- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-9363100

Table 5 Characteristics of rocks and soils.

Engineering unit	Geology unit	Characteristics
Rocks		
'Strong' sandstone	Coal Measures sandstone	Moderately strong to strong, fine- to coarse-grained sandstone with mudstone and siltstone interbeds moderately to well jointed thinly to thickly bedded
'Weak' sandstone	Collyhurst Sandstone Sherwood Sandstone Pebble Beds	Moderately weak to moderately strong reddish brown, generally poorly cemented sandstone. Sometimes pebbly. Weathers to medium dense to very dense sand
'Strong' mudstone	Coal Measures mudstone	Weak to moderately strong, grey, mudstones and siltstones Some thin sandstones are present. Weathers to very soft to very stiff, silty clay and shaley clay of low to high plasticity with sandstone pieces.
'Weak' mudstone	Manchester Marl	Reddish brown or purple, stiff to hard mudstone with grey/green zones and thin sandstones. Weathers to a soft to stiff clay.
Soils		
Mixed cohesive/non-cohesive stiff/dense	Till (Boulder Clay)	Mainly firm to very stiff, becoming hard with depth, brown, fissured stony, silty, sandy, clay. May contain lenses and layers of silt, sand or gravel. The relative thickness of the units varies across the area.
Mixed cohesive/non-cohesive soft/loose	Laminated clay alluvium	Laminated clay mainly soft clay with sandy silty layers. Alluvium very soft to stiff, brown and grey, silty, sandy clay or loose to medium dense, brown or grey, clayey and both with clayey, silty peaty lenses and layers.
Non-cohesive fine	Shirdley Hill Sand	Generally thin, windblown, very loose to loose dark brown, fine to medium sand or sand and gravel with peat lenses and layers.
Non-cohesive coarse	Glacial Sand/Gravel and Outwash Gravel	Loose to dense, fine to coarse, brown, sand and gravel. May be silty or clayey and contain lenses of silt and clay.
Organic	Peat	Up to 3 m thickness of fibrous peat over amorphous peat in the 'moss' areas. Surface layers modified by cultivation and the addition of various soil improvers.
Highly variable mixed	Made ground fill	Very variable in composition colliery spoil, ash, rubble, stones, gravel, sand, clay, etc. Geotechnical properties unpredicable.

Table 6 Subsoil and foundations.

Engineering unit	Geology unit	Foundations
Rocks		
'Strong' sandstone	Coal Measures sandstone	Good founding material.
'Weak' sandstone	Collyhurst Sandstone Sherwood Sandstone Pebble Beds	Generally good, depending upon weathering and the degree of cementation. Settlement is rapid and weathered sand may run into mining fissures and cause settlement.
'Strong' mudstone	Coal Measures mudstone	Dependant upon the depth of weathering, undermining, presence of sandstones. They are subject to long-term consolidation.
'Weak' mudstone	Manchester Marl	Dependant on the depth of weathering. Consolidation can be significant and long-term.
Soils		
Mixed cohesive/non-cohesive stiff/dense	Till (Boulder Clay)	Generally good depending on the presence of sand layers and sand pockets. Consolidation may be long-term. The soils soften rapidly on contact with rain and groundwater A blinding of lean concrete is advisable at foundation level in excavation.
Mixed cohesive/non-cohesive soft/loose	Laminated clay alluvium	Give poor foundation conditions. High settlement may be uneven. There is long-term consolidation. There may be a need for raft or piled foundations, bored piles are prone to necking in water bearing sands. Preloading before the construction of embankments or earthworks may be needed. Buried river channels may be significant to foundation design.
Non-cohesive fine	Shirdley Hill Sand	Dependant on the thickness and presence/absence of included or underlying peat. Settlement may be significant and rapid.
Non-cohesive coarse	Glacial Sand/Gravel and Outwash Gravel	Generally good founding material. Buried river channels may be significant to foundation depth. Loose zones may need to be removed.
Organic	Peat	Unsuitable for foundations, being very weak, highly compressible and associated with acidic groundwater.
Highly variable mixed	Made ground fill	Very variable as foundation material. It may be compressible in the short term, and give uneven settlement. It may require improvement. Hazardous waste may be present. Specialist site investigations are either necessary or desirable.

- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991

SUBSOIL

8.20 Most building projects require stable subsoil if expensive foundation techniques are to be avoided. A summary of the characteristics of subsoil materials in the Wigan area is given in Table 5. Soft, buried river channel deposits in the Douglas valley or compressible peat in the Shirdley Hill Sand in the west of the Borough may give unexpectedly poor foundation conditions. Deeper foundations may be needed in these locations to secure adequate load bearing capacity. Engineering solutions include rafts and piles but these lead to higher costs. Foundation problems can also occur in areas of organic soil such as the Mossland (although planning policies here are highly restrictive of development), and in areas of made ground and fill as indicated on Map 6 (Distribution of Made and Worked Ground).

8.21 The foundation quality of subsoils in Wigan thus varies widely and is summarised in Table 6.

EASE OF EXCAVATION

8.22 The ease or otherwise of excavation will not normally be relevant to planning and development in the Wigan area. However, at the financial and technical margins, ease of excavation may have a direct effect on the location of development if the latter is particularly cost-sensitive. In broad terms the soils may be excavated by digging. Rocks comprise the hard and unweathered 'bedrock' and generally require more vigorous means of excavation than digging. The following table summarises ease of excavation by rock type:

Table 7 Excavations.

Engineering unit	Geology unit	Excavations
Rocks		
'Strong' sandstone	Coal Measures sandstone	Dependant upon joint spacing, and weathering. Ripping or blasting is necessary.
'Weak' sandstone	Collyhurst Sandstone Sherwood Sandstone Pebble Beds	Generally diggable, fresh well-cemented material may need ripping.
'Strong' mudstone	Coal Measures mudstone	Diggable when weathered. They may need ripping at depth or if thick sandstone beds are present. They may heave on the removal of overburden in wet conditions.
'Weak' mudstone	Manchester Marl	Diggable.
Soils		
Mixed cohesive/non-cohesive stiff/dense	Till (Boulder Clay)	Generally diggable. Support is advisable for short and necessary for long-term stability. Ponding of surface water may cause softening and poor trafficability. Running conditions may occur in water bearing, sandy lithologies or heave where clay cover is thin.
Mixed cohesive/non-cohesive soft/loose	Laminated clay alluvium	Diggable although immediate trench support is required. Running conditions are likely in granular material. High water in flows will require cut-offs and/or de-watering. Base heave may occur in laminated material.
Non-cohesive fine	Shirdley Hill Sand	Diggable. Immediate trench support is required. Running conditions are possible.
Non-cohesive coarse	Glacial Sand/Gravel and Outwash Gravel	Diggable, although trench support is needed. They may be water bearing. High water in flows will require cut-offs and/or de-watering.
Organic	Peat	Diggable, trench support required. Dewatering and/or cutoffs may be required.
Highly variable mixed	Made ground fill	Usually diggable.

9 Locations for new development

9.1 The preceding sections of this volume have considered specific ground conditions in the Wigan area and their individual bearing or influence on planning and development decisions. In an attempt to draw together the common threads from each of these specific aspects, this section of the report outlines how Wigan's applied geology could and will affect decisions on the location of new development and redevelopment of land. In practice, many other factors will influence decisions and these will often be more important that the geological characteristics of a particular site. However, it is important that planners and developers take note of geological factors where appropriate in order to ensure safe, cost-effective development.

9.2 Given the complex and varied nature of ground conditions in Wigan, we have focused on two broad ways in which geology influences planning decisions for new development. These are:

- The current extent of **derelict land**, of completed remediation, and of proposals for reclamation.
- The effect of any one adverse ground condition, or of a variety of conditions, upon new **development costs**, for either new or redevelopment schemes.

DERELICT LAND

The significance of derelict land

9.3 Derelict land is commonly defined as land so damaged by industrial or other development that it is incapable of beneficial use without treatment. It includes land on which there are derelict buildings or structures. Outside of this strict definition, which is generally used as a benchmark for the possible attraction of grant aid, there are other unused or seriously under used sites which are wholly or largely vacant or occupied by economically marginal activities.

9.4 Wigan and the North-West region generally have both experienced the problems arising from land dereliction to a greater extent than any other English region. The North-West's industrial history which has included both extractive activities (mining for coal, salt, metal ores and quarrying) and a variety of heavy industrial activities (including iron and steel manufacture) has created a large number of derelict land areas.

9.5 Areas of concentrated dereliction present problems of unsightliness, and impaired environmental amenity. They can:

- depress an area's image and its potential for development and economic growth;
- provide a hazard to public safety;
- diminish the supply of land for development.

9.6 The Metropolitan Borough of Wigan is typical of many North-West local authority areas, in that, despite major reclamation schemes over the past 30 years, there still remains a legacy of extensive tracts of derelict land and buildings, and disused infrastructure. National surveys of derelict land undertaken in 1974, 1982 and 1988 indicate the extent of the problem in Wigan as follows:

Table 8 Derelict land in Wigan, 1974–1988 (all figures in hectares).

Year	Spoil heaps	Excavations and pits	Railway land	Other	Total
1974	580	22	158	257	1017
1982	623	106	211	391	1331
1988	301	99	125	174	699

(Source: Derelict Land Reclamation in Wigan Strategy Statement and Rolling Programme 1993/98)

9.7 A desk top assessment by Wigan MBC in 1992 specified derelict land by type as follows:

Table 9 Derelict land in Wigan, 1992 (all figures in hectares).

Year	Spoil heaps	Excavations and pits	Railway land	Other	Total
1992	263	59	114	97	533

(Source: Derelict Land Reclamation in Wigan Strategy Statement and Rolling Programme 1993/98)

9.8 Thus derelict land in Wigan has been reduced by nearly 60 per cent since 1982 through land reclamation activities. Nevertheless, there still remains a significant area of derelict or despoiled land of 533 hectares.

Key indicators for derelict land

9.9 Derelict land takes many forms. It includes disused spoil heaps; disused buildings, installations and infrastructure; worked out mineral excavations and pits; and disused railway land.

9.10 The main cause of dereliction in Wigan has been the demise of mineral extraction (particularly coal). This has resulted in a significant level of derelict land problems, namely spoil heaps abandoned excavations and pits, and disused railway land. In addition to surface dereliction, Wigan has sub-surface problems — dereliction just below the surface caused by shallow mineworkings. Sub-surface dereliction is a current and future problem in some areas.

Locations where derelict land might be important

9.11 The highest concentration of surface dereliction in Wigan (approximately 80 per cent of the total of 533 hectares) is located in the Wigan to Leigh belt — the Makerfield Basin area; see Map 7 (Previous and Present Industrial Uses). The Wigan Flashes and Westwood are at the centre of the Basin area and represent the largest single concentration of derelict land.

9.12 The Makerfield Basin was granted Derelict Land Rolling Programme status in 1986 by the Department of Environment. Rolling Programme status provides a commitment to future funding from the Land Reclamation Programme under the auspices of English Partnerships. This replaces the Derelict Land Grant scheme as previously run by the Department of the Environment, and assists in the forward planning of reclamation activities.

9.13 English Partnerships is the key national urban regeneration agency for England and will review the new Land Reclamation Programme annually as opposed to receiving bids. However, the grant criteria, will remain essentially the same as the former derelict land grant scheme. No further rolling programmes will be started, although those which have been started will continue.

9.14 Much of the remainder of Wigan's surface derelict land is found in relatively rural areas. Due to English Partnership's primarily urban orientation, there has been concern that Wigan's non-urban derelict land may not receive such high priority for land reclamation funding as would urban sites.

9.15 Derelict land in Wigan remains a constraint to development and investment, and although Rolling Programme activities have had a strong impact in reducing the problem, there still remains a considerable amount of land to reclaim for both hard development such as housing and industry, and soft after-use such as land for amenity use or environmental improvement.

9.16 The significance of continued land reclamation in Wigan is emphasised in the Borough's Unitary Development Plan which identifies a total of 18 priority derelict land reclamation sites as follows:

1. Kirkless, Ince
2. Fairhurst Lane, Standish
3. Wheatlea 2, Wigan
4. Leigh Road 2, Atherton
5. Parsonage Colliery, Leigh
6. Ramsdales Tip, Leigh
7. Princess Road, Ashton
8. Ince Green Lane III, Ince
9. Ince Moss, Ince
10. Whelley Loop North, Wigan
11. May Mill Lodges, Winstanley
12. Gadbury Brickworks, Atherton
13. Bag Lane/Gibfield Colliery, Atherton
14. Crown Chemical Works, Appley Bridge
15. Maypole 2, Abram
16. Gidlow Washery, Wigan
17. Orrell Brickworks, Orrell
18. Bickershaw Colliery, Leigh

Appropriate action on derelict land

9.17 The reclamation of derelict land to bring it into beneficial use has been a major central and local government priority to support local economic and environmental regeneration. Throughout the 1980s and 1990s a large number of land reclamation schemes have been undertaken throughout the United Kingdom to bring back derelict sites to beneficial use. A variety of financial assistance packages have been made available by the UK government (primarily through the Department of Environment and now English Partnerships) and the European Commission (Structural Funds such as ERDF) to facilitate land reclamation. The key package for financial assistance in England remains the Derelict Land Grant (DLG).

9.18 The allocation of DLG funding via English Partnerships is on a discretionary basis. Such funding is intended to contribute towards the cost of reclaiming derelict land so that the subsequent use or development of the land costs no more than if it had taken place on a greenfield site. Grant aid is an important factor in terms of tackling sites with dereliction problems. Funding by English Partnerships is payable to both local authorities and to non-local authority bodies (this includes voluntary bodies, private companies and private individuals). However, and particularly relevant in Wigan, sub-surface dereliction is not eligible for such financial assistance unless surface dereliction is also present.

9.19 Many reclamation schemes have been incorporated in wider area economic regeneration strategies, and local authorities have been encouraged by the Department of the Environment to adopt land reclamation strategies. A strategic approach has proven to be more effective than one-off projects, through co-ordination of local authority activities and/or funding sources to achieve wider area benefits from the development of derelict sites.

9.20 Reviews of derelict land reclamation schemes have demonstrated that the two commonest causes of delays and additional costs to derelict land reclamation schemes are the presence of unforeseen undermining or contamination by past industrial processes. Both those factors are directly relevant in Wigan. Thus early awareness of generalised information relevant to these topics is valuable to help ensure that the design of reclamation schemes takes account of all relevant factors.

9.21 The prevalence of sub-surface dereliction caused by shallow mineworkings is identified clearly on Map 9 (Shallow Mining). The affected areas are extensive and overlap with other causes of dereliction.

9.22 Past and current industrial processes with a potential for contamination are shown on Map 7 (Previous and Present Industrial Uses). Use and analysis of the data from which this map was prepared will help to reduce the risk of encountering this problem unexpectedly. Thus, developers should be able to seek information at an early stage in the reclamation process and will be able to implement appropriate investigations in order to ascertain the exact nature of the problem if any.

9.23 Parts of these areas of past and current industrial use and some of Wigan's stock of made ground are in fact derelict. Use of Map 5 (Mineral Resources), Map 9 (Shallow Mining) and the maps in Wigan MBC's derelict land

reclamation study (referenced below) will enable developers and others to assess the potential for using mineral extraction to finance the reclamation of derelict sites.

9.24 An eligible cost for DLG is the cost of surveys and other studies and investigations to determine the characteristics and conditions of the site to be reclaimed. The British Geological Survey Technical Report WN/95/3, 'A geological background for planning and development in Wigan', provides a comprehensive overview which can be applied at an early stage, and which should result in a reduction of necessary survey costs to be covered by such funding assistance. Thus the Report provides a means of increasing certainty of ground conditions and reducing risk. It also represents a positive strategic tool for the process of planning and implementing land reclamation activities.

9.25 **Reading material on derelict land**

- *Derelict Land Reclamation in Wigan*, Wigan Metropolitan Borough Council (Planning Department), 1988.
- *Derelict Land Reclamation in Wigan: Strategy Statement and Rolling Programme 1993/98*, Wigan Metropolitan Borough Council (Planning Department), undated.
- *Derelict Land Grant: The Operation of the Derelict Land Grant Scheme*. Advice Note 3, Second Edition: July 1993 available from English Partnerships.
- *DGLA1: Derelict Land Grant Policy*, DoE, 1991.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.

9.26 **Initial contacts for primary information on derelict land**

- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- Government Office for the North West, Sunley Tower, Piccadilly Plaza, Manchester, M1 4BE. Tel. 0161-838 5555
- English Partnerships, Lancaster House, Mercury Court, Tithe Barn Street, Liverpool, L2 2QP. Tel. 0151-2363663
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- Wigan Groundwork Trust. Tel. 01942-270770

DEVELOPMENT COSTS

The significance of development costs

9.27 The additional development costs arising from adverse ground conditions may be identified before or during construction. It is clearly in the interests of all parties that new development and redevelopment schemes proceed in the full knowledge of probable building costs. This, in turn, requires detailed examination of existing applied geological data and/or the initiation of an on-site geological survey. Without such information, which is a front-end investment for a developer and may prove abortive, the chances of running into cost difficulties at a later stage are correspondingly higher. This is particularly the case in an area of complex geology, such as Wigan, where costs can arise from development on contaminated land (see Chapter 5), on landfill sites (Chapter 6), or in areas of mining subsidence (Chapter 7).

9.28 Significant additional costs to meet adverse ground conditions may lead to a reduction in the quality of a scheme. This can adversely affect marketability and/or usability, or could prejudice the project's viability so severely that the project is terminated. These outcomes usually occur only when ground condition information is studied late, or not at all, in the development process. Early evaluation, possibly with grant aid, enables the impact of ground conditions on the viability of a scheme to be identified, and assessed, prior to financial and/or legal commitments, thus reducing risk for intending developers.

Key indicators for development costs

9.29 Extra development costs can be imposed on some sites in Wigan by one or more of a wide range of ground conditions. The following potentially adverse conditions are covered earlier in this report:

- contamination and dereliction (Chapter 5 and above in 9)
- landfill sites (Chapter 6)
- unstable land (Chapters 7 and 8)
- land prone to flooding (Chapter 8)
- poor subsoils (Chapter 8)

9.30 Additional costs can also arise indirectly from any of the above conditions. Thus in landfill sites, small amounts of some gases can be corrosive to engineering plant and materials, particularly upon combustion. Permanent gas sampling units at landfill sites can allow analysis of trace components and so indicate potential problems.

9.31 Contaminated sites and sites suspected, reasonably or otherwise, of being contaminated can have a significant impact on (anticipated) development costs in Wigan. As such they may at times be critical in determining whether an intending developer or proposed scheme progresses towards implementation on the ground. Hazards from contaminated sites can be classified as direct or indirect:

- **Direct hazards** include chemical attack on materials such as concrete by sulphate and on plastic pipes (such as water mains) by phenols. As noted above, plastic water pipes passing through contaminated land are especially susceptible to accepting poisons which are then passed into the water supply.
- **Indirect hazards** include damage to buildings as a result of consolidation and settlement of infilled materials, and risks of explosion, asphyxiation and toxicity associated with accumulation of flammable gases within confined spaces. In particular, flammable gases, e.g. methane, which are produced by the degradation of organic material in landfills, may form explosive mixtures where they accumulate

in confined and enclosed spaces such as under buildings or in service ducts.

9.32 Development costs can also be affected by natural surface materials, particularly with reference to foundation costs. Natural superficial materials in the Wigan area are shown in Map 3 (Superficial Geology).

Appropriate action on development costs

9.33 In essence, the most appropriate action for any intending developer or financier is to assess development costs as cautiously as possible and to do so at the earliest possible time. This may incur additional costs but these are effectively an insurance premium best paid before any major finance or legal commitment is undertaken. Such action is, of course, usually common practice for the development industry. But the extensive industrial heritage of the Wigan area makes this precaution all the more valuable. Positive action by Wigan MBC and other holders of applied geological information will enable development costs to be calibrated more accurately prior to development commencing on the ground.

9.34 Specific actions to accurately assess development costs may include the following:

Landfill Developers should consider the installation of permanent gas sampling units at landfill and other suspect sites.

Site investigations Developers should consider the potential corrosion and geotechnical aspects with respect to building/structure stability. Requirements for a full corrosion survey are presented by the Construction Industry Research and Information Association.

Treatment A range of treatment options is available to ensure that materials remain unaffected within aggressive ground conditions, including:

- the removal of contaminated material and replacement with inert fill
- the use of chemical treatment to neutralise effects of fill
- the provision of protective systems
- the isolation of structures — e.g. buffer zones and cut-offs, including piling or membrane installation

Contamination The indirect effects of contamination such as settlement of structures can be overcome by choice of appropriate construction techniques.

Landfill gas Long-term control of gas migration and safeguards against possible accumulation are important considerations in building design. Much work has been done for effective passive gas control options and on-site active pumped control systems. In some cases the extracted gas can be used as an energy source.

9.35 **Reading material on development costs**

- *Site Investigation in Construction*, BS5930.
- *BRE Digests.*
- *A Geological Background for Planning and Development in Wigan,* British Geological Survey, Technical Report WN/95/3, 1995.
- *Material durability in aggressive ground,* Construction Industry Research and Information Association (CIRIA).
- *Catchment Management Planning Guidelines*, NRA, 1993.

9.36 **Initial contacts for primary information on development costs**

- Wigan Metropolitan Borough Council, Planning Department. Tel. 01942-244991
- British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel. 0115-936 3100
- Greater Manchester Waste Regulation Authority, Blackfriars House, 6th Floor, Parsonage, Manchester, M3 2JA. Tel. 0161-832 2776
- Greater Manchester Archaeological Unit, Manchester University, Oxford Road, Manchester. Tel. 0161-275 2314

10 Economic development — attracting investment

The significance of economic development

10.1 New development and redevelopment in Wigan must address general issues, such as the quality of life, as well as wealth creation. The information presented within this report will hopefully be used in securing environmental improvements and conservation on a wider front. Nevertheless the development of the local economy in Wigan is a key priority for Wigan Metropolitan Borough Council. The Borough's economic problems include a high level of unemployment and a weak economic structure. In order to address these problems, both the Council and its partner organisations have been strongly active in the economic development of the Wigan area.

10.2 The three main policy options to address such local economic problems are:

- the attraction of new investment from outside (capital and employment opportunities)
- support for development of existing indigenous businesses
- encouragement of development of new businesses locally

10.3 Applied geology and ground conditions in Wigan have a direct bearing on each of these three economic development options. As outlined in earlier chapters of this report, Wigan has some areas with difficult and potentially expensive ground condition problems. More generally the area has had a legacy of industrial dereliction, contamination and physical despoliation. Despite major improvements over the past three decades, it is possible that some parties, such as investors from outside the region, may still receive a negative image of Wigan.

10.4 Wigan has placed strong emphasis on the attraction of inward investment to help address its economic problems. Inward investment can make a significant contribution to a local economy. Benefits include:

- the provision of additional employment (direct, indirect and induced)
- workforce training and improvement of skills
- local sourcing opportunities
- innovation and technology transfer
- enhanced export potential
- diversification of the local economic base

10.5 Wigan is promoted as a key business area located at the centre of the North West region. A range of major new employers including Milliken Industrials Ltd, Tote Credit Ltd, Girobank PLC, the Tidy Britain Group, and the Department of Social Security have located facilities within the Borough. This diverse selection of companies provides an example of the new industries that are being attracted to the area.

10.6 A positive image, an attractive environment, and the availability of suitable sites and premises are key factors in attracting such companies. Adverse ground conditions in Wigan can act as an obstacle to inward investment, and therefore key economic development measures include environmental improvement, the enhancement of sites and property development including the reclamation of sites for development. However, a prior appreciation of any ground problems, and of the best ways in which to deal with these, may create a degree of certainty which developers may find helpful in relation to consideration of other, less well documented, areas.

10.7 Recently, a strategic economic development organisation — Wigan PLC — was formed to improve the future economic well-being and quality of life of people living in the Borough. Wigan PLC is a partnership organisation with core partners Wigan and District Chamber of Commerce, METROTEC, Wigan Metropolitan Borough Council and the Education Business Partnership. The primary activities of Wigan PLC include the following:

- encouraging growth of new and existing business
- training local people to obtain the jobs created
- regenerating manufacturing activity in the Borough
- maximising inward investment
- marketing the borough

10.8 Wigan PLC provides a vehicle for Wigan which has the capabilities to tackle a wide range of economic problems and opportunities in the borough. It provides a corporate vehicle able to work with key regional and national economic development agencies such as English Partnerships (the urban regeneration agency for England), INWARD (the regional inward investment agency for the North West), and the Department of Trade and Industry.

10.9 All economic development initiatives in Wigan place strong emphasis on improvement of the environment and thus improvement of the image of the Borough, because an improved image is necessary to attract investment.

Locations where economic development might be important

10.10 The development of the economy is a Borough-wide responsibility. However, employment is usually concentrated at particular locations such as industrial estates or business parks. Wigan needs to ensure that it can make available suitable industrial sites and premises to meet employment demand, whether from inward investment; expansion of indigenous companies; or for new company start-ups.

10.11 Wigan Metropolitan Borough Council is strongly active in the stimulation of development of industrial land and premises, much of this through urban regeneration and reclamation of derelict sites. One important example of local area regeneration is Wigan's City Challenge area —

the Douglas Valley Partnership. The Department of the Environment chose Wigan as a priority area for economic regeneration, job creation, and environmental improvement through its City Challenge initiative. A sum of £37.5 million is being provided over a five year period to a locally based economic development partnership (the Douglas Valley Partnership) which includes Wigan Metropolitan Borough Council. Wigan's City Challenge is concentrated in an area at the centre of the Borough. It forms a belt running across central Wigan stretching from the Heinz factory at Marsh Green, including the communities of Marsh Green and Worsley Hall, through to Wigan Pier, Westwood Park, the fringe of Wigan town centre and the communities of Scholes and Ince.

10.12 A key strategic objective for the Douglas Valley Partnership is the encouragement of inward investment through pump-priming development and environmental improvement and by changing the market's perception of the area. Key objectives of the project include 90 acres of development on five key sites by 1998, with a further 135 acres available; 400 000 square feet of vacant industrial or commercial accommodation brought back into use; and 40 per cent of the area 'greened' to a high standard.

Appropriate action for economic development

10.13 Ground conditions play an important role in the process of economic development. They impact on the provision of sites and premises to house economic and employment generating activities; they influence the environment and image of an area which in turn affect investment behaviour; and they determine the level of costs for development and reclamation.

10.14 Ground conditions data included in volume 1 of this report which concentrates on technical aspects and complements this volume (2) which concentrates on planning aspects. Together they will help all parties interested in promoting economic development in a number of specific ways. Improved data and analysis will:

- provide a clearer indication of potential site development costs
- reduce risk by increasing certainty
- help change negative perceptions of Wigan as an area fraught with ground condition problems
- help to demonstrate that Wigan is attempting to overcome a problem
- facilitate land use zoning
- facilitate categorisation of key industrial/commercial and inward investment sites
- identify site resources, e.g. water availability
- help support site improvement activities such as land reclamation and attraction of grant aid for reclamation, e.g. via English Partnerships' Land Reclamation Programme

10.15 **Reading material on economic development**

- *Wigan Economic Development Strategy*, prepared and published by Wigan Metropolitan Borough Council (Economic Development Office).
- *Wigan PLC Partnership Agreement*, prepared and published by Wigan PLC.
- *Wigan's City Challenge — A Summary*, prepared by Wigan City Challenge.
- *Greater Manchester Economic Strategy and Operational Programme*, Association of Greater Manchester Authorities, Consultation Draft, 1993.
- *English Partnerships Outline Guide for Developers and Investors*, produced by English Partnerships.
- *Unitary Development Plan*, prepared and published by the Metropolitan Borough of Wigan.

10.16 **Initial contacts for primary information on economic development in Wigan**

- Wigan Metropolitan Borough, Economic Development Office. Tel. 01942-827166
- Wigan City Challenge, Peter Rowlinson. Tel. 01942-828570.
- English Partnerships, Lancaster House, Mercury Court, Tithe Barn Street, Liverpool, L2 2QP Tel. 0151-2363663
- Wigan New Enterprise Limited. Tel. 01942-496591
- Metrotec. Tel. 01942-36312

11 Key geological considerations in planning and development

INTRODUCTION

11.1 There are many ways in which the geological environment may influence the use and development of land in the Wigan area, and on any one site these will interact in a different and often unique way. As noted at several points in this report, detailed site-specific studies will often be the only satisfactory method of establishing the full set of geological factors which affect a given site. Nevertheless, this study has shown that there are five applied geological factors or themes which are significantly more important in Wigan. These are:

- shallow mining
- potential for contaminated land
- mineral resources
- potential for groundwater contamination
- major faults

11.2 In many respects these five themes are interrelated — some past mining has created contaminated land; some geological faults have increased or decreased the rates of extraction of mineral resources. These themes have been taken from the data gathered during the project and are displayed in a summarised form on Map 10. The intention of this map is to give an initial overview and insight into the most important geological issues which may affect areas under consideration for planning, development or conservation schemes. Each is considered below.

SHALLOW MINING AS A POTENTIAL UNDERMINING HAZARD

11.3 As noted in Chapter 7, coal has been mined in the Wigan area for hundreds of years. Its extraction has left, in places, an extensive legacy of abandoned workings. Map 9 shows information regarding **known** workings, shafts and boreholes that have encountered old workings. However, other areas may contain **unknown**, unrecorded and so far undetected shallow workings. The presence of (currently) unknown workings can have a major effect upon proposed development and on conservation measures. These can include the creation of uncertainty, increased cost of proposals, and possibly physical risks. However, the presence of mined ground is seldom an absolute constraint on development.

11.4 Quantifying the relative risk of encountering previously unknown mining workings has led the study team to derive three general categories indicating the relative probability of unrecorded, old, abandoned, shallow mining being present. These are based on the use of geological information such as: which seams are known to have been worked in the area, the presence of these coal seams within 30 m of the surface and the geological structure defined by fault blocks. The 30 m cutoff has been adopted on the premise that, in general, the increased volume caused when material collapses into abandoned pillar and stall workings will be such that the void will not migrate to the surface if the seam is deeper than ten times the seam thickness. More details are given in Chapter 7 of this Volume and Chapters 10 and 11, Maps 2 and 5 of Volume 1 of this report.

11.5 These three categories are shown on Map 10 with codes A1, A2 and A3 as follows:

A1 Abandoned shallow mine workings are unlikely
Areas where no coal seams are believed to occur within 30 m of the surface.

A2 Abandoned shallow mine workings are possible
Areas where coal is believed to occur within 30 m of the surface, but no evidence was found during the study of seams having been worked locally within the fault block, although they are known to have been mined elsewhere in the Borough.

A3 Abandoned shallow mine workings are possible and proven
Areas where coal is believed to occur within 30 m of the surface and evidence was found of seams having been worked within the fault block.

11.6 In the preparation of Map 10 no attempt was made to show areas where mined seams have subsequently been removed by opencast operations. Reference should be made to Maps 5 and 6 for the location of opencast sites.

POTENTIAL FOR CONTAMINATED LAND

11.7 Chapter 5 of this report considers the issue of contaminated land in the Wigan area. Much land previously so affected has now been reclaimed and of the remaining sites it is important to distinguish between actual and potential contamination. Map 7 shows many sites which are or have been used for industrial purposes some of which may have given rise to contamination. Similarly, Map 6 shows many areas of made ground but only some are landfills which are potentially significant to future land use. Therefore, only those areas where there is a known potential for contamination or landfill problems have been shown. They are coded on Map 10 as follows:

B1 Past and present potentially contaminative industrial uses
As noted above and elsewhere in this report, such sites may or may not be contaminated. In any specific case the extent of actual contamination, if any, can be discovered only by desktop research and/or detailed on-site study. These sites are highlighted on Map 10 only on the basis that they are, or have been, used for industrial purposes which may sometimes have created contamination

and that this should be tested for during site investigation.

B2 Landfill sites potentially restrictive of future development
Likewise, the inclusion of these sites on Map 10 is an indication not of actual contamination but of the potential for such and the need to check for this. Codes of practice for landfilling have, largely in response to Government guidelines, been tightened over the past 10–15 years and there is less likelihood of more recent landfill sites representing contaminative hazards.

11.8 Contamination is, of itself, not usually an absolute deterrent to development or conservation proposals, since remedial measures are possible. However, in parts of the Wigan area, it may be an important factor in the specification of a site-specific investigation in order to assemble a comprehensive understanding of the ground conditions of a site. Further details are given in Chapters 5 and 6 of this Volume and in Chapters 12, 13 and 14 of Volume 1 of this report.

POTENTIAL FOR GROUNDWATER CONTAMINATION

11.9 The Permo-Triassic rocks in the southern part of the Wigan area mainly comprise the Sherwood Sandstone Group. This is a major aquifer for public water supply in a wide geographic area — larger than the Wigan Metropolitan Borough. The aquifer is thus of strategic importance and has a high priority for groundwater protection. The National Rivers Authority classifies groundwater vulnerability according to the nature of overlying soil cover, of drift cover (if any), and of the strata and depth to the water table. Protection zones are then defined around sources of water supply. These features are shown on Map 10 as follows:

C1 Designated total catchment zone
The catchment zone for the Permo-Triassic aquifer includes all land to the south of the Permo-Triassic/Carboniferous boundary. This covers approximately the southern-most third of the Wigan Metropolitan Borough. Irrespective of the features within this zone (see C2–C4 below), all groundwater needs protection and any proposed development which may place this resource at risk requires careful consideration.

C2 Principal recharge area
This area comprises the main recharge area in the Sherwood Sandstone aquifer within the Wigan Metropolitan Borough. This is characterised by rock outcrops and thin layers of permeable drift. As such it has a relatively high potential vulnerability to pollution or to reduced recharge if development takes place. In addition there are scattered recharge areas within the minor aquifer which covers the northern part of the borough; these are not shown on Map 10.

C3 Areas with significant water source protection zones
The NRA defines protection zones around wells, springs and boreholes based on distance from the borehole or time of water travel through the surrounding ground. These zones are subject to revision by the NRA without notice in the event of changes in the abstraction regime or improved hydrogeological modelling. It should also be noted that the presence or absence of a designated zone is no indication of the presence or otherwise of other as yet unmodelled abstractions, and the NRA should be contacted for information on the current position regarding aquifer protection zones. The shaded C3 area is a simplified representation of a number of such source protection zones in the main aquifer. This area may be vulnerable to groundwater pollution and may require protection from potentially polluting development.

C4 Public water supply boreholes
These are located within areas C2 and C3 as described above. The inner source protection zones for these boreholes are unlikely to extend more than 100 m from the source but the outer source protection zones are much larger.

11.10 Details of the ground and surface waters of the area are given in Chapter 4 of this Volume and in Chapter 9, Map 4 of Volume 1 of this report.

MINERAL RESOURCES

11.11 The three main potential mineral resources in the Wigan area are coal, sand and gravel, and sandstone. They are shown on Map 10 with the following codes:

D1 Coal extraction by opencast methods
Coal is currently extracted by opencasting and further such extraction may be possible in areas within the exposed coalfield north of the Permo-Triassic outcrop. However, the extraction of coal by deep mining is not thought to be viable in any part of the Wigan area in the foreseeable future.

D2 Sand and gravel extraction
This resource stems from superficial deposits of glacial origin. This resource has been significant in the past although the current extraction is limited. One component of sand and gravel as a local resource is the extraction of sand from crushed sandstone as included in D3 below.

D3 Sand from bedrock deposits
This extraction derives from weak sandstone where the cover of superficial deposits is not too great. It has limitations for commercial use as outlined in section 7 but nevertheless represents an existing and potential resource.

11.12 In addition to the above main three mineral resources, the Wigan area also includes the following minerals:

- Clay — This has limited value as a local resource.
- Glass sand — This has no current commercial value.
- Peat — This is now a limited resource with strong policy presumptions against further extraction other than two currently permitted workings.

11.13 The role of minerals as both a resource (past and present) and a constraint to development and use is discussed in Chapter 7 of this report and in Chapter 10 and Map 5 of the associated technical Volume.

MAJOR FAULTS

11.14 The Wigan area includes a considerable number of geological faults or natural fractures. The most significant faults are shown on Map 10 and may be a potential hazard to existing and proposed land uses in several ways. Intense underground deep and shallow mining of coal in the past caused subsidence. This was due to the removal of large volumes of material from below the ground and was often concentrated as movement on existing faults. Since deep mining has now ceased this is no longer a major problem. However, existing faults may still be a focus for movement if their stability were to be disturbed by the collapse of any old workings which may be open or only partially collapsed or by future excavations on or below the ground.

11.15 At present, the main potential hazard associated with geological faults is that of their ability to act in some circumstances as a pathway for the transport of liquids or gases. Liquid transport might include the transmission of leachates from a leaking landfill site or the passage of groundwater following a rise in the water table after the halt in mine drainage pumping. Gases which may be transported are methane from landfill or from natural sources with a potential hazard of asphyxiation or explosion if collected in enclosed spaces. The gas radon is present in low levels and is not a significant risk in the area, but can increase the hazard of cancer if concentrated in a living or working environment. It is potentially capable of being transported along fault lines from source areas deep below the surface. More details are given in Chapter 13 of Volume 1 of this report.

11.16 Thus proposals for the use of land, whether as built development, open space or nature conservation, which are located on or near to geological faults should pay regard to the 'upstream' potential for such faults of extending hazards from elsewhere. More details on the extent and importance of faults are given in Chapters 4 and 6 of this Volume and Chapters 9, 12 and 13 of Volume 1 of this report.

LIMITATIONS OF MAPPING

11.17 The information on which Map 10 was based was not comprehensive and the information that can be shown on the map is limited by scale and space. The purpose of this map is:

- to advise the user of the possibility of encountering geological factors which may have implications for the use and development of land.
- to indicate where reference to the accompanying maps and text is necessary, within both volumes of this report
- to indicate, when specialist advice and investigation of a site should be undertaken in addition to the normal site investigation procedures prior to development.