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Mineral Resource Information in Support of National, Regional and Local Planning: West Yorkshire (comprising Metropolitan Boroughs of Bradford, Calderdale, Kirklees and Wakefield and City of Leeds)

Commissioned Report CR/04/172N

BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT CR/04/172N

Mineral Resource Information in Support of National, Regional and Local Planning: West Yorkshire (comprising Metropolitan Boroughs of Bradford, Calderdale, Kirklees and Wakefield and City of Leeds).

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This report accompanies the 1:100 000 scale map: West Yorkshire (comprising Metropolitan Boroughs of Bradford, Calderdale, Kirklees and Wakefield and City of Leeds).

Key words

West Yorkshire, Mineral Resources, Mineral Planning

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1 Introduction

This report is one of a series prepared by the British Geological Survey for various administrative areas in England for the Office of the Deputy Prime Minister's research project *Mineral Resource Information in Support of National, Regional and Local Planning.*

The accompanying map relates to West Yorkshire, comprising the Metropolitan Boroughs of Bradford, Calderdale, Kirklees and Wakefield and the City of Leeds, and delineates the mineral resources of current, or potential, economic interest in the area and the sites where minerals are, or have been, worked. It also relates these to national planning designations, which may represent constraints on the extraction of minerals.

Three major elements of information are presented:

- the geological distribution and importance of mineral resources;
- the extent of mineral planning permissions and the location of current mineral workings; and
- the extent of selected, nationally-designated planning constraints.

This wide range of information, much of which is scattered and not always available in a consistent and convenient form, is presented on a digitally-generated summary map on the scale of 1:100 000. This scale is convenient for the overall display of the data and allows for a legible topographic base on which to depict the information. However, all the data are held digitally at larger scales using a Geographical Information System (GIS), which allows easy revision, updating and customisation of the information together with its possible integration with other datasets. The information will form part of a *Summary of the Mineral Resources of the Yorkshire and the Humber Region*.

The purpose of the work is to assist all interested parties involved in the preparation and review of development plans, both in relation to the extraction of minerals and the protection of mineral resources from sterilisation. It provides a knowledge base, in a consistent format, on the nature and extent of mineral resources and the environmental constraints, which may affect their extraction. An important objective is to provide baseline data for the long term. The results may also provide a starting point for discussions on specific planning proposals for mineral extraction or on proposals, which may sterilise resources.

It is anticipated that the map and report will also provide valuable background data for a much wider audience, including the different sectors of the minerals industry, other agencies and authorities (e.g. The Planning Inspectorate Agency, the Environment Agency, the Countryside Agency and English Nature), environmental interests and the general public.

Basic mineral resource information is essential to support mineral exploration and development activities, for resource management and land-use planning, and to establish baseline data for environmental impact studies and environmental guidelines. It also enables a more sustainable pattern and standard of development to be achieved by valuing mineral resources as national assets. The mineral resources covered are sand and gravel, crushed rock aggregate, brick clay, building stone, coal and hydrocarbons.

1.1 Resources and Reserves

Mineral resources are natural concentrations of minerals or bodies of rock (or fluids such as oil and gas) that are, or may become, of potential interest as a basis for the economic extraction of a mineral product. They exhibit physical and/or chemical properties that make them suitable for specific uses and are present in sufficient quantity to be of intrinsic economic interest. Areas that are of potential economic interest as sources of minerals change with time as markets decline or expand, product specifications change, recovery technology is improved or more competitive sources become available.

That part of a mineral resource, which has been fully evaluated and is commercially viable to work is called a mineral reserve. In the context of land-use planning, the term mineral reserve should strictly be further limited to those minerals for which a valid planning permission for extraction exists (i.e. permitted reserves). Without a valid planning consent no mineral working can take place and consequently the inherent economic value of the mineral resource cannot be released and resulting wealth created. The ultimate fate of mineral reserves is to be either physically worked out or to be made non-viable by changing economic circumstances.

Mineral resources defined on the map delineate areas within which potentially workable mineral may occur. These areas are not of uniform potential and also take no account of planning constraints that may limit their working. The economic potential of individual sites can only be proved by a detailed evaluation programme. Such an investigation is also an essential precursor to submitting a planning application for mineral working. Extensive areas are shown as having no mineral resource potential, but some isolated mineral workings may occur in these areas. The presence of these operations generally reflects local or specific situations.

1.2 Environmental designations

The map shows the extent of selected, nationally-designated planning constraints as defined for the purposes of this study. These are defined on a common national basis and therefore represent a consistent degree of constraint across the country. No interpretation should be made from the map with regard to the relative importance of the constraints, either in relation to mineral development proposals or in relation to each other. Users should consult policy guidelines issued by the relevant Government department, statutory agency or local authority.

The constraints shown on the map are:

- Part of the Peak District National Park
- National nature conservation designations – National Nature Reserves (NNR) and Sites of Special Scientific Interest (SSSI)

- International nature designations – Special Areas of Conservation (SAC), Special Protection Areas (SPA) and Ramsar sites
- Scheduled Monuments.

Mineral development may also be constrained by many other factors not shown on the map, including local landscape designations, considerations relating to the protection of other resources, such as groundwater, and local amenity or environmental concerns, such as noise, traffic and visual impact. These have been excluded because the constraint is not defined on a national basis or the information is not generally available. The extent or degree of relevance of such constraints can be ascertained from the relevant statutory agency or the appropriate Mineral Planning Authority.

2 Sand and gravel

Sand and gravel are defined on the basis of particle size rather than composition. In current commercial practice, following the introduction of new European standards from 1st January 2004, the term 'gravel' (or more correctly coarse aggregate) is used for general and concrete applications to define particles between 4 and 80 mm, and the term 'sand' for material that is finer than 4 mm, but coarser than 0.063 mm. For use in asphalt 2 mm is now the break point between coarse and fine aggregate. Most sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint), but other rock types may occur locally.

The principal uses of sand are as fine aggregate in concrete, mortar and asphalt. The main use of gravel is as coarse aggregate in concrete. Substantial quantities of sand and gravel may also be used for construction fill.

Between 1998 and 2004 annual production of land won sand and gravel in West Yorkshire has increased from 290,000 tonnes to 489,000 tonnes. Recent production is shown on the graph.

Sand and gravel resources occur in a variety of geological environments. In West Yorkshire these resources occur mainly within superficial deposits, subdivided into glaciofluvial sand and gravel and river terrace sand and gravel.

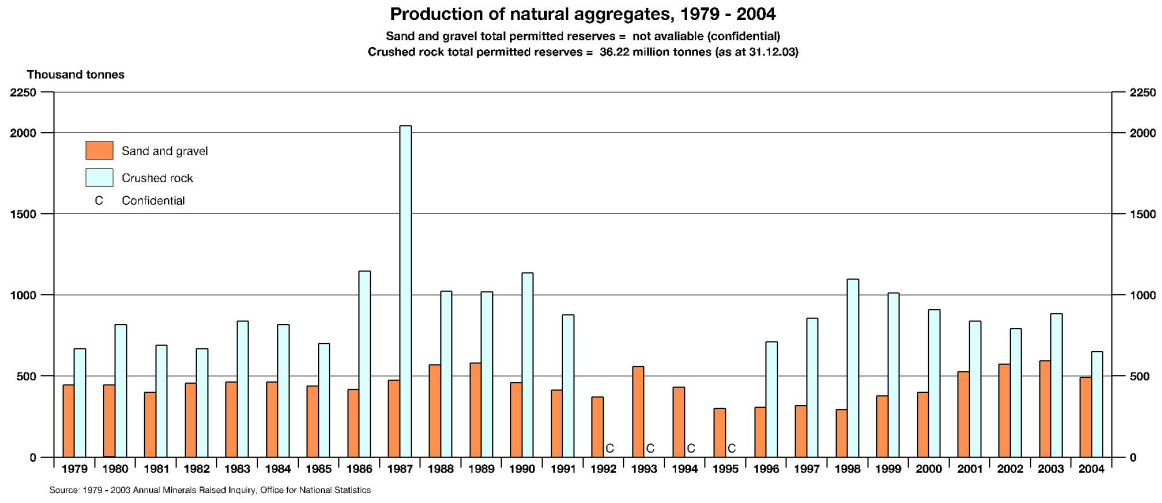

Figure 1. Production of natural aggregates in West Yorkshire, 1979 - 2004.

2.1 Superficial deposits

Generally, only exposed sand and gravel is defined, although sub-alluvial inferred resources of sand and gravel occurring beneath modern river flood plains may be extensive in some places. Narrow (< 200 metres) spreads of sub-alluvial deposits are mainly excluded from the map. Their limited width is likely to preclude economic working of any sand and gravel present.

2.1.1 Glaciofluvial sand and gravel

These are deposits mapped as the products of deposition by glacial meltwaters and are nowadays commonly labelled on BGS maps as glaciofluvial deposits, a more accurate description of their origin. The sequence of these deposits is complex with mappable units commonly exhibiting intricate relationships. Bodies of sand and gravel may occur as sheet- or delta-like layers above till deposits or as elongate, irregular lenses within the till sequence. Areas of wholly concealed, and thus unknown, bodies of sand and gravel may occur under spreads of till and other drift deposits.

West Yorkshire was affected by at least three glaciations although evidence of earlier phases has largely been obliterated by the final, Devensian phase. Earlier, Pre-Devensian, glaciofluvial deposits occur south of Leeds and Bradford. These deposits comprise thin bodies of sandy gravels with a variable content of fines. They are heavily dissected by erosion and thus are patchily preserved, typically on the higher ground. Small isolated patches occur in the Calder Valley, at Hebden Bridge and north of Elland, where up to 5 m of fairly well bedded gravel with numerous pebbles of red and grey granite, quartzite and volcanic rocks are preserved. It is thought that the same material may underlie the entire alluvial plain of the River Calder. In the easternmost part of the map, Pre-Devensian deposits occur at lower elevations, for example at Castleford. These deposits are compositionally distinguishable reflecting their source materials. Deposits occurring on the Pennine Coal Measures crop, near Oulton and Rothwell, are dominated by Carboniferous sandstone clasts while on the Permian crop, dolomitic limestone accounts for over 90 per cent of the clast content. The deposits at Rothwell comprise an overall mean grading of 12 per cent fines, 44 per cent sand and 44 per cent gravel but are considerably variable, from very clayey sandy gravel to gravel. The gravel fraction is predominantly coarse-grained with rounded to angular clasts of Carboniferous sandstone with subordinate chert and limestone. The sand fraction is mainly medium-grained, sub-angular to rounded quartz. Fines consist of yellowish brown silt and clay.

Later Devensian deposits occur north of Bradford and Leeds buried in the former channels of the rivers Aire and Wharfe. These valleys broadly coincide with buried channels infilled with superficial deposits, locally in excess of 50 m deep. The Wharfe valley commonly has a narrow course and is incised into a gorge between Wetherby and Boston Spa. Upstream of Linton, erosion of pre-existing till deposits resulted in erosional terraces that were incised, and at wider points along the Wharfe valley terraces of sandy gravel were deposited. These deposits, which grade eastwards into proglacial deposits, are worked at Firgreen for building sand and construction fill. A series of smaller late-glacial, melt water channels are present in

the valley sides and upland areas especially in an arc from west of Keighley to Bradford and Shipley. These small, highly variable, isolated patches comprise bedded sands and gravels with some thin, laterally impersistent beds of clay.

2.1.2 Glaciolacustrine sand

During the Devensian glaciation, ice occupying the present coastal zone farther east blocked the eastward-draining valleys including the Humber Gap between Brough and Winterton and thus impounded 'Lake Humber' in the southern part of the Vale of York. Deposits associated with this glacial lake, termed glaciolacustrine deposits, occur in the easternmost part of West Yorkshire, around Knottingley, forming undulating low ground at about 8 m above OD and conceal local developments of older sand and gravel. These deposits comprise buff to pale orange sand, ranging from fine to medium in grain size, and are locally clayey or silty. A characteristic feature is the presence of thin gravely layers of coal and carbonaceous mudstone clasts.

2.1.3 River sand and gravel (Terrace and Sub-alluvial deposits)

Resources occur in both raised river terrace sequences flanking the modern floodplains and in flood plain terrace deposits associated with, and underlying, present day alluvium. This sequence of deposits is best developed along the rivers Wharfe, Aire and Calder with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in Pleistocene times. The pattern of these deposits was largely controlled by both the existing bedrock and newly formed glacial features.

In the Wharf valley, three terraces occur between 3 and 12 m above the present floodplain, whereas in the Aire valley, two terraces have been identified, occurring between 2 and 12 m above the floodplain. In the Aire valley, the most extensive terrace deposits occur between Leeds and Castleford. In the Leeds area, much has been sterilised by urban development but resources remain further downstream in the Oulton-Castleford area, particularly at the confluence of the rivers Aire and Calder. In 1998, a detailed assessment of the deposits in this area, undertaken by the BGS, identified potentially workable fluvial deposits ranging from very clayey pebbly sand to gravel with a mean grading of 12 per cent fines, 55 per cent sand and 33 per cent gravel. The sand fraction is mainly medium-grained, angular to rounded quartz with lithic grains. The gravel fraction is predominantly medium-grained with sub-rounded to sub-angular clasts of Carboniferous sandstone, which commonly forms more than 90 per cent of the clasts. Minor amounts of siltstone, mudstone, chert, quartz, ironstone and coal together form the remaining 10 per cent. Aggregate Impact Values quoted for the gravel fraction ranged between 40 and 42.

The terrace deposits associated with the River Calder are worked at several localities, including Sands Lane Quarry, near Mirfield, Grange Farm, near Wakefield and Methley, near Mickletown. At Methley, approximately 180,000 tonnes of aggregate are extracted per annum. The deposit is on average 4-5 m thick and contains around 10 per cent silt and clay, with a sand:gravel ratio of 70:30. Carboniferous sandstone is the dominant lithology with some mudstone and variable amounts of coal and carbonaceous material. At Grange Farm, although geologically similar, the deposit is significantly coarser with 60 per cent gravel and 40 per cent sand.

3 Brick clay, including fireclay

'Brick clay' is the term used to describe clay used predominantly in the manufacture of bricks and, to a lesser extent, roof tiles, clay pipes and decorative pottery. These clays may sometimes be used in cement manufacture, as a source of constructional fill and for lining and sealing landfill sites. The suitability of a clay for the manufacture of bricks depends principally on its behaviour during shaping, drying and firing. This will dictate the properties of the fired brick such as strength and frost resistance and, importantly, its architectural appearance.

Most facing bricks, engineering bricks and related clay-based building products are manufactured in large automated factories. These represent a high capital investment and are increasingly dependent, therefore, on raw materials with predictable and consistent firing characteristics in order to achieve high yields of saleable products. Blending different clays to achieve improved durability and to provide a range of fired colours and textures is an increasingly common feature of the brick industry. Continuity of supply of consistent raw materials is of paramount importance.

Brick clay has been worked extensively in the past, mostly from a number of mudstone horizons in the Pennine Coal Measures, and today the Coal Measures remain the principal brick clay resource in the northern England. Resources of brick clay are extensive in West Yorkshire and there are several large production units for facing bricks, near Elland, Leeds, Dewsbury, Normanton and Wakefield. Several quarries in the vicinity of Denby Dale and Holmfirth extract Coal Measures mudstone for use in the manufacture of vitrified clay pipes at a plant in South Yorkshire. The suitability of Carboniferous mudstones for brick manufacture depends, in part, on their carbon and sulphur contents. Both may lead to firing problems and sulphur may also give unacceptable emission levels. Blending of clays may reduce these problems. The location of brick pits is principally the result of proximity to the centre of demand and ease of accessibility, rather than on factors simply of resource quality. Some 257,000 tonnes of brick clay were produced in West Yorkshire in 2004.

Fireclays typically occur beneath coal seams and resources are confined to coal-bearing strata. The close association of fireclay and coal means that opencast coal sites are one of the few viable sources. Resources of fireclay are thus coincident with opencast coal. Although originally valued as refractory raw materials, fireclay is now valued by the brick industry for its combination of good technical properties allied to its cream/buff-firing characteristics. However, not all fireclays are suitable for buff brick production because of the presence of impurities.

In the Halifax-Bradford-Leeds area all the fireclays from the Soft Bed to the Better Bed have been worked in the past by shallow mining and surface extraction. Today the only fireclay of economic importance is that associated with the Hard Bed Coal. The Hard Bed fireclay is a unique siliceous clay which, despite a relatively low alumina content, is unusual in having low alkalis and iron contents. The Hard Bed fireclay is selectively worked on a small scale from both the Shibden No 2 Mine in the Halifax area and the Dog and Gun Quarry at Oxenhope. It is blended and used for the manufacture of glasshouse pots, a refractory pot used for melting special glasses, such as lead crystal glasses. The advantage of siliceous clay with a low iron content is its ability to dissolve into the glass without causing contamination. Fireclay is also

produced in association with brick clay from sites near Denby Dale and Normanton for use in pipe manufacture. In 2003, the total production of fireclay in West Yorkshire was 10,000 tonnes.

4 Crushed rock aggregates

A variety of hard rocks are, when crushed, suitable for use as aggregates. Their technical suitability for different applications depends on their physical characteristics, such as crushing strength and resistance to impact and abrasion. Higher quality aggregates are required for coating with bitumen for road surfacing, or for mixing with cement to produce concrete. For applications such as constructional fill and drainage media, with less demanding specifications, lower quality materials are acceptable.

The crushed rock aggregate resources of West Yorkshire are confined to Carboniferous sandstones and Permian dolomites (or dolostones). Sales of crushed rock were a modest 649,000 tonnes in 2004, the major proportion of which was sandstone. Permitted reserves of crushed rock were 36 million tonnes at the end of 2003.

4.1 Sandstone

The Carboniferous sandstones of the Millstone Grit and Pennine Coal Measures of Yorkshire have traditionally been extensively used as a source of building stone and today both disused and working quarries are a common feature of the landscape.

Carboniferous sandstones consist of sand-sized particles, with minor pebbles, composed dominantly of quartz, but also with some feldspar, which are cemented by silica, to a greater or lesser extent. The sandstones are typically buff-coloured, although locally grey, and vary from fine- to coarse-grained.

Most of the sandstones are too weak and porous to make good quality aggregate for roadstone and concrete, but may be suitable for fill and for the production of manufactured sand to produce reconstituted stone products.

There are currently around 45 working sandstone quarries in West Yorkshire, the largest concentration of sandstone quarries in Britain. Most quarries produce blockstone or a range of masonry products, and some crush and process significant amounts of sandstone to produce manufactured sand for aggregate use. Some quarries produce crushed rock aggregate for less demanding specifications and very small amounts of building sand are also produced. Some 450,000 tonnes of sandstone was produced in West Yorskhire in 2004, mainly for aggregate use, although in terms of value, building sandstone is important.

There are many sandstone units within the Carboniferous, but the Woodhouse Grit (now known as the Midgley or Brandon Grit), the Woodhouse Grit Flags (Scotland Flags), the Rough Rock, the Rough Rock Flags and the Huddersfield White Rock (all Millstone Grit) and the Elland Flags and Greenmoor Rock (Lower Coal Measures),

plus the Thornhill Rock (Middle Coal Measures) and the Ackworth Rock (Upper Coal Measures) are the most extensively worked of the sandstones. These sandstones represent the main sandstone resource and only the extent of these sandstones is shown on the map.

4.2 Dolomite

Dolomites (and subordinate limestones) of Permian age occupy a narrow outcrop at the eastern margin of the area. These Permian rocks – commonly known as the Magnesian Limestone – are highly variable lithologically and in their rock properties. They are relatively soft, with high porosity and are frequently too weak and friable to make high quality aggregate. Nevertheless, they are quarried for low-grade applications, such as sub-base roadstone and fill, and some of the beds are sufficiently sound, strong and durable to be used as concreting aggregate or coated roadstone. Production in West Yorkshire is modest.

In West Yorkshire, the Permian sequence is made up of two carbonate rock units, separated by calcareous mudstone. The carbonate units are known as the Cadeby Formation (formerly Lower Magnesian Limestone) and the Brotherton Formation (formerly Upper Magnesian Limestone). The Cadeby Formation is between 55-90 m in thickness and consists of a varied sequence of dolomites and limestones. The Brotherton Formation is around 20 m in thickness and is fairly homogeneous, consisting mostly of hard flaggy limestones and dolomites.

5 Building stone

Historically the area has been the UK's most prolific source of Carboniferous building sandstones and has also produced a number of other building limestones for local use. The sandstones are generally marketed under the generic term 'York Stone'.

The oldest rocks that have been used for building are the hard, quartzose sandstones of the Millstone Grit Group. They have been worked for block stone, rubblestone, flagstone and roofing stone throughout the area. Extensive quarrying of the many sandstones beds present in the Group is generally associated with the development of the principal industrial settlements of the area. Quarrying centred around Horsforth, Guisley, Keighley, Halifax, Huddersfield and Holmfirth, in the north and west, and Pontefract and Ackworth in the east. The best known sandstone unit of the Group is perhaps the Rough Rock, the principal source of building stone in Huddersfield, obtained from the quarries of Crosland Moor.

Figure 2 Spinkwell Quarry, Crosland Moor, south-west of Huddersfield in 1929.

Spinkwell Quarry produced high quality yellow-brown, building sandstone (York Stone) from the Millstone Grit Group over a long period of time. The hard, siliceous sandstone was used extensively for building houses, churches and industrial mills in Huddersfield and other local towns.

The overlying Pennine Coal Measures Group succession has also been a prolific source of building sandstones in the past at Leeds, in the Harehills, Potternewton and Scott Hall quarries, and at Bradford, in for example the Bolton Woods, Fagley Flappit and Idle quarries. All of the many sandstones that occur in the succession have, however, been used for local building purposes. The best known of these sandstone units are probably the Gaisby Rock (Spinkwell Stone) and Elland Flags in the Bradford–Leeds area, from the Pennine Lower Coal Measures. In 1900 there were more than 40 Elland Flagstone quarries and mines operating around Halifax at Northowram, Southowram, Hipperholme and Brighouse.

Cropping out along the eastern margin of the area are the magnesian limestones of the late Permian, Cadeby Formation. These pale coloured dolostones have been extensively quarried, since Roman times, for local building stone along much of their outcrop, most notably around Wetherby, Bramham, Castleford and Pontefract.

The area currently has the largest concentration of active sandstone quarries in the UK. Magnesian limestone is worked for building stone at Highmoor Quarry.

6 Coal

Part of the East Pennine Coalfield is covered by the central and southeastern parts of West Yorkshire. The coal-bearing strata are rocks of the Pennine Lower and Middle

Coal Measures (Upper Carboniferous) and generally dip to the east or south. Coal seams crop out at the surface, except in the extreme east of the county where they are concealed by younger rocks, down to depths of 1200 m below OD. Coal seams are numerous and many are developed at a regional scale. They vary laterally in both thickness and composition, chiefly by variation in the number of dirt partings present within the seam. Twenty-two coal seams are recognised in the Lower Coal Measures and nine in the Middle Coal Measures. The seams are mainly bituminous and the calorific value and rank of the coals broadly increase eastwards. Sulphur is an impurity associated with all Yorkshire coals, with the most easterly parts of the coalfield recorded as moderately high in sulphur. In recent years, underground production in Yorkshire has been concentrated in the Barnsley seam complex, a thick, relatively undivided seam with lower values of sulphur (1.01 per cent). In West Yorkshire, the Barnsley seam occurs along the southeastern margin.

Following the closure of the Prince of Wales Mine, near Pontefract in 2002, West Yorkshire is now only a modest source of coal. From 1999 to 2005, total coal production fell from 2.3 Mt to 0.33 Mt. The small, Hay Royds Colliery, south of Skelmanthorpe, was the only operational underground coal mine at the end of 2005 and opencast coal extraction in the area ceased during 2005. However, prospects for opencast coal remain.

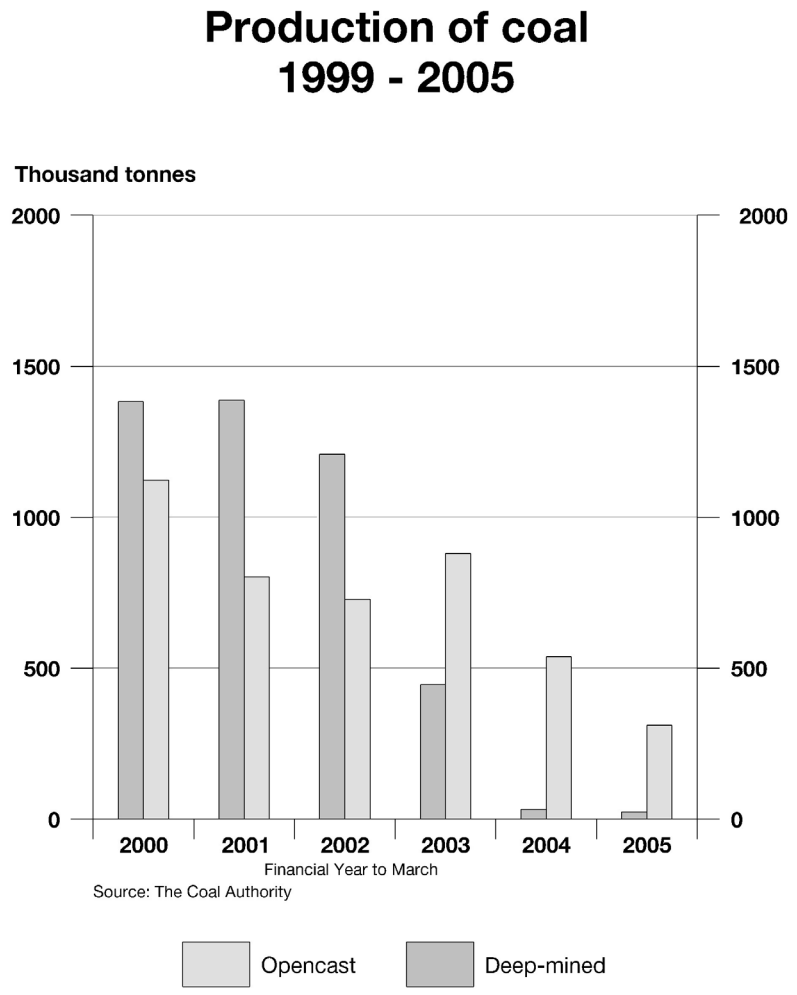

Figure 3. Production of coal in West Yorkshire, 1999 – 2005.

7 Hydrocarbons

7.1 Conventional Oil and Gas

Upper Carboniferous (Namurian and Westphalian) strata are at crop over the vast majority of West Yorkshire, only in the extreme east of the county are Permian strata at crop. Pennine Coal Measures (Westphalian) strata constitute part of the important East Pennines Coalfield, which is divided into important regions, the majority of which have been heavily mined.

The potential for oil and gas relies on conditions similar to those occurring in the East Midlands Oil Province. This requires Carboniferous source rocks, with traps formed during the end of the Carboniferous Variscan Orogeny which have been little disturbed since their formation.

West Yorkshire lies towards the northwestern end of the Gainsborough Trough, a major Carboniferous basin within which oil and gas source rocks were deposited. To the southeast these rocks have produced significant quantities of hydrocarbons, forming the East Midlands Oil Province. There has, however, been little hydrocarbon exploration activity in the county, perhaps reflecting the presence of large urban areas as well as coal mining activity. It is only the southeast and northeast of the county where a few seismic reflection lines have been acquired for hydrocarbon exploration. The South Kirkby well was drilled to the northwest of the Trumfleet gasfield in neighbouring South Yorkshire. This well was found to be dry and subsequently abandoned.

The only other oil exploration wells located in the county was drilled at Low Bradley in the far northwest and at Wessenden in the far southwest of the county. Others in neighbouring counties have been drilled close to the West Yorkshire boundary at Boulsworth and Weeton. All proved dry and were subsequently abandoned.

The paucity of exploration to date thus indicates that the hydrocarbon potential of the county is poor, being perhaps highest in the southeast, where there is potential for the discovery of oil and gas as found at Trumfleet and Hatfield in South Yorkshire. However, the majority of the exploration licences held in the county relate to the extraction of methane (see below).

Well name	Date Drilled	Operator at time of drilling	Well Status
Low Bradley	1991	Teredo	Plugged & abandoned, dry
South Kirkby	1967	Safari Oil Company	Plugged & abandoned, dry
Wessenden	1987	Enterprise Oil plc	Plugged & abandoned, dry

Table 1. West Yorkshire hydrocarbon exploration wells.

7.2 Abandoned Mine Gas Drainage (AMM), Coal Mine Methane (CMM) and Coal Bed Methane (CBM) Potential

Pennine Lower to Middle Coal Measures forming part of the East Pennine Coalfield crop out over much of the eastern half of the county. These Coal Measures are generally simple eastwards dipping and locally folded. They continue eastwards beneath the Permian cover rocks in the east of the county, being continuous with the concealed Eastern England Coalfield.

Within the county the coalfield has been heavily worked. However, by 2005, only one small drift mine remained in operation; although working from Kellingley Colliery in North Yorkshire extends into the east of the county. The coal across the county is a high volatile bituminous coal with a seam gas content of between 4.1 and 6.1 m^3 CH_4 per tonne.
In the USA, most coalbed methane production is from coals containing 7 or more m^3 CH_4 per tonne. The lower gas content of the coal, combined with the fact that the coalfield has been heavily worked suggests that coalbed methane development from virgin coal seams in West Yorkshire is probably not economic at present and will be dependent on areas of undisturbed coal, which will probably be limited. Future coalbed methane potential would require significant changes in the economics of extraction for the area to prove prospective.

Initially AMM potential in the county appears good, given the intense coal mining in the area. Alkane Energy hold a number of licences. They permit the extraction of gas from abandoned coal mines at Wheldale, near Castleford, which was then supplied either direct to local consumers or used on site for power generation. However, the potential for water entering and flooding areas of the mines, which are often interconnected, could impact greatly on prospects. Prospects in the county are thus thought to be good if the mines are not flooded. The schemes operated by Alkane have, however, seen rapid declines in the volumes of gas extracted.

A potential future area for development in undisturbed coalfield areas is Underground Coal Gasification. This is very much an unproven, new technology, which is under review and test in a number of countries. The level of former mining across the county and the depth of the coals might rule against this being a realistic resource in West Yorkshire.

7.3 Licensing

The Department of Trade and Industry grants licences for exclusive rights to explore and exploit oil and gas onshore within Great Britain. The rights granted by landward licences do not include rights of access, and the licensees must obtain any consent under current legislation, including planning permission. Licensees wishing to enter or drill through coal seams for coalbed methane and abandoned mine methane must also seek the permission of the Coal Authority.

8 Aims and limitations

The purpose of the maps in this series is to show the broad distribution of those mineral resources which may be of current or potential economic interest and to relate these to selected nationally-recognised planning designations. The maps are intended to assist in the consideration and preparation of development plan policies in respect of mineral extraction and the protection of important mineral resources against sterilisation. They bring together a wide range of information, much of which is scattered and not always available in a convenient form.

The maps have been produced by the collation and interpretation of mineral resource data principally held by the British Geological Survey. Information on the extent of mineral planning permissions has been obtained from the relevant Mineral Planning Authority (MPA). Some of these permissions may have lapsed or expired. The status of individual areas can be ascertained from the appropriate MPA. Location information on national planning designations has been obtained from the appropriate statutory body (Countryside Agency, English Nature and English Heritage). For further information the relevant body should be contacted.

The mineral resource data presented are based on the best available information, but are not comprehensive and their quality is variable. The inferred boundaries shown are, therefore, approximate. Mineral resources defined on the map delineate areas within which potentially workable minerals may occur. These areas are not of uniform potential and also take no account of planning constraints that may limit their working. The economic potential of specific sites can only be proved by a detailed evaluation programme. Such an investigation is an essential precursor to submitting a planning application for mineral working. Extensive areas are shown as having no mineral resource potential, but some isolated mineral workings may occur in these areas. The presence of these operations generally reflect very local or specific situations.

The maps are intended for general consideration of mineral issues and not as a source of detailed information on specific sites. The maps should not be used to determine individual planning applications or in taking other decisions on the acquisition or use of a particular piece of land, although they may give useful background information which sets a specific proposal within context.

9 Planning permission for the extraction of minerals

The extent of all known extant and former planning permissions for mineral working is shown on the map on the following page, irrespective of their current planning or operational status. The polygons were supplied as digital files by Calderdale, Kirklees and Wakefield Metropolitan Borough councils and by Leeds City Council, and were also digitised by BGS from Plotting Sheets and other documents supplied by the City of Bradford Metropolitan Borough Council. In addition, planning permission information was digitally acquired from Ministry of Housing and Local Government maps for the area and incorporated in the data. This data has been checked and amended by the local Authorities shown below. Any queries regarding the sites

shown should be directed to these authorities at the addresses shown below. The polygons cover active, former and restored mineral workings and, occasionally, unworked deposits.

Planning Permissions represent areas where a commercial decision to work mineral has been made, a successful application has been dealt with through the provisions of the Town and Country Planning legislation and the permitted reserve will have been depleted to a greater or lesser extent. The current planning status is not qualified on the map but is available in the underlying database.

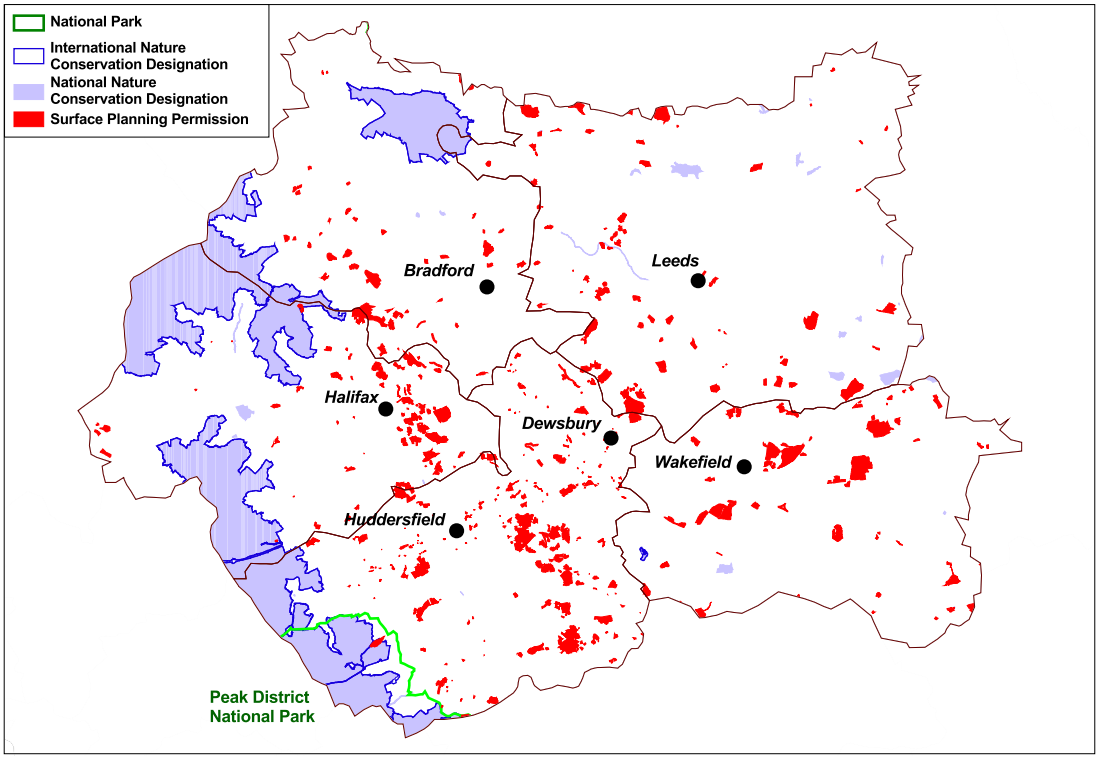

Figure 4. Surface Mineral Planning Permissions in West Yorkshire.

Contact addresses:

City of Bradford Metropolitan Borough Council, Planning Division, Transportation & Planning Service, 3rd Floor, Jacob's Well, Manchester Road, Bradford BD1 5RW, Tel: 01274 7537700, Fax: 01274 722840, web address: www.bradford.gov.uk

Calderdale Metropolitan Borough Council, Environmental Services Department, Northgate House, Northgate, Halifax HX1 1UN, Tel: 01422 357257, Fax: 01422 392238, web address: www.calderdale.gov.uk

Kirklees Metropolitan Borough Council, Planning Services Department, PO Box B93, Civic Centre, Huddersfield HD1 2JR, Tel: 01484 221593, Fax: 01484 221585, web address: www.kirklessmc.gov.uk

Leeds City Council, Planning, Department of Planning, Merrion House, 110 Merrion Centre, Leeds LS2 8SH, Tel: 0113 247 82304, web address: www.leeds.gov.uk

Wakefield Metropolitan Borough Council, Regeneration Department, Newton Bar, Wakefield WF1 2TX, Tel: 01924 206090, Fax: 01924 306690, web address: www.wakefield.gov.uk

10 Appendix

10.1 Topographic Base

Topography reproduced from the OS map by British Geological Survey with the permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office, © Crown copyright.

10.2 Constraint Information

Constraint information published on the accompanying map has been provided from the various agencies listed below; any enquires on the information should be addressed to the relevant agency.

10.2.1 English Nature

Digital SSSI, NNR, SAC, SPA and RAMSAR boundaries © English Nature 2004

Contact address: English Nature, Northminster House, Northminster, Peterborough PE1 1UA. Tel: 01733 455000. Fax: 01733 455103. Web page: www.english-nature.org.uk

10.2.2 English Heritage

Positions of scheduled monuments at 25th September 2003.

The majority of monuments are plotted using a centred NGR symbol. Consequently the actual area and/or length of a monument protected by the legal constraints of scheduling cannot be represented here. Monuments scheduled since that date are not accounted for. © Copyright English Heritage.

Contact address: English Heritage, 23 Savile Row, London W1S 2ET. Tel: 0207 973 3132. Web page: www.english-heritage.org.uk

10.2.3 Countryside Agency

Digital AONB boundaries © Countryside Commission 1986 (now Countryside Agency).

Contact address: Countryside Agency, John Dower House, Crescent Place, Cheltenham, Gloucestershire GL50 3RA. Tel: 01242 521381. Fax: 01242 584270. Web page: www.countryside.gov.uk

10.2.4 The Coal Authority

Coal Licence Areas © The Coal Authority 2006

Contact address: The Coal Authority, 200 Lichfield Lane, Mansfield, Nottinghamshire NG18 4RG. Tel: 01623 427162. Fax: 01623 638338