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Mineral Resource Information in Support of National, Regional and Local Planning: North Yorkshire (comprising North Yorkshire, Yorkshire Dales and North York Moors National Parks and City of York)

Commissioned Report CR/04/228N

BRITISH GEOLOGICAL SURVEY

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Mineral Resource Information in Support of National, Regional and Local Planning: North Yorkshire (comprising North Yorkshire, Yorkshire Dales and North York Moors National Parks and City of York)

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This report accompanies the two 1:100 000 scale maps: North Yorkshire (comprising North Yorkshire, Yorkshire Dales and North York Moors National Parks and City of York).

Key words

North Yorkshire; mineral resources; mineral planning

Front cover

Coldstones Quarry, Carboniferous limestones, view to southwest. North Yorkshire

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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 maps relate to the county of North Yorkshire, comprising North Yorkshire, Yorkshire Dales and North York Moors National Parks and the City of York, 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 two 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 maps 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, chalk, brick clay, industrial limestone, silica sand, potash, salt, 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:

- Yorkshire Dales and North York Moors National Parks;
- Heritage Coast;
- 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;
- Areas of Outstanding Natural Beauty (AONB): Nidderdale Hills, Howardian Hills, Forest of Bowland (part) and North Pennines (part); and
- Scheduled Monuments.

Mineral development may also be constrained by many other factors not shown on the maps, 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 amounts of sand and gravel may also be used as constructional fill.

Between 1997 and 2004 annual production of land won sand and gravel in North Yorkshire has varied between 2.5 million and 2.7 million tonnes. Recent production is shown on the graph and permitted reserves are estimated at about 29 million tonnes.

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

Figure 1. Wykeham Quarry, Scarborough, North Yorkshire.

2.1 SUPERFICIAL DEPOSITS

Parts of the areas assessed for sand and gravel by BGS resource surveys are identified on the maps. Resources shown here are taken from these maps where available. In these areas, the possible extent of sand and gravel concealed beneath other material is shown. These indicated resources were defined be overburden to mineral ratios. Outside these areas, available data are more limited. 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.

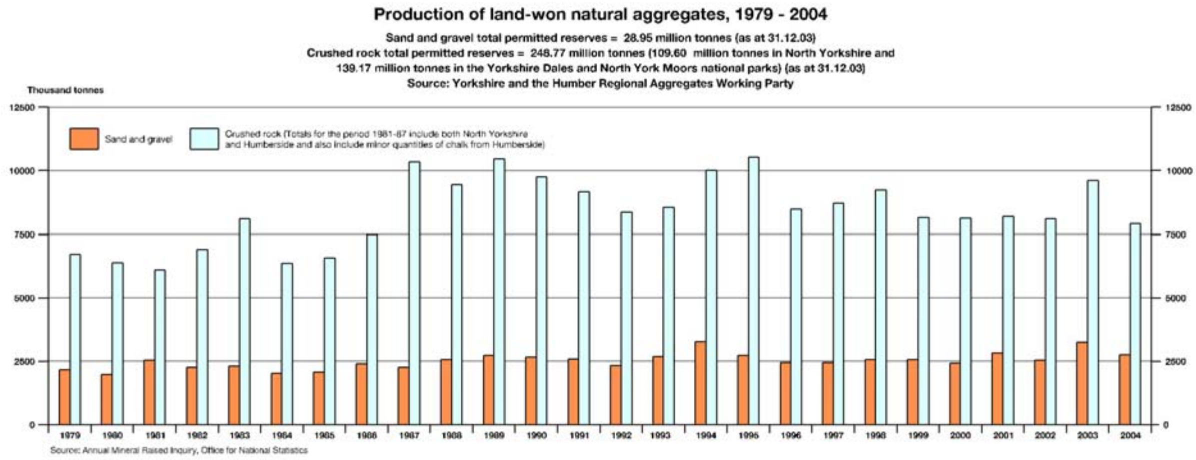

Figure 2. Production of natural aggregates in North Yorkshire, 1979 - 2004.

2.1.1 Glacial sand and gravel

This category comprises water-lain sands and gravels deposited in close proximity to the ice-sheets associated with the Quaternary glaciations. These deposits mainly occur on top of the sheet of till (boulder clay) or on, within or under the shoulders of the existing valleys indicating early down cutting along the present lines of drainage that were established by the Quaternary glaciations. In some areas, e.g. around Thirsk, the deposits occur in well developed linear esker systems trending south-southeast. The dominant lithology in the eskers is a moderately well-sorted, fine-grained sand although a broad range of sizes, from silt to boulders may also be present in places. Clast lithologies are dominated by Carboniferous sandstones with minor amounts of Carboniferous and Permian limestones. South of Newby Wiske the deposits are characterised by red to red-brown, fine- to medium-grained sand, with beds of coarse-grained sand and fine to coarse gravel. Clasts are again dominated by Carboniferous sandstones with 10 to 50 per cent Carboniferous limestone. Elsewhere the deposits show less structure and occur as irregular spreads and ridges of red-brown clayey sand with variably rounded pebbles, cobbles and sparse boulders of quartzite, sandstone, mudstone, chert and both Jurassic and Carboniferous limestones. These deposits can be up to 6 m thick in places, although other deposits in the Thirsk area, e.g. between Topcliffe and Brafferton, reach 22 m in thickness.

2.1.2 Glaciolacustrine deposits

During the, last Devensian glaciation, ice occupying the present coastal zone 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 lake, termed glaciolacustrine deposits, occur from south of York to the Humber estuary. When the ice began to melt, the lake spread round its northern side, depositing laminated clays with sand from Thirsk southwards to north of Knaresborough.

The deposits associated with Lake Humber were originally termed the ‘25-foot drift’ as they lie at an average height of about 25 feet above OD and fill and conceal the former valleys and landscape. The deposits of the 25-foot drift are predominantly laminated clay and silt with sand deposits occurring below, flanking and overlying the silt and clay. The lower part of the 25-foot drift consists in most places of sand, which is fine-grained and is commonly silty and clayey, with locally abundant coal particles. Thicknesses of up to 10 m are recorded but generally the lower sand is not more than 5 m thick. Sand deposits occur marginal to the silt and clay and thin out against peripheral slopes and pass laterally into the adjacent laminated clays. The marginal sand is fine to, rarely, medium grained, commonly silty and clayey with abundant coal particles and a few small pebbles and generally not more than 3 m thick. The upper sand is not more than 2.5 m thick and is discontinuous, forming low ridges and mounds. It is fine grained, increasingly silty and clayey towards the edges and contains thin beds and lenses of clay. In some areas the sand contains coal particles. Glaciolacustrine deposits are too fine grained to be used as concrete aggregate, for which there is the largest demand.

2.1.3 Glaciofluvial deposits

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.

In North Yorkshire, extensive spreads of these deposits occur in the mid and lower reaches of the Esk, Ure, Swale, Ouse, Wharfe, Nidd and Aire valleys. Some of these deposits form broadly rounded and elongate ridges and which overlie and clearly postdate the till and older glacial sand and gravels. They are composed of yellow to reddish-brown, fine-grained sands with varying proportions of gravel, pebbles, cobbles and occasional boulders. In the Hambleton Hills, these deposits have a sloping, steep sided, terrace-like form and are composed of red-brown gravels with thin lenses of medium- to coarse-grained sand. Clast lithologies include local Jurassic sandstone, ironstone, limestone and siltstone with a few pebbles of Carboniferous limestones. North of Thirsk, these deposits form broad ridges of red-brown sandy gravel associated with underlying glaciolacustrine sediments. Glaciofluvial sediments also occur in terrace deposits where drainage from the glaciers in the Pennine valleys entered the west side of the Vale of York, depositing spreads of sand and gravel in front of the ice sheets. The deposits are generally gravelly, with Carboniferous limestones and sandstones the dominant clast lithologies, and form the highest, flat-topped terraces along the valleys. These deposits show a progression northwards, mirroring the retreat of the Vale of York ice sheet. This type of deposit is typified in the workings at Marfield Quarry near Masham, where up to 15 m of coarse-grained sand and gravel is dry worked for concreting aggregate. The deposit is typically 60 per cent gravel and 40 per cent sand with a significant proportion of oversized material reflecting the coarse grained nature of many of these deposits.

Figure 3. Marfield Quarry, Masham, North Yorkshire

2.1.4 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 Swale, Nidd, Wharfe, Aire, Tees and Derwent with a succession of terraces 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 by newly formed glacial features. The extensive terraces associated with the River Ure are the result of reworking of the glaciofluvial deposits in the area. The terraces flank the river alluvium at various heights above the floodplain and are mainly composed of sandy gravel but with thin layers of silt and clay in the lower terraces, representing overbank deposits. The terrace deposits associated with the River Swale are worked at several localities, including Pallet Hill near Catterick, where 250,000 tonnes of aggregate are extracted per annum. The deposits have 60-70 per cent gravel with the remainder mostly sand but with up to 15 per cent silt and clay in places. The deposit is up to 15 m thick with the upper 5 m worked dry and the remainder wet worked.

2.1.5 Blown sand

These deposits are generally composed of fine- to medium-grained sand with a mean fines (<0.075 mm) content of around 8 per cent. The sand comprises sub-rounded to well-rounded quartz grains. These deposits are believed to be largely of late Quaternary age resulting from aeolian reworking of fluvial and glaciofluvial sands. The most favourable sites for blown sand accumulation are along the lower slopes of major west-facing escarpments, along the east side of the Vale of York. Near Thirsk, the sand is red-brown-yellow in colour and well-sorted, although the deposits are generally less than 2 m thick.

2.1.6 Beach sand and gravel

Included in this category are deposits marked on BGS maps as 'Shoreface and Beach Deposits', 'Storm Beach Deposits' and a variety of other beach deposits. Typically these occur as accumulations of sand and gravel restricted to the modern coast and a relatively narrow belt of country adjacent to it.

3 Crushed rock aggregate

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.

3.1 SANDSTONE

Sandstones are common rocks and occur in many parts of the county, but most sandstones are too weak and porous to make good quality aggregate for roadstone and concrete. The Lower Palaeozoic (Ordovician and Silurian) rocks of the Settle-Ingleton area, however, contain indurated sandstones which produce some of the best natural road surfacing materials available in Britain. These rocks are strongly folded and comprise a mixed sequence of siltstones and sandstones (often known generally as ‘gritstone’) and are quarried at Ingleton Quarry in Chapel-le-Dale and at Arcow and Dry Rigg quarries in Ribblesdale. Because of their hard-wearing, skid-resistant properties (average PSV of 61-63) the crushed-rock products are used mainly as high-quality road surfacing aggregates. These deposits form an important regional resource of high specification aggregates.

Very small tonnages of gritstone are also used for building stone and sandstones of Carboniferous age are also quarried on a small scale for the production of building stone at Keld in the Yorkshire Dales National Park and at Gatherly Moor near Richmond.

Figure 2. Arcow Quarry, Settle, Yorkshire Dales National Park

3.2 LIMESTONE

North Yorkshire is rich in limestone resources with potential uses in many industries, although most is used in construction, as crushed rock aggregate.

Carboniferous limestones are the major source of limestone aggregate materials. These limestones are commonly thick-bedded, pale grey or grey, consistent deposits which are structurally simple and can be quarried extensively and economically. Other limestones being worked for aggregates are the Permian 'Magnesian Limestone' and certain of the more indurated Jurassic limestones. Small amounts of Cretaceous Chalk are also quarried at the margins of the Yorkshire Wolds, for less demanding aggregate applications.

Large areas of the northern Pennines are underlain by Carboniferous limestones which, in the more northern areas (Wensleydale northwards), are thinner and associated with units of mudstone and sandstone. The most consistent limestones are found within the thick (>150 m) Malham Formation and equivalent beds which crop out widely between Ingleton, Settle and Grassington. Most limestone quarries in the area are worked solely for aggregates but some quarries produce, or have the potential to produce, industrial limestone raw materials. Further north, these lower limestones are concealed beneath limestone units of lower and more variable quality (the Wensleydale Group) which are interbedded with mudstones and sandstones. Such limestones are generally not thick enough for economic extraction, although the Great Limestone at the base of the Namurian is thicker and is actively quarried for aggregates.

Dolomites (and subordinate limestones) of Permian age occupy a narrow outcrop of easterly dipping strata from Knottingley to the River Tees. These Permian limestones and dolomites – commonly known as the 'Magnesian Limestone' – are highly variable lithologically and in their rock properties. They are much softer than typical Carboniferous limestones, with higher porosity and frequently are too weak and friable to make high quality aggregate. Nevertheless, they are extensively quarried for low-grade applications, such as sub-base roadstone and fill, and some of the rocks are sufficiently sound, strong and durable to be used as concreting aggregate or roadstone. In Yorkshire, the Permian sequence is made up of two carbonate units, separated by a 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 30-70 m in thickness and consists of a varied sequence of dolomites and limestones. The Brotherton Formation is usually less than 20 m thick and is a fairly homogeneous carbonate, with dolomite greatly exceeding limestone.

Jurassic rocks occur extensively in the North York Moors and adjacent areas. Limestones only form part of the sequence which also contains clays, siltstones and sandstones. The limestones, which are generally soft, friable and porous, occur in units which are usually relatively thin and may be laterally impersistent. Certain limestone units, however, such as the Upper Jurassic Malton Oolite Member of the Coralline Oolite Formation, which flanks the Vale of Pickering, are sufficiently indurated to produce good quality aggregates. The Malton Oolite is an impure limestone with high and variable silica contents and is quarried at several sites for general-purpose crushed rock aggregate. Locally, at Spaunton Quarry, it is suitable for producing coated roadstone, although the permission at this site which is within the National Park expires in 2007 and the quarry will close. The Coralline Oolite is shown on the map.

Figure 3. Coldstones Quarry, Pateley Bridge, North Yorkshire.

4 Chalk

Chalk is a relatively soft, fine-grained, white limestone consisting mostly of the debris from planktonic algae. The Chalk is of Upper Cretaceous age and occurs extensively in eastern and southern England where it forms an important resource of 'limestone raw materials'. In North Yorkshire, the Chalk occurs only at the south-eastern margin of the county, where the Yorkshire Wolds flank the broad Vale of Pickering. Here, and in adjacent areas of the East Riding of Yorkshire, the Chalk is somewhat harder and contains less moisture than in southern England; hence its value as aggregate, but only for less demanding applications such as fill and sub-base roadstone.

Chalk is currently extracted at two sites for low-grade aggregates use. The Yorkshire Wolds, however, are marked by numerous small disused quarries where the Chalk has been dug for local use as agricultural lime and hard core.

In northern England the Chalk is divided into five distinct formations: the Hunstanton Formation (Red Chalk) passing up into the Ferriby Chalk; the Welton Chalk, the Burnham Chalk and the Flamborough Chalk. The most obvious difference between the formations is in the occurrence of flint. The Ferriby and Flamborough chalks are flint-free, while the Welton and Burnham chalks are characterised by flint nodules and bands. Most of the Chalk contains numerous partings of calcareous mudstone (marl), which are most common in the Ferriby and Flamborough chalks. Thin and widely spaced mudstone bands are a feature of the Welton and Burnham chalks. The numerous mudstone partings in the Ferriby and Flamborough chalks lead to higher alumina, iron and silica contents and this part of the sequence is thought to be mainly of medium purity (>93% $CaCO_3$). The middle part of the sequence (the Welton and Burnham chalks) is generally of higher purity (>97% $CaCO_3$), although the silica content is variable depending on the flint content.

5 Brick clay

'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.

Both bedrock and superficial deposits have been used in the past to provide the raw material for brick and tile manufacture, and the laminated clays formed in glacial lakes in the Vale of York were a widely utilised source. There small clay pits at Alne, which makes handmade bricks and drainage pipes, and at Littlethorpe, near Ripon, which makes pottery and gardenware. Both pits work the laminated glacial clays. These clays have been also been extensively worked for bricks at York and more recently for pipe manufacture at Escrick. They are also used in the manufacture of lightweight expanded clay aggregate for block production and are worked at Hemingborough.

6 Industrial limestone

Limestone is an important economic resource because of its physical and chemical properties. It has a wide variety of applications but its primary use is in the construction industry. Limestone is also important in steelmaking, in glass manufacture, in sugar refining, in numerous chemical processes, as a mineral filler in paints, plastics and rubbers and in agricultural applications and waste treatment. In these non-constructional or industrial applications, limestone (or lime derived from the calcination of limestone) may be used either as a chemically reactive raw material or as an inert filler or pigment. For these applications, limestone is generally required to be of high chemical purity. Industrial uses of limestone account for a small and decreasing proportion of total limestone output in Britain.

The Carboniferous limestones of the northern Pennines contain thick sequences of very pure (>97 per cent $CaCO_3$) limestone associated with other units of more variable chemical quality. The most consistently pure limestones are found within the Malham Formation and equivalent beds. These crop out widely between Ingleton and Grassington but further north they are largely concealed beneath limestones of lower and more variable quality. The Cove Limestone, forming the lower part of the Malham Formation, is chemically very pure and the overlying Gordale Limestone is also characterised by high-purity limestones. Local variations in rock quality may result from dolomitisation, silicification, lead-zinc mineralisation and clay contamination related to faults and fractures. However, the Malham Formation forms a thick resource of high-grade industrial limestone. Limestone for industrial use has been produced from several limestone quarries in the past but currently all limestone is used as aggregate.

Figure 4. Horton Quarry, Settle, Yorkshire Dales National Park

7 Silica sand

Silica (industrial) sands contain a high proportion of silica in the form of quartz and are marketed for purposes other than for direct application in the construction industry. They are essential raw materials for the glass and foundry casting industries, but also have a wide range of other industrial uses, including ceramics and chemicals manufacture, and for water filtration media, and in sports and horticultural applications. Silica sands are valued for both their chemical and physical properties. These include a high quartz content and, more importantly, low levels of deleterious impurities such as clay, iron oxides and chromite, and typically a narrow grain-size distribution (generally in the range 0.5 to 0.1 mm). For most applications silica sands have to conform to very closely defined specifications, specific uses demanding different combinations of properties.

Silica sand processing is of varying degrees of complexity and depends on the nature of the raw materials and the end use of the sand. It typically requires a high capital investment in plant. Processing is aimed at modifying both the physical and chemical properties of the sand to meet user specifications. The ease with which contaminants (such as iron-bearing impurities and clay) can be removed, together with the level of losses incurred in removing oversize and undersize fractions from a sand, has a major bearing on its potential use. Within the UK, deposits of silica sand occur in only limited areas and quantities, and the special characteristics of silica sand extraction, in particular the cost of processing, means that the industry has a restricted distribution.

North Yorkshire has only limited resources of silica sand and production is confined to a relatively small site at Burythorpe, near Malton. Here, fine-grained, pale-coloured sands from the Jurassic Osgodby Formation are quarried, predominantly for the production of resin-coated foundry sand. Current production is around 30 000 tonnes/year. Because of its only local importance, the map shows the outcrop of the Osgodby Formation only in the Burythorpe area.

A large silica sand operation based on Carboniferous sandstones within the Millstone Grit Group (Hall Moor Sandstone) at Blubberhouses, near Harrogate formerly produced glass sand, mainly for the colourless glass container market. The quarry closed in 1991 after only three years operation due, in part, to difficulties in processing the sand.

Figure 5. Burythorpe silica sand quarry, Malton, North Yorkshire.

8 Evaporite minerals

Evaporite minerals, including gypsum and anhydrite, rock salt (halite) and, more rarely, potash and magnesium salts are precipitated during the evaporation of seawater. The arid conditions that existed in north-east England during Permian times resulted in several cycles of evaporite deposition. The most extensive led to the deposition of the Boulby Halite Formation, which includes the Boulby Potash Member. Both are worked at the Boulby Potash Mine near Loftus in the North York Moors National Park.

8.1 POTASH

Potash is a generic term for a variety of potassium-bearing minerals and refined products. Sylvite (potassium chloride, KCl) is by far the most important and has accounted for all the potash produced in the UK to date. Potassium is one of the three primary nutrients, with nitrogen and phosphorus, that are essential for plant growth. Most of UK potash production is consumed in the manufacture of fertilisers. Smaller quantities are also used by the chemical and pharmaceutical industries.

Potash resources occur in rocks of late Permian age that underlie the eastern part of North Yorkshire. The resource comprises the Boulby Potash, which occurs at the top of the Boulby Halite Formation. The sub-surface extent of the Boulby Potash and its conjectured western limit is shown on the map. The bed underlies extensive parts of east Yorkshire but is only worked at the Boulby Mine. Mining operations extend some 12.5 km, reaching 5 km offshore to the north where they are approximately 800 m below the seabed. In the south, a combination of seam dip and topographic relief leaves the workings more than 1300 m below the land surface. The Boulby Potash averages 7 m in thickness but ranges from nil to over 20 m. The bed consists of sylvinite (a mixture of sylvite and halite) with minor clay minerals and anhydrite, and traces of other minerals. The material mined is of high-grade by international standards with a mean KCl content of 34 per cent (21 per cent K_2O). However, grade varies both vertically and laterally.

The Boulby Mine, together with the southern mining area, is located within the North York Moors National Park. Some of the northern mining area extends into Redcar and Cleveland Borough in the North East Region, and the eastern mining district extends out beneath the sea.

Potash production was nearly 1 million tonnes refined KCl in 2005, with a record output of 1.04 million tonnes in 2003. The Boulby Mine is the UK's only potash mining operation. Two other proposals to extract potash in North Yorkshire, one of which involved solution mining, were permitted in the late 1960s, but were never finally implemented.

Figure 6. Boulby potash mine and underground workings, North York Moors National Park.

8.2 SALT

Salt (sodium chloride, NaCl), occurs as rock salt (halite) in beds ranging in thickness from a few centimetres up to several hundred metres. The purity of individual salt beds depends on the extent of mudstone interbedding.

Salt-bearing strata of late Permian age underlie extensive areas and extend at depth from Teesside beneath much of north and east Yorkshire, and into north Lincolnshire. Deposits occur at several horizons, the most extensive, and the only one of economic importance, being the Boulby Halite. The sub-surface extent of the Boulby Halite and its conjectured western limit is shown on the map. At the Boulby Mine, the Boulby Halite achieves a total thickness of about 40 m. About 8–10 m below the Boulby Potash is a bed of pure and strong halite through which the mine's arterial roadways are driven to access current mining areas and to explore and develop new areas for potash production. The rock salt produced through driving these roadways is very suitable for de-icing roads and substantial quantities are produced for this purpose. Output of rock salt was 600 000 tonnes in 2005. The Boulby Mine is one of only two mines producing rock salt in England.

Thick salt deposits also occur lower in the Permian sequence within the Fordon Evaporites. At Hornsea, in the East Riding of Yorkshire, these deposits have been used to create large cavities some 100 m high and 100 wide at depths of between 1710 m and 1840 m for use in natural gas storage to meet peak demands. A stratigraphically higher salt horizon, the

Sneaton Halite, occurs above the Boulby Halite but is less extensive. These are not shown on the map.

8.3 GYPSUM AND ANHYDRITE

Gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$) are, respectively, the hydrated and anhydrous forms of calcium sulphate, which occur in beds up to a few metres thick. Anhydrite occurs at depth, becoming hydrated near surface and passing into gypsum. Anhydrite is thus much more extensive than gypsum, but in its pure form is not of economic importance because of its limited commercial application. Gypsum is soluble and often dissolves at outcrop, locally causing subsidence problems. Gypsum is used in the manufacture of plaster and plasterboard and as a retarder in Portland cement.

Calcium sulphate may also be derived as a by-product of certain industrial processes. The most important is flue gas desulphurisation (FGD), a process that removes sulphur dioxide from the flue gases at coal-fired power stations. The product, known as desulphogypsum, is now an important supplement to the supply of natural gypsum. Synthetic gypsum has a higher purity (96 per cent) than most natural gypsum (80 per cent).

Gypsum occurs in a narrow, north-south belt at two horizons within the Edlington and Roxby formations near the western boundary of the Permian succession. However, because of dissolution the occurrence of gypsum is somewhat unpredictable. The most persistent bed is the Upper (or Sherburn Anhydrite) in the Roxby Formation. This bed occurs east of Leeds and was formerly mined at Sherburn-in-Elmet for plasterboard manufacture. The mine was sunk in 1966, but flooded in 1988 and was abandoned. There is no other production in the area. There is no other production in the area. Gypsum resources are not shown on the map because of their association with water-bearing strata. Gypsum also occurs in the Triassic Mercia Mudstone Group at levels comparable to the Tutbury/Newark Gypsum in Nottinghamshire and Leicestershire. There is no information on the thickness and quality of any beds present in North Yorkshire.

Large quantities (565 000 tonnes in 2005) of desulphogypsum are produced at the Drax power station and are used for plasterboard manufacture. Eggborough power station also started supplying desulphogypsum during 2005.

9 Building stone

Historically the area has produced and used a wide range of stones for building purposes. The oldest rocks of the area are the Lower Palaeozoic metasedimentary rocks of the Craven inliers, near Settle and Ingleton that provided walling, roof and flag stones for local use.

The Carboniferous rocks, however, are the main source of building stones in the county. The hard, pale grey Carboniferous limestones are commonly used across their outcrop in Swaledale, Ribblesdale and Wharfedale, in farm buildings, villages and railway viaducts. Occasionally the black, organic rich limestone varieties were used decoratively e.g. Nidderdale Marble. In some areas thin sandstones in this Lower Carboniferous succession (‘Yoredale’ facies) were also worked for flagstones and building stone.

The many sandstones of the Carboniferous Millstone Grit Group were extensively quarried over their outcrop, most notably in the Nidderdale-Harrogate area, supplying building and roofing stone to many of the nearby towns and cities. To the west of Ripon these sandstones was also used extensively for local building e.g. Fountain’s Abbey.

The dolomitic limestones of the Permian (Cadeby Formation) have been widely exploited as freestone. Former quarries occur along much of the outcrop but are principally concentrated in the south from Tadcaster to Sherburn-in-Elmet. Limestones from these quarries were used to construct York and Beverley Ministers, Selby Abbey and numerous parish churches and houses in the area.

In the Middle Jurassic succession the sandstones (Cloughton, Aislaby, Sneaton, Rosedale, Riccal Dale etc) and limestones (Scarborough Formation) in the Ravenscar Group and the Kellaways and Hackness sandstones (Osgodby Formation), were important local sources of building stone e.g. Whitby and Rievaulx abbeys.

The limestones and sandstones in the Upper Jurassic Corallian Group, cropping out from the Hambleton and Howardian Hills to the coast, provided building stone for many local buildings e.g. at Castle Howard, Hildenley, Rievaulx, Bridlington and Scarborough. Both Aislaby sandstone (Ramsgate and Margate piers) and Hildenley limestone were also exported into London and the south-east.

The Lower Cretaceous succession is mudstone dominated with no suitable building stone units, however, the Chalk of the Upper Cretaceous is locally important, as around Flamborough.

10 Mineralisation

Fluorite-baryte-lead mineralisation occurs within the southern part of the Northern Pennine Orefield (Askrigg) as semi-vertical veins that are mainly confined to the uppermost Lower Carboniferous limestones. The most intensively worked areas were around Grassington and Greenhow, where veins occur in the unconformably overlying Namurian Grassington Grit, and in the North Swaledale area where deposits, such as Lownathwaite, Old Gang and Arkengarthdale mines were worked in a linked system of faults. There has been little activity in the area for many years. Vein mineralisation is encountered within the limestones at the Coldstones Quarry near Pateley Bridge. Small amounts of fluorspar-bearing ore are transported to the Cavendish Mill in the Peak District for processing.

The Lower Carboniferous Craven Basin, which extends over an area approximately 60 km by 30 km from Lancashire into North Yorkshire, has potential for base-metal mineral deposits. BGS and industry have carried out mineral exploration in the area in the past and there were attempts to explore along the Craven Faults for 'Irish-style' stratabound lead-zinc mineralisation in the 1970s. The Craven Basin is still regarded as prospective for base metal mineralisation.

11 Coal

The county includes the concealed East Pennine Coalfield. Coal-bearing strata are principally confined to the Pennine Lower and Middle Coal Measures (Upper Carboniferous). In general the coal-bearing horizons dip from west to east under the south and southeast of the county. These horizons generally occur at depths of between 50 to 1200 m beneath the surface. There is some shallow coal in the extreme southwest of the county. Coal seams are widespread and many are developed on a regional scale. However, there are lateral variations in thickness, composition and the number of 'dirt' partings they contain. The seams are mainly bituminous and the calorific value and rank of the coals broadly increases eastward. Sulphur is an impurity associated with all Yorkshire coals, with the more easterly parts of the coalfield being recorded as moderately high (2.01 per cent) and high for the Beeston and Middleton

Mains coals but with low values (1.01 per cent) in the Barnsley coals. Ash contents are variable but are good to medium quality in the Beeston coals (2.6 to 7.5 per cent). North Yorkshire was, until recently, one of the main sources of deep-mined coal in Britain. However, with the closure of the Riccall Mine in October 2004 all the operations of the Selby Complex of mines came to an end after only 22 years production and with a total output of 121 million tonnes. Kellingley colliery, near Knottingley, is now the only remaining deep mine in the county. Production is from the Silkstone seam but reserves also occur in the Beeston seam. Proven reserves are 50 million tonnes. The output of Kellingley Mine was 1.96 million tonnes in 2005. A prospect area for deep coal mining - the North Ouse prospect – has been identified to the north of York. There are no opencast coal resources in North Yorkshire

12 Hydrocarbons

12.1 CONVENTIONAL OIL AND GAS

North Yorkshire lies towards the southern margin of the Cleveland Basin, an important fault-bounded Jurassic and early Cretaceous structure, that itself overlies part of an early Carboniferous basin. Over the western part of the county, Carboniferous (Dinantian and Namurian) strata are at crop. Westphalian (Pennine Coal Measures) strata have a limited occurrence, but are present beneath the Permian in the area of Robin Hood's Bay and in the south of the county where they extend eastwards from crop in West Yorkshire beneath the Permian to the coast just south of the line of the Vale of Pickering-Flamborough Head Fault Zone. As a result the area contains potential source rocks for both oil and gas in both Carboniferous (Namurian and Westphalian) and Jurassic (Liassic) strata. Phases of uplift and basin inversion have also led to the development of potential trapping structures and the area thus has the potential to contain commercial hydrocarbon accumulations.

The significant number of exploration wells (Table 1) and the existence of a dense network of seismic reflection surveys across much of the eastern and southern parts of the county, illustrates that in some areas, North Yorkshire has been intensively explored for oil and gas since before the Second World War. This has led to many discovery wells and the development of a number of producing gasfields in the county. To date, six gasfields have been developed, with the majority still producing and a number as yet to be developed. The status of each field is shown in Table 2.

In 1937 BP and ICI drilled at Eskdale and tested gas from the Permian Upper Magnesian Limestone. The field was developed in 1960 and the gas fed from wells Eskdale 2 & 12 into the town gas system of the Whitby area until it was shut down in 1967. Hydrocarbons have subsequently been found in rocks of Namurian to Jurassic age within the county. The majority of the proven gas fields occur as a result of gas being trapped in fractured Permian carbonate and dolomite sequences and some basal Permian sandstones. However, gas has also been produced from Namurian sandstones in, for example, the Kirby Misperton and Malton gas fields.

Exploration to date indicates that the best potential for the discovery of further hydrocarbons lies in the eastern third of the county, where large tracts are currently licensed for oil and gas exploration and a number of prospects remain as yet untested or undeveloped. Viking Oil (UK) operate the majority of the producing gas fields (see inset map). Other small and focused operators have taken up acreage around these producing fields and it is likely that there will be further small gas and perhaps oil discoveries in the future. Dinantian strata crop out over much of the ground in the west and northwest of the county where hydrocarbon prospectivity is perceived to be lower. This is reflected in the fact that only two wells, at Weeton and Low Bradley on the border with West Yorkshire, have been drilled in these parts to date. Both proved dry and were abandoned.

Well Name	Date Drilled	Operator at time of drilling	Well Status
Aldfield	1945	D'Arcy Exploration Ltd	Plugged & abandoned
Barlow	1973	Candecca Resources Ltd	Plugged & abandoned
Barton	1973	Home Oil of Canada Ltd	Plugged & abandoned
Cleveland Hills	1940	Gulf Exploration Company (Great Britain) Ltd	Plugged & abandoned
Cloughton	1986	Bow Valley Petroleum Ltd	Plugged & abandoned, with gas shows
Crayke	1964	Home Oil of Canada Ltd	Plugged & abandoned
Duggleby	1990	Amoco (UK) Exploration Company	Plugged & abandoned
Egton High Moor	1968	BP Development Ltd	Plugged & abandoned
Elenthorpe	1945	D'Arcy Exploration Ltd	Plugged & abandoned
Fordon	1974	BP Development Ltd	Plugged & abandoned, with gas shows
Harlsey	1965	Home Oil of Canada Ltd	Plugged & abandoned
High Hutton	1987	Entreprise Oil plc	Plugged & abandoned, with oil and gas shows
Hunmanby	1973	Burmah Oil (North Sea) Ltd	Plugged & abandoned
Kirby G1-G11	1938	Gulf Exploration Company (Great Britain) Ltd	Plugged & abandoned
Kirk Smeaton	1985	RTZ Oil & Gas Ltd	Plugged & abandoned
Low Bradley	1991	Teredo Petroleum plc	Plugged & abandoned, dry
Marton	1978	British Geological Survey	Scientific hole
Newton Mulgrave	1965	Home Oil of Canada Ltd	Plugged & abandoned
North Fordon	1955	D'Arcy Exploration Ltd	Plugged & abandoned
Ralph Cross	1966	Home Oil of Canada Ltd	Shut-in gas well
Rosedale	1966	Home Oil of Canada Ltd	Plugged & abandoned
Sawley	1945	D'Arcy Exploration Ltd	Plugged & abandoned, dry
Sessay	1988	Kelt UK Ltd	Plugged & abandoned
Speeton	1960	Shell UK Exploration and Development	Plugged & abandoned
Stoupe Beck	1997	Candecca Resources Ltd	Plugged & abandoned
Thornton le Clay	1990	Enterprise Oil plc	Plugged & abandoned
Weeton	1984	RTZ Oil & Gas Ltd	Plugged & abandoned, dry
Wheldrake	1973	Candecca Resources Ltd	Plugged & abandoned
Whenby	1975	Candecca Resources Ltd	Plugged & abandoned
Whitwell on the Hill	1961	BP Exploration Company Ltd	Plugged & abandoned
Wykeham	1971	Home Oil of Canada Ltd	Plugged, gas well

Table 1. North Yorkshire hydrocarbon exploration wells

Name of well	Field Type (oil/ gas)	Operator at time of discovery	Current operator of licence block	Discovery date	Production started	Production ceased	Total Production ($x10^6$ cuft)- up to 2005
Eskdale	Gas	D'Arcy Exploration (forerunner of BP)	Roc Oil (UK) Ltd	1937	1960	1967	860
Lockton	Gas	Home Oil of Canada Ltd	Viking Oil	1966	1971	1974	Unknown
Kirby Misperton	Gas	Taylor Woodrow	Viling Oil	1985	1995	Producing	Unavailable
Malton	Gas	Candecca	Viking Oil	1970	1995	Producing	Unavailable
Marishes	Gas	Kelt	Viking Oil	1988	1995	Producing	Unavailable
Pickering	Gas	Kelt	Viking Oil	1992	2001	Producing	Unavailable

Table 2. North Yorkshire gasfields

12.2 ABANDONED MINE METHANE (AMM), COAL MINE METHANE (CMM) AND COALBED METHANE (CBM) POTENTIAL

Pennine Lower to Middle Coal Measures forming part of the Eastern England Coalfield occur in the south of the county, but are entirely concealed beneath the Permian and younger cover rocks. These strata come to crop to the west in West Yorkshire, where they form part of the heavily worked Yorkshire and Nottinghamshire coalfields. Their northern extent is just to the south of the Vale of Pickering-Flamborough Head Fault Zone. Generally easterly-dipping from outcrop in the south of the county, their Permian subcrop pattern suggests that they are folded about a gentle NW-SE trending fold. The coals of the Yorkshire Coalfield are highly volatile bituminous types with an average total thickness of 15 m, and an average gas content of 4.1 m^3 CH_4 per tonne. The Pennine Coal Measures in the Eastern England Coalfield have not been mined and are not well documented. However, where measured they have a gas seam content of 1.5-5.9 m^3 CH_4 per tonne and are thought to have an average total thickness of around 10 m, with non likely to be thicker than 4m.

Coal Measures also subcrop the Permian in the area around Robin Hood's Bay, where they extend offshore. Here there is only 0.6 m of poor coal recorded and no mining has taken place.

In the USA, most CBM production is from coals containing 7 or more m^3 CH_4 per tonne. The lower gas content of the coal, suggests that CBM development from virgin coal seams in North Yorkshire is probably not economic at present. Future CBM potential will depend upon favourable changes in the economic situation when the Coal Measures beneath the county might prove prospective.

The prospects for Coal Mine Methane and Abandoned Mine Methane in areas of worked pits are analogous to other areas of the Yorkshire-Nottinghamshire Coalfield in general, being perceived as good. This is reflected in the acreage taken up for Coal Mine and Coal Bed prospects by companies like Evergreen, Octane, Alkane and Stratagas. Alkane Energ have already constructed and are operating coal mine methane extraction plants at Monk Bretton and Wheldale in neighbouring areas of South and West Yorkshire respectively. Rapid declines in the volumes of gas extracted and concerns in 2003 over the classification and taxing regimes of the resource have, however, led to doubts and concerns over the economic viability of this resource.

The concealed Pennine Coal Measures around Robin Hood's Bay have not been mined and with the poor and thin coal recorded, provide little or no CBM prospects.

A potential future area for development in coalfield areas is Underground Coal Gasification (UCG). This is very much an unproven, new technology, which is under review and test in a number of countries. Areas of suitable deep Coal Measures in North Yorkshire probably exist, notably around York and eastwards, and therefore might provide potential for developing this technology.

12.3 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 any rights of access, and the licensees must also obtain any consent under current legislation, including planning permissions. 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.

13 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.

14 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, irrespective of their current planning or operational status. The polygons were supplied as digital files by North Yorkshire County Council, North York Moors National Park and Yorkshire Dales National Park. 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. The polygons cover active, former and restored mineral workings and, occasionally, unworked deposits.

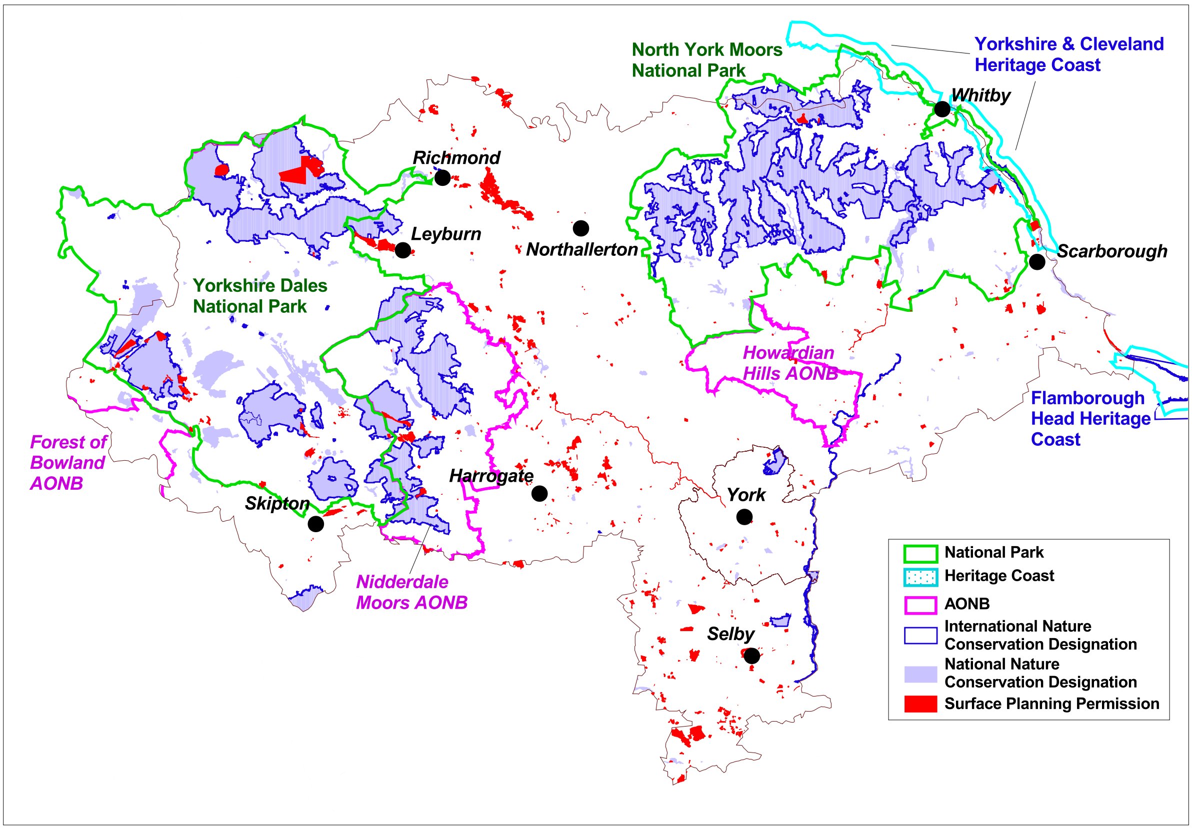

Figure 7. Planning permissions and designations in North Yorkshire

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.

Contact addresses:

North Yorkshire County Council, Environmental Services, County Hall, Northallerton DL7 8AH, Tel: 01609 780780, Fax: 01609 779838, web address: www.northyorks.gov.uk

Yorkshire Dales National Park, Yoredale House, Bainbridge, Leyburn DL8 3EL, Tel: 0870 1666 333, Fax: 01969 652300, web address: www.yorkshiredales.org.uk

North York Moors National Park, Planning Department, The Old Vicarage, Bondgate, Helmsley YO6 5BP, Tel: 01439 770657, Fax: 01439 770691, web address: www.northyorkmoors-npa.gov.uk

City of York Council, Directorate of Environment & Development Services, 9 St Leonard's Place, York YO1 2ET, Tel: 01904 613161, Fax: 01904 551390, web address: www.york.gov.uk

15 Appendix

15.1 TOPOGRAPHIC BASE

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15.2 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.

15.2.1 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

15.2.2 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

15.2.3 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

15.2.4 The Coal Authority

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