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# Yorkshire and Humber Regional Aggregates Working Party: Sand and Gravel Study

Economic Minerals and Geochemical Baseline Programme

Commissioned Report XX/00/00

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BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT XX/00/00

# Yorkshire and Humber Regional Aggregates Working Party: Sand and Gravel Study



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# 1 Introduction

The Yorkshire and Humber Assembly and the Yorkshire & Humber Regional Aggregates Working Party (RAWP) are seeking advice for the sub-regional apportionment of the guidelines for aggregates provision within their region. Although the region has adequate permitted reserves to meet the crushed rock guideline figure to 2016, a sand and gravel shortfall is anticipated. The guidelines indicate that the region will need to make provision for 73 million tonnes of land-won sand and gravel in the period 2001-2016. Identified permitted reserves at the beginning of 2001 were approximately 55 million tonnes and are unevenly distributed in the region.

The Yorkshire and Humber Assembly and the RAWP commissioned the British Geological Survey to carry out a study to identify the broad areas of sand and gravel resources in the region and to further identify potentially suitable resources for use as concrete aggregate. In addition, information on the potential environmental constraints and planning considerations associated with these areas was requested. This information will form the basis of a further study to assess the environmental costs of meeting the apportionment, with a view to recommending possible sub-regional locations/apportionments for future provision, following the guidelines set out in the *Good Practice Guidance on the Environmental Appraisal of the Provision of Aggregates* (ODPM, 2004). The guidance is an aid to decision makers evaluating various supply scenarios at the strategic scale.

This report and associated digital data, carried out by BGS, forms Step 4 of the Guidance and involved the production of:

- a digital resource map showing the broad distribution of sand and gravel resources in the region;
- a digital map showing those sand and gravel resources potentially suitable for concreting aggregate; and
- a digital environmental constraints map.

The digital outputs that accompany this report are listed in Appendix 1. All data is supplied in MapINFO GIS format.

# 2 Project objectives

The objectives of the project are:

1. **Resource identification*:*** Identify the general extent of superficial sand and gravel resources in the region and further refine these resources to indicate areas potentially suitable for concrete aggregate (Stage 1);

2. **Identification of constraints:** Identify the potential environmental constraints and other planning considerations in the study area relevant to aggregates extraction (Stage 2); and

3. **Production of a composite constraints layer:** Produce a composite constraints layer showing the number or 'density' of constraints at a one-hectare resolution (Stage 3).



The project was carried out in three stages, reflecting the project objectives.

# 3 Overview of Yorkshire and Humber Region

The Yorkshire and Humber Region is the fifth largest region in England with an area of 15 624 $km^2$. The region consists of the county of North Yorkshire, seven unitary authorities - East Riding of Yorkshire, York, North Lincolnshire, North East Lincolnshire, City of Kingston upon Hull, North York Moors and Yorkshire Dales National Parks - and the metropolitan districts of Barnsley, Bradford, Calderdale, Doncaster, Kirklees, Leeds, Sheffield, Rotherham, Wakefield. The study area for this project includes the entire North York Moors and Yorkshire Dales National Parks and excludes the Peak District National Park.

The Yorkshire and Humber Region has important mineral resources and a range of minerals are produced, including limestone, sand and gravel, coal, brick clay, sandstone, chalk and potash. Limestone dominates output, followed by sand and gravel. Total sand and gravel sales in 2002 were 4.999 Mt, 97 per cent of which was land won (Table 1). Of the total sand and gravel produced, 74 per cent was used for concreting purposes. In Yorkshire and Humber, by MPA, North Yorkshire is the greatest producer of sand and gravel accounting for 53 per cent of total production, followed by South Yorkshire (20 per cent), East Ridings of Yorkshire and North Lincolnshire (15 per cent) and West Yorkshire (12 per cent) (Table 2).

Identified permitted reserves of land won sand and gravel at the beginning of 2001 were approximately 55 million tonnes (Table 3). If the guideline figures set out in the regional apportionment are to be met (73 million tonnes in the period from 2001-2016), shortfalls will begin to occur as the 16-year period progresses.

**Table 1 Sales of sand and gravel for aggregate purposes by MPA, 2002**

| . | Thousand tonnes | |
|---|---|---|
| | **2002 (AM)** | **2002 (AMRI)** |
| North Yorkshire | 2,489 | 2,550 |
| West Yorkshire | { 1,409 | 573 |
| South Yorkshire | | 956 |
| E. Riding/North Lincolnshire | 787 | 753 |
| Marine dredged | 237 | 167 |
| **REGIONAL TOTAL** | **4,922** | **4,999** |

Sources: AMRI: Annual Minerals Raised Inquiry, Office for National Statistics. AM: Yorkshire & the Humber Regional Aggregates Working Party Annual Report 2002.

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**Table 2 Sales of sand and gravel for aggregate purposes by MPA**

| | Thousand tonnes | | | |
|---|---|---|---|---|
| | **1999** | **2000** | **2001** | **2002** |
| North Yorkshire | 2,647 | 2,595 | 2,627 | 2,489 |
| South and West Yorkshire | 1,039 | 944 | 1,418 | 1,409 |
| East Riding of Yorkshire | 501 | 463 | 579 | 461 |
| North Lincolnshire | 235 | 205 | 311 | 326 |
| **REGIONAL TOTAL** | **4,422** | **4,206** | **4,936** | **4,686** |
| Marine (Hull) | 295 | 322 | 275 (a) | 237 (a) |

For aggregate use only. (a) Also landings at Immingham

**Table 3 Identified permitted reserves of land won sand and gravel 1999 – 2002**

| | Thousand tonnes | | | |
|---|---|---|---|---|
| | **1999** | **2000** | **2001** | **2002** |
| North York Moors NP | - | - | - | - |
| Yorkshire Dales NP | - | - | - | - |
| North Yorkshire | 28,555 | 28,040 | 27,901 | 31,280 |
| South Yorkshire (Doncaster) | 20,193 | 19,604 | 15,075 | 14,100 |
| West Yorkshire | C | C | C | C |
| East Riding of Yorkshire/ N. Lincs | 7,654 | 6,839 | 6,744 | 5,910 |
| **Regional Total** | **Na** | **Na** | **Na** | **Na** |

Na: not available. C: Confidential. Source: Yorkshire & the Humber Regional Aggregates Working Party. Annual Report 2002. Figures relate to year ending 31st December.

# 4 Resource identification (Stage 1)

## 4.1 DEFINITION OF RESOURCES AND LIMITATIONS

Mineral resources are natural concentrations of minerals, or bodies of rock, that are or may become of potential economic interest as a basis for the extraction of a commodity. They will exhibit physical and/or chemical properties and be present in sufficient quantity to be of intrinsic economic interest. Mineral resources are thus economic as well as physical entities.

The identification and delineation of mineral resources is inevitably somewhat imprecise as it is limited not only by the quantity and quality of data currently available but also involves predicting what might, or might not, become economic to work in the future. The assessment of mineral resources is, therefore, a dynamic process, which must take into account a range of factors. These include geological reinterpretation as additional data becomes available, as well as the continually evolving demand for minerals, or specific qualities of minerals, due to changing economic, technical and environmental factors. Consequently areas that are of potential economic interest as sources of minerals may change with time. In addition, criteria used to define resources, for example in terms of mineral to waste ratios, also change with location and time. Thus a mineral deposit with a high proportion of waste may be viable if located in close proximity to a major market, but uneconomic if located further away. These criteria vary depending on the quality of the information available. The extent of sand and gravel resources outlined for this project are generally the surface expression of the resource. However, users should note that workable minerals may extend beneath overburden which is adjacent to the outcrop area shown.

Two categories of mineral resource linework were outlined reflecting differing degrees of geological assurance: **inferred** and **indicated** explained as follows:

**Inferred resources:** are those defined from available geological information. The majority of resources in the region fall within this category. They have neither been evaluated by drilling or other sampling methods, nor had their technical properties characterised, on any systematic basis.

**Indicated resources:** are those in which there is a greater degree of geological assurance and the tonnage and grade are computed partially from specific measurements, in this case borehole data. Indicated resources only in areas assessed for sand and gravel by BGS resource surveys (Industrial Minerals Assessment Unit) and were defined by overburden to mineral ratios. In these areas, the possible extent of sand and gravel concealed beneath till and/ or other material is shown.

Users should note that, at the interface between areas surveyed at different levels of detail, apparent mismatches between mineral resource linework may occur (e.g. between indicated and inferred resources).

This digital information has been produced by collation and interpretation of mineral resource data principally held by the British Geological Survey. 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. The individual merits of the site must then be judged against other land-use planning issues. 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.

## 4.2 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 1$^{st}$ 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’ (or fine aggregate) for material that is finer than 4 mm, but coarser than 0.063 mm. For use in asphalt 2 mm is now taken as the break point between coarse and fine aggregate.

Sand and gravel deposits are accumulations of the more durable rock fragments and mineral grains, which have been derived from the weathering and erosion of hard rocks mainly by glacial and river action. The properties of gravel, and to a lesser extent sand, largely depend on the properties of the rocks from which they were derived. However, water action is an effective mechanism for wearing away weaker particles, as well as separating different size fractions. Most sand and gravel is composed of particles that are durable and rich in silica (flint, quartz and quartzite). Other rock types, mainly limestone, may also occur, including deleterious impurities such as mudstone, chalk and carbonaceous material.



The principal aggregate uses of sand are as fine aggregate in concrete, mortar and asphalt. The main use of gravel is as coarse aggregate in concrete. In 2002, approximately three quarters of all sand and gravel produced in the Yorkshire and Humber Region was for concrete production. Substantial quantities of sand and gravel may also be used for constructional fill.

The variability of sand and gravel deposits together with their possible concealment within or beneath till (boulder clay), means that it is more difficult to infer the location and likely extent of potentially workable resources from geological maps. This is particularly the case in Yorkshire and Humber, which has been subjected to a number of extensive glaciation events.

The properties which influence the economic potential of a sand and gravel deposit include:

- sand to gravel ratio;
- proportion of fines (< 63 μm) and oversize material;
- presence of deleterious rock types (such as coal, chalk or mudstone);
- thickness of deposit and overburden ratio;
- position of the water table;
- possible presence of unwanted interbedded material;
- the ease with which material can be processed to produce a saleable product (clay fines are more difficult to remove than silt); and
- location relative to demand.

## 4.3 CLASSIFICATION METHODOLOGY

The classification and refinement of the sand and gravel resources for the region was carried out in incremental stages. Figure 1 summarises the key steps and information used in the refinement process. Each progressive stage, with the addition of additional information, further reduces the area covered by resources. From the selection of the broad sand and gravel resources for the region to the refinement of these areas to identify areas potentially suitable for concreting aggregate, a 70 per cent reduction in resource area occurred (approximately). The sand and gravel resources selected for the Yorkshire and Humber Region are described in Section 3.4

**LEVEL 1: Identification of broad sand and gravel resources in Yorkshire and Humber**

Selection of all superficial sand and gravel resources from 1:50,000 scale BGS digital geological maps

Categorisation and refinement of selected resources using published materials and geologists knowledge, into standardised BGS sand and gravel categories

**LEVEL 2: Identification of resources potentially suitable for concreting aggregate**

Overlying and merging of Industrial Minerals Assessment Unit indicated sand and gravel resources with inferred resources identified in Level 1

Elimination of sand and gravel resources not suitable for concreting aggregate using (where available) deposit type, variability, grain size and clast composition

Overlying and intersection of available regional borehole information to refine areas of sub-alluvial resources. Use of 3D geological models for the Vale of York similarly.

**Figure 1 Key stages in sand and gravel resource selection and refinement**

## 4.4 SAND AND GRAVEL RESOURCES IN YORKSHIRE AND HUMBER REGION

The sand and gravel resources in the Yorkshire and Humber Region were primarily derived from the BGS digital dataset known as *DiGMap GB-50 Version 1* (1:50 000 scale), the digital superficial geology map data. Superficial sand and gravel resources were selected, extracted and refined using the resource geologist's expert knowledge and understanding of the area. The derived digital datasets for this project show the broad distribution of those sand and gravel mineral resources, which may be of current or potential economic interest.

The superficial or 'drift' sand and gravel deposits in the region occur in a number of different geological environments, each with different characteristics. The sand and gravel resources identified in the first stage (Stage 1) of this project can be broadly subdivided into river sand and gravel, sub-alluvial deposits, glaciofluvial deposits, glaciolacustrine deposits, blown sand, head gravel and beach sand and gravel. A brief overview summarising the key characteristics of each of these categories of sand and gravel is provided below. Further details on each resource type are also provided in Appendix B.

### 4.4.1 River sand and gravel

Resources of river sand and gravel take the form of extensive spreads of sand and gravel that occur in both raised river terrace sequences flanking the modern floodplains and in flood plain terrace associated with, and underlying, present day alluvium. River sand and gravel resources are reasonably consistent over considerable distances, their petrographic composition reflecting, in general, the geology of the countryside in which they are located.

River terrace deposits are best developed along the Rivers Trent, Ouse, Ancholme, Hull, Eau, Derwent in North Yorkshire, the rivers Wharfe, Aire, Calder in West Yorkshire, the River

Don in South Yorkshire and the rivers Swale, Nidd, Wharfe, Aire, Tees and Derwent in Humberside with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in post-glacial times. The pattern of these deposits was largely controlled by both the existing bedrock and newly formed glacial features and their variations in composition reflect their source material. The sand to gravel ratio of the river terrace deposits in the region varies greatly from up to 70 per cent sand in parts of the River Calder to 30 per cent sand in the River Swale, near Catterick. Up to 15 per cent silt and clay occurs in some deposits. In areas rich in Carboniferous-derived sediments, coal (carbonaceous) detritus, usually in the form of coarse sand-sized particles can comprise up to 1 per cent of the deposit. For further description of the deposits by county level see Annex A.

#### 4.4.2 Sub-alluvial deposits

Generally, only exposed sand and gravel is defined in the 1:50,000 geological linework, although sub-alluvial inferred resources of sand and gravel occurring beneath modern river flood plains may be extensive in some places.

#### 4.4.3 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, as elongate, irregular lenses within the till sequence and as terrace type deposits. Areas of wholly concealed, and thus unknown, bodies of sand and gravel may occur under spreads of till and other drift deposits. The Yorkshire and Humber Region was affected by at least three glaciations although evidence of earlier phases has largely been obliterated by the final, Devensian phase. Most of the pre-Devensian deposits have been removed or reworked and when present, comprise heavily dissected thin bodies of sandy gravels with a variable content of fines. Late Devensian glacial landforms and sediments dominate the region. The deposits vary considerably from fairly well sorted lenses and layers of pebble-free sand to gravel with a sand matrix. The ratio of sand to gravel varies from 75:25 near Rossington, to 50:50 at Finningley to 40:60 at Masham. The deposits often contain large pockets of silty material. In some areas, for example south of the Humber, the deposits contain an abundance of chalk and flint pebbles. The high chalk, shell and coal contents of some of these deposits, can restrict their use as concreting aggregate.

#### 4.4.4 Glaciolacustrine deposits

During the Devensian glaciation, ice occupying the present coastal zone of the Yorkshire and Humber Region 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. These deposits associated with Lake Humber were originally termed the ‘25-foot drift’ as they lie at an average height of about 25 feet OD, fill and conceal the former valleys and landscape. The deposits of the 25-foot drift are predominantly laminated clay and silt with fine to medium grade 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 passes 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. It is 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.

### 4.4.5 Blown Sand

These deposits are generally composed of fine- to medium-grained sand with a mean fines (<0.063 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. Appreciable thickness variations occur across short distances in these deposits due to its undulating top. Deposit thickness varied from 6 m to 0.3 m with general thickness less than 2 m. Blown Sand deposits are typically worked as a source of silica sand and for mortar sand production.

### 4.4.6 Head Gravels

These comprise gravelly deposits that have been involved in mass movement downslope to their present position. Such movement commonly takes place under cold climatic conditions when vegetation is sparse and frozen ground leads to increased run off. The gravel is commonly mixed with other lithologies present on the slope and so the resulting lithologies are very variable; most contain significant clay contents and are only suitable for working as ‘hoggin’. The clast composition reflects that of the parent material. The deposits often accumulate as lobes or fans, which are then dissected by subsequent down cutting.

### 4.4.7 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. In this region, however, with its long history of coastal changes and migrations, such deposits can also be identified up to 6 km inland from the present coastline. Along the coast from Holderness to Spurn Head the Shoreface Deposits consist mostly of sand and gravelly sand, with gravel dominating towards the top of the beach. At North Somercotes, Storm Beach and associated deposits are up to 9 m thick, composed of sand and shingle, with lag gravels set in a clay matrix, whilst at Spurn Head, up to 20 m of such deposits are recorded. These deposits reflect the long and complex history evolution of the coast in this region.

## 4.5 SAND AND GRAVEL RESOURCES POTENTIALLY SUITABLE FOR CONCRETING AGGREGATE

The second stage of the study involved identifying sand and gravel resources potentially suitable for concreting aggregate.

This desk assessment integrated a variety of disparate datasets and interpreted them with the guidance of the regional geologists expert knowledge. Such datasets included the twenty-one Industrial Minerals Assessments (IMAU) carried out in the region between 1976 and 1984, the extensive BGS borehole database (SOBI), memoirs, field notebooks from 1:10 000 mapping and other sources of published information relevant to the study. Where available, information on technical specifications such as grading curves etc aided the selection process.

Three categories of sand and gravel resources were selected as having characteristics suitable for use for potential concreting aggregate. They are:

1. River sand and gravel;
2. Glaciofluvial deposits; and
3. Sub-alluvial deposits.

### 4.5.1 River sand and gravel

River sand and gravel deposits are typically washed, clean, graded and consistent deposits of sand and gravel. They usually occur as deposits several metres in thickness and in most parts of Britain they area the preferred source of sand and gravel for concreting applications. The sand component is usually medium to coarse grained and ‘sharp’ in texture. The gravel component varies with the lithology of the source rocks.

In Yorkshire and Humber, river sand and gravel deposits are the most important deposit type in terms of concreting aggregate, followed closely by glaciofluvial deposits. Of all the sand and gravel deposit types in the region, the grading of river sand and gravel deposits is the most consistent and they usually contain a lower percentage of ‘fines’, that is silt and clay which passes the 63 micron sieve. These deposits also generally have a more uniform thickness. Normally the water table lies close to the surface in all but the high river terraces, so that most of the pits in these deposits are wet workings. The Swale, Ure, Wharfe and Calder are the main valleys exploited in Yorkshire.

### 4.5.2 Glaciofluvial deposit

Glaciofluvial deposits are more variable and are less predictable in thickness, composition and particle-size distribution than river sands and gravels. Glaciofluvial deposits often contain more fines (silt and clay) then river sand and gravel. They also frequently contain large amounts of over-sized material (cobbles, boulders) and in addition, may be interbedded with lenses or beds of silt and clay. However, they often occur in locally, thick units (over 10 m) and certain deposits are very important sources of sand and gravel.

### 4.5.3 Sub-alluvial sand and gravel

Large areas of Humberside, particularly in the flood plain of the Humber Estuary, across to the southern tip of North Yorkshire and extending down to South Yorkshire contain extensive spreads of alluvium (chiefly silt and clay). Sub-alluvial inferred resources of sand and gravel may occur beneath this material and in fact may be extensive in places. Their presence, however, can only be proved from borehole data.

The large areas of alluvium were reduced to exclude areas without potentially workable sand and gravel resources underneath the alluvium. This refinement process primarily relied on borehole information from the BGS corporate SOBI database. In addition, narrow (<200 m) spreads of sub-alluvial deposits were excluded from the dataset, as their limited width is likely to preclude economic working of any sand and gravel present.

Sub-alluvial sand and gravel resources are likely to be similar in lithology to river sand and gravel. Such resources would require wet-working.

### 4.6 SAND AND GRAVEL RESOURCES NOT SUITABLE FOR CONCRETING AGGREGATE

Glaciolacustrine, blown sand, beach and head gravels were eliminated as a potential resource for concreting aggregate. Both glaciolacustrine and blown sand deposits are too fine for the production of aggregate for concrete although small quantities can however be blended with coarser fractions as a filler in the production of concrete.

# 5 Constraints identification (Stage 2)

### 5.1 DEFINITION

Environmental constraints are defined as environmental and cultural assets that may need to be considered when planning for aggregates provision. For this reason environmental and planning constraints are numerous and diverse. They may include biodiversity, archaeology, landscape and nature conservation assets. Assets can be international, national, regional and local in importance. Planning constraints are defined as other relevant features that may need to be considered when planning for aggregates provision. For example, planning constraints may include residential areas and transport infrastructure.

### 5.2 IDENTIFICATION OF ENVIRONMENTAL AND PLANNING CONSTRAINTS

A summary of potential constraints is provided in the ‘Good Practice Guidance on the Environmental Appraisal of the Provision of Aggregates (ODPM, 2004) and the BGS report ‘Strategic Environmental Assessment (SEA) and future aggregates extraction in the East Midlands Region’ (Steadman et al, 2004). Many of these environmental and planning constraints are freely available digitally through third parties, others are not. Many of these can be viewed spatially and downloaded via the ‘magic’ online GIS (www.magic.gov.uk).

In consultation with the Assembly the environmental and planning constraints required for their in-house GIS were agreed (Table 4 and 5). The BGS provided contact details to the Assembly of where to obtain these digitally for use in their GIS. These same datasets were used to create the composite constraints map (Stage 3).

**Table 4 Potential environmental and cultural constraints**



| Potential environmental constraints & | Data provider |
|---|---|
| Agricultural land: Best & Most Versatile (BMV) | DEFRA |
| Ancient Woodland | English Nature |
| Area of Outstanding Natural Beauty | Countryside Agency |
| Community Forest | Countryside Agency/Forestry Commission |
| Doorstep Greens | |
| Groundwater Protection Zones | Environment Agency |
| Heritage Coast | |
| Local nature Reserves | |
| Millennium Greens | |
| National Nature Reserve | English Nature |
| National Park | Ordnance Survey |
| Ramsar Wetlands | English Nature |
| RSPB Important Bird areas (IBAS) | RSPB |
| RSPB Reserve | RSPB |
| Scheduled Ancient Monument | English Heritage |
| Site of Special Scientific Interest | English Nature |
| Special Protection Area | English Nature |
| Special Area of Conservation | English Nature |
| Woodland Trust Sites | Woodland Trust |

**Table 5 Potential planning constraints**

| Potential planning considerations | Data provider |
|---|---|
| Urban areas | Ordnance Survey |
| Transport infrastructure: Roads | Ordnance Survey |
| Transport infrastructure: Rail | Ordnance Survey |
| Wharves | BGS |
| Location of civil and military airports | BGS |
| 13 km buffer of civil and military airports | BGS |

# 6 Environmental and cultural assets composite layer (Stage 3)

Displaying the numerous and diverse environmental and cultural (assets) and planning constraints within a GIS makes for a very cluttered display, that is not easy to understand due to the overlapping nature of many constraints. The ODPM guidance suggests that 'the final map should be produced by determining which groupings of environmental constraints are most useful'. The BGS has developed a method that enables all the datasets to be integrated into a single composite layer so that a strategic overview of all the environmental constraints can be provided. This composite layer is called an 'environmental sensitivity layer'. The methodology is described in more detail below. Once the environmental sensitivity layer has been created the planning constraints can then be added separately.

## 6.1 DEFINITION

Environmental sensitivity layer is based on the number of environmental and cultural assets in a given location. The layer is analogous to a density map whereby the darker the colour on the map, the higher the number of environmental and cultural assets in that area. Environmental sensitivity indicates those areas that have high sensitivity compared to those that have lower sensitivity. Higher sensitivity does not mean an area will be unsuitable for development, just that there may be more to consider and more stakeholders to consult.

## 6.2 ENVIRONMENTAL SENSITIVITY METHODOLOGY

The environmental sensitivity layer was created in GIS using a one hectare grid resolution. Grids are commonly used in GIS and enable the analysis and generalisation of datasets. Each data layer was converted to a one hectare grid. Each hectare cell was given a value of one to denote the presence of an asset or a zero to denote its absence. The total number of assets in each one hectare grid cell was then calculated and converted to a graduated colour for display. The darker the colour on the environmental sensitivity layer the higher the number of assets at that location. Figure 2 shows the environmental sensitivity for the Region. Within the GIS the layer can be interrogated to determine which assets are at a given location.

**Image to be inserted. Too large for sending by email.**

**Figure 2 Environmental sensitivity mapping for the Yorkshire and Humber Region**

(note incomplete not all data layers included 17/09/2004)

## 6.3 FLEXIBILITY AND USES

The environmental sensitivity layer can be recalculated to display different groupings of assets as suggested in the ODPM guidance. For example, nature conservation assets could be calculated on a hectare basis for the region or heritage groupings could be calculated and displayed without the need to turn on or off numerous layers.

The Assembly can use the sensitivity layer to produce its resource and constraints map as outlined in the ODPM guidance. The environmental sensitivity layer provides a quick, visual, strategic overview of where there is likely to be more or less to consider (within the limitations of the data) in terms of the environmental and cultural assets in the Region. The aggregate resource layers developed in Stage 1 can be added to the GIS to enable the relationship between the two to be spatially analysed and understood.

### 6.4 LIMITATIONS



The environmental sensitivity layer can only use those assets that have been mapped or measured and are digitally available. Environmental sensitivity is dependent on the digital data it uses and the quality and accuracy of this may vary. It must be remembered that the data has been generalised by conversion to a grid in the GIS so does not depict exact boundaries. However as the Assembly has permission to use the original data this is not an issue.

# 7 Conclusions

- The sand and gravel resources identified in the first stage (Stage 1) of this project can be broadly subdivided into river sand and gravel, sub-alluvial deposits, glaciofluvial deposits, glaciolacustrine deposits, blown sand, head gravel and beach sand and gravel.
- Of these, river sand and gravel, glaciofluvial deposits and sub-alluvial deposits have the greatest potential for use as concreting aggregate.
- The key properties that influence the potential of a sand and gravel deposit for concreting aggregate include sand to gravel ratio, proportion of fines ($< 63\ \mu m$) and oversize material, presence of deleterious rock types (such as coal, chalk or mudstone) and thickness of deposit and overburden ratio.
- The resources identified as potentially suitable for concreting aggregate are divided into inferred and indicated resources reflecting differing degrees of geological assurance.
- It is critical to understand the limitations of the data and to understand that the areas outlined are not of uniform potential.
- 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.

# Appendix 1 Table of digital outputs



| Date Layer | Name | Comments | |
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Table of digital outputs. To be inserted on completion of digital products.

# Appendix 2 Sand and gravel resources of the Yorkshire and Humber Region

The Yorkshire and Humber Region has been divide into the following four geographical areas for ease of description:

1. **North Yorkshire:** comprising North Yorkshire, Yorkshire Dales and North York Moors National Parks and City of York;
2. **Humberside:** comprising the East Riding of Yorkshire & North & North East Lincolnshire and City of Kingston Upon Hull;
3. **South Yorkshire**: comprising the Metropolitan Boroughs of Barnsley, Doncaster and Rotherham and City of Sheffield; and
4. **West Yorkshire:** comprising the Metropolitan Boroughs of Bradford, Calderdale, Kirklees and Wakefield, and City of Leeds.

The sand and gravel resources identified in the first stage (Stage 1) of this project can be broadly subdivided into river sand and gravel, glaciofluvial deposits, glaciolacustrine deposits, blown sand, head gravel and beach sand and gravel. A brief overview of these deposits is provided n the main body of the report. This section provides details of each deposit type on a county basis.

## RIVER SAND AND GRAVEL

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.

In **North Yorkshire**, terrace deposits are best developed along the Rivers Trent, Ouse, Ancholme, Hull, Eau and Derwent with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in post - glacial times. River Terrace deposits *sensu stricto* are not widespread in the region, being localised to the upper reaches of the River Eau, south of Scunthorpe and on the banks of the Gypsey Race, west of Bridlington. The terrace deposits east of the Trent have been described as comprising mainly sand with a few scattered pebbles although some gravel is present at depth. The terrace rests on the silts and clays of the 25-foot drift of the Vale of York and continues under peat and alluvium. It is probable that further “terrace” deposits are buried under recent alluvium and warp in the lower reaches of these watercourses. Pebble lithologies include coal fragments, quartzites, sandstones and limestones.

Sub-alluvial gravels are encountered beneath the alluvium of the major valleys throughout the region. The extent of alluvium in this region has been modified in places by land management practices, including the construction of drainage channels and the deposition of Warp during periods of artificially controlled flooding. The deposits are compositionally similar to the river terrace deposits, indeed some are their downstream equivalents where they pass below OD. They were mainly laid down during periods of deep downcutting during the ultimate Devensian cold phase when sea-levels fell to at least -100 m OD. The subsequent rise in sea level enabled silting up of these river channels producing thick overlying alluvial deposits (silty clays, peat). The deposits rest on an irregular channelled surface and are thus of very variable thickness; locally 20 m of deposits are present (e.g. Trent and Ouse valleys), but they are commonly thinner, generally less than 4 m. These deposits are always saturated and require wet working.

In **West Yorkshire,** river terrace deposits are 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 post-glacial 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 12m above the present floodplain, whereas in the Aire valley, two terraces have been identified, occurring between 2 and 12m 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 % fines, 55 % sand and 33 % gravel. The sand fraction is mainly medium, angular to rounded quartz with lithic grains. The gravel fraction is predominantly medium with sub-rounded to sub-angular clasts of Carboniferous sandstone, which commonly forms more than 90% of the clasts. Minor amounts of siltstone, mudstone, chert, quartz, ironstone and coal together form the remaining 10%. 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 contains around 10 percent silt and clay, with a sand to gravel ratio of 70:30. Carboniferous sandstone is the dominant lithology with some shale and variable amounts of coal and carbonaceous material. The deposit is on average 4-5 m thick. At Grange Farm, although geologically similar, the deposit is significantly coarser with 60 percent gravel and 40 percent sand.

In **South Yorkshire**, terrace deposits are best developed along the River Don with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in post-glacial times. In the southwest, localised terrace deposits occur in the upper reaches of the Don between Sheffield and Rotherham and are predominantly sterilised by urban development. More extensive terrace deposits occur around Bentley at up to 12 m above OD. These deposits consist of sand, some of which is coarse grained, thin beds of fine gravel in which most of the pebbles are of Carboniferous rocks, and thin clay beds. Coal particles are present in the sand fraction. The deposits pass laterally into glaciolacustrine silt and clay deposits.

East of Doncaster, fluvial deposits of sand and gravel form extensive flattish spreads, commonly referred to as Older River Gravels. These deposits consist of beds, lenses and layers of both pebble-free sand and well-sorted fine to medium gravel with a sand matrix. There is a wide variation in the composition of the pebbles in the Older River Gravels, as shown in the inset map. Variations in composition show that the more northerly deposits, around Dunsville and Holme Wood, were derived from the west, presumably via the Don, with the predominant composition of the pebbles being Carboniferous sandstone. In areas rich in Carboniferous-derived materials, coal detritus, usually in the form of coarse sand sized particles can comprise up to 1% of the deposit.



The more southerly deposits were derived from farther south, via the River Idle and to a lesser extent the Torne. The predominant composition of the pebbles in these deposits is Triassic (Bunter) quartzite. Near Misson and Finningley, the deposits have an average grading of about 28% gravel, 59% sand and 13% fines. The pebbles are typically subrounded and comprise about 50% quartzite, 25% quartz and 15% sandstone, with minor amounts of limestone, mudstone, chert and igneous rock. Thin clay seams are present in the deposits but coal fragments are generally absent. The

Older River Gravels are worked at several sites in the Doncaster district, primarily in the Finningley area, for example at the Wroot Road Quarry and to the northeast of Doncaster for example, at Dunsville Quarry. At both Finningley and Austerfield Quarry, Older River Gravels were the original focus of extraction but have now been depleted. Current extraction at Finningley focuses on fluvioglacial deposits while extraction at Austerfield is now from on the underlying Sherwood Sandstone Group.

Sub-alluvial gravels are encountered beneath the alluvium of the major valleys throughout the region. The extent of alluvium in this region has been modified in places by land management practices, including the construction of drainage channels and the deposition of Warp during periods of artificially controlled flooding. The deposits are compositionally similar to the river terrace deposits, indeed some are their downstream equivalents where they pass below OD. They were mainly laid down during periods of deep downcutting during the ultimate Devensian cold phase when sea-levels fell to at least -100 m OD. The subsequent rise in sea level enabled silting up of these river channels producing thick overlying alluvial deposits (silty clays, peat). The deposits rest on an irregular channelled surface and are thus of very variable thickness. These deposits are always saturated and require wet working.

In **Humberside**, this sequence of deposits is best developed along the Rivers Swale, Nidd, Wharfe, Aire, Tees and Derwent with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in post - glacial times. The pattern of these deposits was largely controlled by both the existing bedrock and 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 percent gravel with the remainder mostly sand but with up to 15 per cent silt and clay in places. The deposit is up to 15 metres thick with the upper 5 metres worked dry and the remainder wet worked.

## 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 north 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 have been intersected. 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 and Knottingley. These deposits are compositionally distinguishable reflecting their source materials. Deposits occurring on the Coal Measures crop near Oulton and Rothwell, are dominated by Carboniferous sandstone clasts while on the Permian crop, dolomitic limestone accounts for over 90 % of the clast content. The deposits at Rothwell comprise an overall mean grading of 12 % fines, 44 % sand and 44 % gravel but are considerably variable, from very clayey sandy gravel to gravel. The gravel fraction is predominantly coarse with rounded to angular clasts of Carboniferous sandstone with subordinate chert and limestone. The sand fraction is mainly medium, 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, drift-filled channels, 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.

In **South Yorkshire**, glaciofluvial deposits occur in the east of the county, where they form elongate ridges and mounds capping the Doncaster and Rossington ridges and adjacent hills (see inset map below). These deposits have been described in detail in Mineral Assessment Reports No’s. 37 and 92 of the British Geological Survey and are shown on the map. The deposits comprise beds, lenses and layers of both pebble-free sand, and gravel with a sand matrix. They are fairly well sorted, though a few cobbles and a few small boulders are present. The deposits rest mainly on Sherwood Sandstone and transgress locally over clay till and glacial channel deposits.

**Schematic map showing the variation in composition of the pebbles in the Older River Gravels around Doncaster**

The glaciofluvial deposits near Rossington have an average grading of 24% gravel, 65% sand and 11% fines, although the formation varies laterally and vertically from a pebble-free sand to a sandy gravel. The pebbles are usually subrounded and comprise about 60% quartzite, 20% quartz and 15% sandstone, with minor amounts of limestone, chert and igneous rock. The Rossington Ridge deposits are thought to be derived from the Sherwood Sandstone Group in Nottinghamshire and the northern Midlands. These deposits are worked at Finningley Quarry where approximately 300,000 tonnes of aggregate is extracted per annum. The deposit contains around 6 percent silt and clay, with an equal ratio of sand to gravel ratio of 50:50. The deposit is variable with pockets of silty material which are though to represent small lake features. The pebbles in the gravel fraction comprise predominantly vein quartz and quartzite.

The more northerly Doncaster Ridge deposits differ in composition in their absence of pebbles of limestone, chert, and igneous rock. These deposits, almost exclusively covered by urban development, were derived from the Coal Measures to the west.

In **Humberside**, the most extensive deposits in the area occur between the western limit of the chalk crop and the east coast and from Bridlington in the north to Waltham in the south.

The distribution of these deposits is strongly controlled by topography as they occupy the floor and lower slopes of valleys draining the Wolds, northeastwards towards the former ice front. In the Humber area these deposits include the Kelsey Hill Beds, a sequence of brown, coarse-grained sands and gravels characterised by an abundant and diverse fossil fauna, of both marine and freshwater molluscs. The sand and gravel are inter-bedded with silts and clays, occasionally laminated, together with sheets of till and have a total thickness of about 15 m. The Kelsey Hill Beds are worked at Mill Hill, near Keyingham where a 4.5 m thick bed is extracted to produce washed sand and gravel for use in general construction. Here pebble lithologies are very variable, including quartzite, flint, chalk, Carboniferous and Jurassic limestones and sandstones, dolerite and other igneous and metamorphic rocks.

The deposits around Pocklington form the Pocklington Gravel Formation, and these gravels contain an abundance of chalk and flint pebbles, with some Jurassic limestones and in one place a large amount of ironstone pebbles (ca.10%). Average clast composition is 75% well-rounded chalk, 15% sub-angular flint, plus 10% accessory lithologies. The deposit is about 1 m thick on average.  South of the Humber, significant deposits of glaciofluvial sand and gravel occur between Habrough and Laceby, where up to 15 m of well sorted sand with interbedded chalk and flint gravels overlie tills. The high chalk, shell and coal contents of some of these deposits may restrict their use as concreting aggregate.

Between Winteringham and Winterton, glaciofluvial deposits form elongate ridges and mounds on top of till, and up to 7 m of well sorted gravel, composed mainly of chalk with minor flint and sandstone pebbles, is reported from an old pit.

In **North Yorkshire**, extensive spreads of these deposits occur in the mid and lower reaches of the Esk, Urr ,Swale, Ouse, Wharfe, Nidd and Aire valleys. Some of these deposits are form broadly rounded and elongate ridge’s which overlie and clearly postdate the till and older glacial sand and gravels, and 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 limestone. 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 gravely, 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 by the occurrence at Marfield Quarry, on the River Ure near Masham, where up to 15 meters 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.

**Glaciolacustrine Deposits**

During the 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.

In **Humberside,** deposits associated with this glacial lake, occur in the west and south, west of the Chalk crop.  An extensive area of glaciolacustrine deposits occurs to the west of Pocklington, running down to the Humber at North Ferriby and across into the Ancholme Valley. These deposits, originally termed the ‘25-foot drift’ as they lie at an average height of about 25 feet OD, 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 consist 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 also 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.

In **West Yorkshire**, glacial lake 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 coarse 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.

In **North Yorkshire,** on the western limit of the northern extension of Lake Humber, glaciofluvial deposits occur in close association with glaciolacustrine deposits, laid down by glacial meltwaters. These deposits occur as fans comprising coarse sand and gravel with sand, silt and clay deposited in more distal parts into Lake Humber. South of Newby Wiske these 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 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 metres thick in places although other deposits in the Thirsk area, e.g. between Topcliffe and Brafferton, reach 22 metres in thickness.

## 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. In North Yorkshire, extensive amounts of blown sand occur to the northeast of York, southeast of Richmond and around Stokesley. Near Thirsk, the sand is red-brown-yellow in colour and well sorted, although the deposits are generally less than 2 metres thick.

In **Humberside**, aeolian deposits include the Beighton Sands Formation. Thickness is very variable, with up to 6 m being recorded around Messingham and Fonaby but generally thickness is less than 2 m, with extensive areas of sand less than 0.3 m thick. In this area the Blown Sand deposits are mainly worked as a source of silica sand around Messingham (see above) and at Haxey for mortar sand production.

Blown Sand also occurs along the coast south of Grimsby and Cleethorpes and at Spurn Head. These deposits are largely Recent in age, resulting from aeolian reworking of adjacent dry beaches. Deposits are generally thin, mostly less than 2 m, but locally up to 5 m thick and occur mainly as dunes but also as thin linear spreads of sand.



In **South Yorkshire**, blown sand deposits occur in the east and are largely concealed beneath peat and alluvium. The most extensive blown sand deposits crop out on the flanks of Thorne Moor, Hatfield Moor and south of Finningley. Extensive deposits of sand, which rest in turn on glaciolacustrine silt and clay, also extend under the peat and alluvium of Thorne Moor and adjacent areas. This concealed sand varies from 0 to 3 m in thickness, with appreciable thickness variations across short distances due to its undulating top.

# Appendix 3 Glossary

**Aggregate:** Particles of rock which, when brought together in a bound or unbound condition, form part or whole of a building or civil engineering structure.

**Alluvium:** A general term for unconsolidated detrital material such as clay, silt, sand and gravel, deposited by rivers and streams as sorted or semi-sorted sediment in the stream-bed or on the floodplain.

**Asphalt:** A natural or artificial material in which bitumen is associated with a substantial proportion of mineral matter.

**Boulder clay:** A glacial deposit consisting of sub-angular pebbles and boulders of all sizes embedded in stiff or hard reworked clay or rock flour. The term ‘till’ is preferable because it covers the wide range of lithologies included here and does not imply the presence of either boulders or true clay.

**Building sand**: Sand with a grading suitable for use in mortars.

**Carboniferous:** The geological period of time (360 to 286 Ma B.PP.) and the corresponding system of rocks, which in Britain contains Carboniferous Limestone, an important source of crushed rock aggregate, and the ‘Coal Measures’.

**Chert:** Microcrystalline rock comprising quartz and, sometimes, chalcedony, a cryptocrystalline variety of silica.

**Clast:** A rock fragment; commonly applied to a fragment of pre-existing rock included in a younger sediment.

**Constraint:** Any environmental and cultural assets that may need to be considered when planning for aggregates provision (for example National Nature Reserves, Scheduled Ancient Monuments, Agricultural Land).

**Cryptocrystalline:** Very finely crystalline material in which the crystals are so small as to be indistinguishable except under powerful magnification.

**Cultural asset:** Cultural feature that society places a value on.

**Deposit:** Indicates a mineral occurrence of some significance but which is not closely defined.

**Devensian**: The most recent glacial stage of the Quaternary period in Britain, beginning about 20,000 years ago.

**Dolerite:** A dark coloured, fine to medium grained igneous rock of basic composition (that is without free quartz), found in intrusions of moderate size so allowing moderately rapid cooling of the magma.

**Environmental asset:** Environmental feature that society places a value on.

**Environmental sensitivity:** The number of environmental and cultural assets in a given location compared to another location.

**Fines:** Material finer than 60 microns, i.e. the silt and clay-sized fraction, but in connection with aggregates it usually refers to material finer than 75 microns.

**Flint**: Variety of chart occurring in the chalk of northern Europe.

**Fluvial:** Relating to a river; a deposit produced by the action of a river.

**Glaciofluvial:** May be applied to sediment transported and deposited by running water discharged from an ice mass.

**Glacial deposits**: Heterogeneous material transported by glaciers or icebergs and deposited directly on land or in the sea without sorting of the constituents

**Grade:** Size sorting category in which all the particles fall within specified size limits.

**Grading**: The proportions of different sizes present in aggregate, established by sieve analysis; particle size distribution.

**Granite:** Generally, any completely crystalline quartz-bearing plutonic rock with light-coloured feldspar and mica minerals as essential components.

**Gravel**: Granular material between 4 and 80 mm; coarse aggregate. Used for general and concrete applications.

**Igneous**: Describes a rock or mineral that solidified from molten or partly molten material.

**Ironstone:** Imprecise term but usually denoting an impure iron carbonate occurring as modules in some clays.

**Lacustrine**: Relating to materials formed in or by lakes.

**Limestone:** A sedimentary rock composed mainly of calcium carbonate occurring as the mineral calcite.

**Lithology:** The general characteristics of a rock

**Mineral:** A naturally formed chemical element or compound and normally having a characteristic crystal form and a definite composition.

**Mineral deposit:** Generally synonymous with mineral resources but usually applied to a readily identifiable mineral body i.e. more geographically or spatially confined.

**Mortar:** A mixture of cement, water and fine aggregate, usually sand, and may contain lime. Mortar is used for brick and blockwork and for plastering and rendering.

**Mudstone:** Fine-grained clay-rich sedimentary rock.

**Outcrop:** The area over which a particular rock unit occurs at the surface, whether visibly exposed or not.

**Overburden:** Waste rock, either loose or consolidated, overlying a mineral deposit, which must be removed prior to extraction.

**Planning constraint:** Any relevant features that may need to be considered when planning for aggregates provision (for example roads, residential areas).

**Quartz:** Crystalline silica; an important durable rock-forming mineral.

**Quarry:** An open-pit mining operation.

**Quaternary**: The latest era of geological time, from 2 Ma B.P. to the present, largely represented in Britain by superficial deposits such as glacial drift.

**Recent:** The current epoch in the earth's history, comprising the 10,000 years or so since the end of the last glaciation.

**Reserve:** That part of a mineral resource that is economical to work and has been fully evaluated on a systematic basis by drilling and sampling and is free from legal or other obstruction that might inhibit extraction.

**Resource:** Natural accumulations of minerals, or bodies of rock, that are or may become of potential economic interest as a basis for the extraction of a commodity.

**Sand**: A granular material that is finer than 4 mm, but coarser than 0.063 mm.

**Sandstone:** A sedimentary rock made of abundant fragments of sand size set in a fine-grained matrix or cementing material. The sand particles are usually of quartz.

**Sedimentary rock:** A rock resulting from the consolidation of loose sediment that has accumulated in layers, or a chemical rock formed by precipitation or an organic rock consisting largely of the remains of plants and animals.

**Shale**: Fine-grained clay-rich sedimentary rock with pronounced lamination.

**Silt**: A deposit which has the average grain size between that of sand and clay.

**Sorted:** Referring to size distribution of unconsolidated sediments, e.g. sands, gravels etc, size separation having taken place naturally.

**Sorted, well:** Having a relatively narrow size distribution free of coarse particles and fine clays.

**Sorted, poorly:** Having a relatively wide size distribution.

**Superficial deposit:** Deposits formed on or close to the present land surface by processes (e.g. glaciation) usually of Quaternary age. Their distribution and thickness are related essentially to the surface relief and not to the structure of the underlying bedrock.

**Till:** Unstratified, unsorted drift deposited directly by a glacier without reworking by water from the glacier; comprises a heterogeneous mixture of clay, sand, gravel and boulders.