Provision of Geological Information and a Revision of Mineral Consultation Areas for Staffordshire County Council

Economic Minerals Programme
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Provision of Geological Information and a Revision of Mineral Consultation Areas for Staffordshire County Council

E J Bee, D M Minchin, D Bridge and D E Highley.

Contributor/editor

F M McEvoy & A J Bloodworth

Bibliographical reference


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Foreword

This report presents the findings of commissioned work conducted by the British Geological Survey (BGS) on behalf of Staffordshire County Council. Staffordshire County Council licensed the digital mineral resource data displayed on the BGS County series map for Staffordshire held by the British Geological Survey. This information was used and further refined by geological experts and industry in order to define Mineral Safeguarding Areas and Mineral Consultation Areas for Staffordshire County Council.

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Ms F McEvoy (BGS),
Mr M Griffin (Staffordshire County Council),
Mr T Billings (Staffordshire County Council).

BGS literature has been used to supplement this report. This includes the BGS report on Industrial Minerals, Issues for Planning., Bloodworth, A. J et al. (2004) and the Mineral Resource Information for Development Plans Staffordshire: resources and constraints. Highley, D. E and Cameron D. L (1995) published report. The use of BGS interim reports to the Department of Communities and Local Government (DCLG) for the Aggregate Levy Sustainability Fund (ALSF) project Safeguarding Aggregates and the environment is also acknowledged.
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Summary

This report describes work carried out by the British Geological Survey on behalf of Staffordshire County Council to assist in the review of the Staffordshire and Stoke-on-Trent Minerals Local Plan (1994 –2006). The work involved the provision of maps showing the extent of individual mineral resources in the county and more importantly, it also involved creating Minerals Safeguarding Areas and updating Mineral Consultation Areas for each mineral resource. These were provided in digital form for use within a geographical information system.
1 Introduction

Staffordshire County Council is in the process of reviewing the Staffordshire and Stoke-on-Trent Minerals Local Plan 1994 - 2006. This review is in accordance with reforms to the planning system under the Planning and Compulsory Purchase Act 2004 and specifically, guidance within Planning Policy Statement (PPS) 12: Local Development Frameworks (ODPM, 2004).

The Local Development Framework comprises local development documents, which include development plan documents. The Local Development Framework, together with the Regional Spatial Strategy, provides the essential framework for planning in a local planning authority’s area. The key development plan documents are:

- Core strategy;
- Site specific allocations;
- Adopted proposals map; and
- Area action plans;

Each Mineral Planning Authority (MPA) is required to prepare development plan documents to form a mineral and waste development framework for their area. A minerals core strategy development plan document “should take account of the need to contribute appropriately to national, regional and local requirements at acceptable social, environmental and economic costs”(ODPM, 2004a). An adopted proposals map must be also included in the Minerals and Waste Development Framework and in particular, Minerals Consultation Areas (MCAs) will need to be shown on the adopted proposal map indicating where there are significant mineral resources subject to safeguarding policies.(ODPM 2004a).

In two tier Planning Authority areas, such as Staffordshire, district planning authorities must also include on their adopted proposals map, minerals matters including MCAs and areas allocated for future mineral extraction which are adopted in a development plan document by the MPA.

Staffordshire County Council commissioned the British Geological Survey (BGS) to carry out a revision of its MCAs to assist in the review of its Minerals Local Plan. The unitary authority area of the City of Stoke on Trent was not included in this work.

The following mineral resources were identified for inclusion in this review.

- Sand & gravel
- Limestone
- Brick clay - Etruria Formation (‘Etruria Marl’)
- Gypsum/ anhydrite
- Silica sand
- Coal and associated fireclay
- Shale used for cement manufacture
- Building stone
The first part of the review was to define the extent of the listed mineral resources within Staffordshire County Council MPA. This involved using the BGS mineral resource digital data, based upon the *Mineral Resource Information for Development Plans Staffordshire: resources and constraints* (Highley, D. E and Cameron D. L. 1995) published report. This information was re-examined by regional and economic geologists at the BGS and their revisions are included in this review. Industry was consulted regarding the delineated Mineral Safeguarding Areas (MSAs) and MCAs. The delineation of MCAs forms the second part of this review.

1.1 PROJECT OBJECTIVES

The objectives of the project were to:

1. Provide mineral resource maps for the Staffordshire County Council MPA area. These are based on BGS geological line work, but amended where appropriate based on information obtained from regional geologist input and consultation with industry. This will allow for the delineation of MSAs as described in section 2.1.

2. Provide MCAs to be incorporated in district authorities proposal maps. These will be based on the MSAs, but will incorporate criteria determined in consultation with industry and Staffordshire County Council.

2 Mineral Safeguarding

2.1 DEFINITION OF A MINERAL SAFEGUARDING AREA (MSA)

At the time of writing, the former Office of the Deputy Prime Minister (ODPM), now the Department for Communities and Local Government (DCLG) are funding a project through the Aggregate Levy Sustainability Fund (ALSF). This eighteen-month project titled, *Safeguarding Aggregates and the environment* is being undertaken by the BGS in partnership with Somerset County Council, Durham County Council and Mineral Resource Planning Associates. The project objective is to provide DCLG with recommendations to ensure the effective safeguarding of the nation’s mineral resources. The general conclusions from the projects interim report are that Draft Mineral Policy Statement 1 (MPS1) is not clear enough about the importance of safeguarding mineral resources or the mechanism for safeguarding them.

The project recommends there be more emphasis on defining mineral safeguarding, rather than just consultation, areas and as such, proposes a new planning term ‘Mineral Safeguarding Areas’ (MSAs). MSAs, unlike MCAs, will be relevant in all MPAs including two-tier authorities, unitary authorities and National Park authorities. To ensure that MSAs are effective and of value, it also recommends that MSAs should be based upon or include the following criteria:

- Should be resource wide, based primarily on nationally available, and thereby consistent datasets, with additional data provided by industry where available;
- Should safeguard mineral resources for the long term;
- Be identified for all economic minerals because principles of sustainability apply to all natural resources;
- Be as extensive as is practical, reflecting longer term safeguarding, and detailed discussions with industry, and consultation with other stakeholders;
- Be defined irrespective of other designations;
• Have no presumption for extraction;
• Be defined in all planning authority areas and clearly shown in the core strategy as well as proposals maps and in the relevant Local Development Framework and/or Minerals Development Framework.

2.2 DEFINITION OF A MINERAL CONSULTATION AREA (MCA)

The delineation of MCAs within a MPA is currently the only mineral safeguarding mechanism proposed in current planning guidance. The process is described in Mineral Planning Guidance 1 (MPG1). Draft Mineral Policy Statement 1 (MPS1), which will replace MPG1 over the coming months, states that MCAs should be defined to ensure that “valuable resources for future use are protected from non-mineral development”. The guidance document associated with MPS1 states “MCAs provide the mechanism for district councils to consult county councils before granting permission on any planning applications they receive, for developments which fall within the boundary of a MCA, and which would be likely to affect the winning and working of minerals” (ODPM 2004b).

The MCA is in essence a planning tool, enabling land use planners within the MPA to consider the value of the mineral resource identified against the benefits and impact of proposed development. MCAs do not imply a presumption for mineral extraction, nor should they be considered as being related to Preferred Areas or Areas of Search.

3 Identifying Mineral Safeguarding Areas

3.1 MINERAL RESOURCE CLASSIFICATION

Mineral resources are natural concentrations of minerals which might now, or in the foreseeable future, be of economic value. The identification and delineation of mineral resources is imprecise as it is limited by the quantity and quality of data currently available and involves predicting what might or might not become economic to work in the future. The pattern of demand for minerals is continually evolving due to changing economic, technical and environmental factors. The economic potential of mineral resources is not static, but it changes with time.

3.2 DATA QUALITY

The mineral resource maps are derived from geological linework forming part of the national 1:50 000 scale digital coverage DiGMapGB-50 from the British Geological Survey (BGS). This dataset is based on surveys carried at 6-inch or 1:10 000 scales, and acquired at different times (Figure 1). Whilst every effort has been made to ensure consistency of approach across the county, the level of detail reflects in part the age of the mapping, with more recent surveys placing greater emphasis on subdivision and characterisation of the superficial deposits. Hence, some rationalisation has been necessary to accommodate different eras of mapping.

3.3 OVERVIEW OF THE MINERAL RESOURCES IN STAFFORDSHIRE

The mineral resources of Staffordshire reflect the complex geological history of the area over the last 340 million years. These events have produced a wide range of rock types of potential economic interest, mainly sedimentary, either exposed at the surface or found at relatively shallow depth beneath a cover of younger sedimentary rocks, including superficial (unconsolidated) deposits. These sediments were laid down under a variety of environmental and climatic conditions very different from those existing in the area today. Following deposition, the
sediments were altered by hardening and compaction and now form the major part of the mineral resources in the county. Unconsolidated cover comes from the geologically recent action of ice and rivers on the environment depositing sand and gravel, which make up the remainder of the resources.

Historically, rocks of Carboniferous age, particularly the Coal Measures found in the exposed coalfields and the outcrops of Carboniferous limestone, were of major economic importance. These rocks provided coal, iron (from ‘Blackband’ ironstones), lime and a wide variety of clays which laid the foundations of important local industries such as iron and steel, brick and of course, the pottery industry.

During the last half of the 20th century, however, mineral production changed, with a marked shift away from coal, iron and lime, to an increasing demand for raw materials for construction use. This is now the dominant sector of the mineral industry in the county. Carboniferous limestones are extensively worked for aggregates and cement manufacture. The Triassic Sherwood Sandstone is a major regional resource of sand and gravel for aggregate as, to a lesser extent, are the river gravels.

### Quantities of minerals quarried in Staffordshire, 2004

**Source**: Annual Minerals Raised Inquiry 2004, by the Office of National Statistics Business Monitor PA1007

- **Sand and gravel**: 5761
- **Limestone**: 326
- **Brick clay**: 2017
- **Cement shale**: 912
- **Fire clay**: 25

Note: Values for Building stone, Gypsum and Silica sand are not included due to confidentiality agreements under The Statistics of Trade Act 1947.

**Figure 1: Quantities of minerals quarried in Staffordshire, 2004**

Approximately 64% of quarrying activity in Staffordshire is sand and gravel for use in the construction industry. A further 22% of activity is limestone quarrying, of which about half is used as aggregate while the remainder goes into cement production. The remainder of mineral production in Staffordshire is focussed towards extraction of clay for brick making, although the county is also an important producer of silica sand and gypsum/anhydrite and has potential to extract opencast coal.
Although sand and gravel is the most important mineral produced in the county in terms of quantities extracted, other minerals are also important at regional and national scales. For example, limestone from the Cauldon district of north east Staffordshire supplied 12% of the nation’s cement in 2004, due to the geological proximity of high purity limestone to shales of suitable quality for cement. (Table 1). Staffordshire also has the largest output of clay and shale in Britain. The Etruria Formation is the principal clay resource in Staffordshire and one of the most important in Britain.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Staffordshire production</th>
<th>Regional production</th>
<th>% of regional supply</th>
<th>National production</th>
<th>% of national supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand and Gravel</td>
<td>5761</td>
<td>9401</td>
<td>61.3%</td>
<td>86057</td>
<td>6.7%</td>
</tr>
<tr>
<td>Limestone</td>
<td>2017</td>
<td>2903</td>
<td>69.5%</td>
<td>86846</td>
<td>2.3%</td>
</tr>
<tr>
<td>(of which cement)</td>
<td>1147</td>
<td>1147</td>
<td>100.0%</td>
<td>9474</td>
<td>12.1%</td>
</tr>
<tr>
<td>Brick Clay</td>
<td>912</td>
<td>2130</td>
<td>42.8%</td>
<td>7629</td>
<td>12.0%</td>
</tr>
<tr>
<td>Cement Shale</td>
<td>326</td>
<td>326</td>
<td>100.0%</td>
<td>1910</td>
<td>17.1%</td>
</tr>
<tr>
<td>Fire clay</td>
<td>25</td>
<td>86</td>
<td>29.1%</td>
<td>402</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

Table 1: Mineral supply from Staffordshire to the West Midlands region and nationally. (Thousand Tonnes)


3.4 CONSULTATION WITH INDUSTRY

The guidance note to Mineral Planning Statement 1 (Draft), paragraph 30 states that “MPAs should seek advice from the minerals industries operating in their areas when they are considering the delineation of MCAs.” (ODPM 2004b).

The identification and delineation of mineral resources changes with time and is dependant on economic influences, advances in technology and environmental factors. Consultation with industry was therefore fundamental at all stages of the MSA and MCA delineation process. Commercial operators often have the best local knowledge about the quality and viability of working geological formations which may be considered resources.

Consultation was conducted by BGS by email, telephone and where agreeable, by on-site meetings. The BGS contacted a number of key mineral operators within Staffordshire, who kindly agreed to comment upon the mineral resource areas identified by BGS and discuss criteria for the delineation of MSAs and MCAs. This additional information enabled BGS to supplement their existing mineral resource linework to provide more up-to-date information to Staffordshire County Council. Table 2 shows the operators who took part in the consultation and the associated mineral resource.
Table 2: List of the operators who took part in consultation exercise.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Mineral Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibstock Brick</td>
<td>Brick clay</td>
</tr>
<tr>
<td>Lafarge Cement</td>
<td>Limestone/ shale</td>
</tr>
<tr>
<td>WBB Minerals</td>
<td>Silica sand</td>
</tr>
<tr>
<td>British Gypsum</td>
<td>Gypsum/ anhydrite</td>
</tr>
<tr>
<td>Tarmac Ltd</td>
<td>Sand &amp; gravel</td>
</tr>
<tr>
<td>Baggeridge Brick</td>
<td>Brick clay</td>
</tr>
</tbody>
</table>

Comments received during the consultation exercise have been included in the text describing the mineral resource maps in section 3. Other comments obtained through consultation relating to the criteria for delineating MCAs are noted in section 4.

3.5 SAND AND GRAVEL RESOURCES

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 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, river 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 (quartz, quartzite and flint). Other rock types, mainly limestone, may occur locally, including deleterious impurities such as mudstone and coal.

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. Substantial quantities of sand and gravel may also be used for constructional fill. In the West Midlands about 80% of the total sand and gravel production is used as concrete aggregate. Mortar (building) sand and constructional fill are the other most important applications.

Sand and gravel resources are divided into two broad categories:

- **Superficial deposits** of Quaternary age
- **Bedrock deposits** comprising conglomerates within the Triassic Sherwood Sandstone Group, formerly known as the 'Bunter Pebble Beds'

This division reflects the distinctly different forms of the deposits, their likely workable extent and yields, their particle size and need for processing, and thus their relative importance as aggregate resources.

**SUPERFICIAL DEPOSITS**

The separation of the superficial resources into two subdivisions, as shown in Figure 2, reflects differences in the mode of occurrence of the deposits and, to some extent, their likely particle-size distribution.

**River gravels**

The most extensive and widely worked deposits are river gravels associated with the rivers Trent and Tame. On the resource map a distinction is drawn between three mapped divisions:
• river alluvium,
• river terrace deposits and
• glaciofluvial sheet deposits.

The river alluvium in the valley floors comprises silts, clays and peats, which conceal coarser channel lag sands and gravels. River terraces are well developed on the flanks of the larger valleys and are the principal sand and gravel resource. Other terrace-like spreads, classified as glaciofluvial deposits, occur within the upper reaches of the modern valley systems or at elevations higher than the river terraces. Many of these were deposited by glacial meltwaters draining a melting ice sheet. Where they clearly form part of the modern valley drainage system, they are included in the River Gravel category.

The combined thickness of the River Gravel deposits rarely exceed 10 m, with 4–8 m being typical for the River Trent gravels, but thinner elsewhere. The deposits are likely to be relatively consistent in thickness and composition locally, but different depositional conditions, caused by such factors as changing valley shape and stream confluences, can cause considerable variation.

The composition of the river gravels varies across the county. In the west and centre, gravels are likely to be dominated by quartzite pebbles derived from the Sherwood Sandstone Group; in the north they will contain a significant content of limestone fragments derived from the Carboniferous limestone uplands. Farther east, flint pebbles are incorporated from the erosion of glacial deposits.

Glaciofluvial deposits

In addition to the river terrace glaciofluvial deposits described in the previous section, more restricted deposits of sand and gravel, also of glacial origin, are present at surface over much of the county. Glaciofluvial sands and gravels deposits were associated with glacial action and laid down by the glacial meltwaters issuing from, or flowing on top, within and beneath, ice sheets and glaciers. The deposits are commonly associated with till (boulder clay), and may exhibit complex relationships, occurring as sheet or delta-like layers above till deposits, or as elongate, irregular lenses within the till sequence. Bodies of wholly concealed, and thus unknown, sand and gravel may occur under spreads of till. As a result, the distribution of glaciofluvial deposits is less predictable in geographical extent than river sand and gravel deposits.

Glaciofluvial deposits may also exhibit considerable lateral variations in thickness, composition and particle size distribution, generally contain more fines (silt and clay) and frequently contain a larger amount of over-sized materials. The essential feature of these deposits, critical in terms of their economic value, is their variation in both thickness and composition. In general, these deposits are likely to be less than 10 m thick but thicknesses of over 30 m have been reported where infilling hollows and channels scoured into the underlying rock surface. However, overburden thicknesses can also be high. As Britain has been subjected to several periods of glaciation, their distribution is complex. Due to the complex nature of these units and their consequent limiting economic potential, deposits with an outcrop area less than 1 ha have been omitted from the resource map. Glacial deposits have been worked in the past to provide construction sand and gravel, principally for local use. Small-scale production continues in the south–west of the county.

BEDROCK DEPOSITS

Staffordshire is one of the few counties in England that has important resources of bedrock gravel consisting of loosely bound, sandy pebble beds (conglomerates) of Triassic age that are a major source of concrete aggregate. In extraction, the proportion of gravel to sand is of prime
importance and where devoid of pebbles the formation is of limited value as an aggregate resource.

Bedrock deposits of sand and gravel are mainly confined to the conglomerate members of the Kidderminster Formation (which is part of the Sherwood Sandstone Group), although other units have been worked locally in the past. The resource extent is shown in Figure 3. In general, the gravel fraction, comprising poorly-cemented beds of well-rounded quartzite pebbles and cobbles in a fine-grained sand matrix, is a very important resource of coarse aggregate for concrete, when processed by crushing and screening. Matrix sand can be blended with coarse ‘sand’ derived from crushing the pebbles to meet specifications for concreting, building and asphalting sand.

3.5.1 Comments after consultation

The sand and gravel resource map shown in Figure 4 is based upon the BGS’s geological information and expertise. The resultant resource map was used in the consultation exercise with representatives from Tarmac. As a result of this consultation, no significant changes were made to the resource linework. Some quarries do hold more detailed site-specific information, but only relating to their working areas. Alluvium filled channels less than 25 m wide have been removed from the map as they were considered to be uneconomical in extent to work. Similarly, fluvioglacial deposits covering less than 10 ha have been removed. Industry was in agreement with these amendments.

3.6 LIMESTONE

Limestone is a sedimentary rock composed principally of calcium carbonate, occurring as the mineral calcite (CaCO$_3$). With an increase in magnesium carbonate content (MgCO$_3$) limestone grades into dolomite [CaMg(CO$_3$)$_2$] or, more correctly, dolostone. The economic importance of limestone is based mainly on thickness, extent, strength and consistency and the location of outcrops with respect to major centres of demand. Limestones of Carboniferous age are economically the most important. Limestone is an important source of crushed rock aggregate. It is also an essential raw material for cement manufacture. Some limestones are also highly valued for their chemical purity (>97% CaCO$_3$) and are used for a wide range of industrial applications, as well as a source of agricultural lime. However, the industrial uses of limestone account for a small (4%) and decreasing proportion of total output in Britain. Their important industrial uses include iron and steelmaking, glassmaking, numerous chemical processes and for filler applications. Some uses require lime (CaO), which involves burning limestone in kilns to remove carbon dioxide and to produce a more reactive product.

Figure 5 shows the distribution of limestone resources in Staffordshire. The limestones are of Carboniferous age and form the southern part of a much larger limestone outcrop in the Peak District. Limestones of Carboniferous age are of considerable national importance and are quarried extensively in England and Wales for a range of construction and industrial uses. They are both the principal source of limestone and of crushed rock aggregate in Britain. Carboniferous limestones commonly occur in thick consistent beds that are easy to quarry. They usually produce strong, durable, low porosity aggregate materials.

Limestone deposits in Staffordshire can be divided into two broad categories, depending on the environment in which they were deposited.

- Shelf limestones - pale-coloured, massive, shallow-water limestones, which are uniform over wide areas.

- Off-shelf limestones - dark-coloured, well-bedded, deeper-water limestones which are more variable in character, commonly contain chert nodules, and include interbedded mudstones.
This division reflects the resource potential of the limestones. The shelf limestones are a major source of aggregates and also of limestone for cement manufacture. In contrast, the off-shelf limestones are predominantly of low chemical purity and, therefore, of limited value for industrial uses.

3.6.1 Comments after consultation

Limestone is extracted for use as aggregate and is one of the raw ingredients of cement. 12% of the nation’s cement is produced in Staffordshire (ONS 2004) and the resources of the Kevin Limestone Formation and Milldale Limestone Formation in the Cauldon area are of high regional importance. Planning permissions for active quarries in this area date back to 1947 and until the 1990s were believed to contain sufficient reserves for 200 years of extraction. However, an increasing number of constraints to working, such as the discovery of a cave system under Cauldon Low, have more than halved reserve estimates.

Given the high demand for limestone aggregates both within the county and in the East and West Midlands, industry is concerned that sufficient reserves of limestone are safeguarded for future generations. It is believed that the best way to safeguard resources to allow future extraction to continue in an environmentally acceptable manner would be to safeguard the entire resource of the Kevin, Milldale, Hopedale and Ecton limestones. These limestones were therefore incorporated in the mineral resource map shown in Figure 5.

3.7 SHALE FOR CEMENT MANUFACTURE

12% of the UK’s cement is produced in Staffordshire (ONS 2004) and the limestone and shale resources to the north east of the county are of high regional importance. The manufacture of Portland cement requires raw materials that contain four main components; lime, silica, alumina and iron oxides. Limestone, or chalk, is the main source of lime (CaO) and typically accounts for 80–90% of the raw mix. Clay or mudstone accounts for some 10–15% and provides most of the silica, alumina and iron oxides.

Resources of clay and mudstone suitable for cement manufacture are widespread and normally obtained from quarries adjacent to cement plants. The limiting factor regarding the use of shale in cement manufacture is transportation costs to deliver the shale to the cement plant.

3.7.1 Comments after consultation

Through consultation with industry, the BGS increased the limits of the cement shale resource boundary from 1 km to 5 km from the limestone. As costs relating to the obtaining of planning permission, mitigation of environmental effects and the freehold purchase of land or mineral rights has increased, the relative importance of transport costs has decreased. Shale from environmentally acceptable sources will now be transported greater distances to the cement plant than would have been economic in the past. Therefore suitable shale units that can be found within 5 km of the limestone resource can be considered as a resource. These refinements are included in the resource map shown in Figure 5.

3.8 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 produced from both loosely consolidated sand deposits and by crushing weakly cemented sandstones. Unlike construction sands, which are used for their physical properties alone, silica sands are valued for both their chemical and physical properties and it is on a combination of properties that their industrial applications are based. These include a high silica content in the form of quartz and, more importantly, an absence 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 and specific uses, demanding different combinations of properties. Consequently different grades of silica sand are not usually interchangeable. Consistency of quality is also of critical importance.

Depending on the end use of a silica sand, processing is of varying degrees of complexity and often requires a high capital investment in plant. A critical factor in defining a sand or sandstone deposit as a silica sand resource is the ease with which contaminants, such as iron-bearing impurities and clay can be removed, together with the level of losses incurred in removing coarse and very fine fractions to obtain the desired size distribution. Resources of silica sand occur in only limited areas and the special characteristics of silica sand extraction and, in particular, the cost of processing means that the industry has a restricted distribution. Silica sands command a higher price than construction sand, which allows them to serve a wider geographical market, including exports.

Silica sands are essential raw materials for glassmaking and foundry casting, but also have a wide range of other industrial and horticultural applications, such as in ceramics and chemicals manufacture and for water filtration purposes. Silica sand has been worked from two geological horizons in Staffordshire, the Rough Rock Sandstone of the Carboniferous Triassic (Millstone Grit) in the north and the Wildmoor Formation of the Sherwood Sandstone Group in the south. The Rough Rock Sandstone is generally thick and is actively exploited. The silica sand of the Wildmoor Formation, however, is no longer regarded as an economically important source of silica sand and is therefore not shown on the resource map in Figure 6.

Current reserves of silica sand are running low in Staffordshire, quarries are approaching the limit of what can be produced from current sites and operators will be looking to develop new locations in the future. The location of future silica sand production in the county is uncertain. The resource map shows the Rough Rock Formation outcrop and shows the interrupted nature of exposures of the potential silica sand resource in Staffordshire. 60% of exposures are less than 5 ha in size and only 14% of the outcrops have areas greater than 25 ha. The map also shows that many exposures are long and thin. This often makes them difficult and uneconomical to work. Two quarries currently work the Rough Rock Formation for silica sand in Staffordshire; Moneystone (WBB Minerals) and Hurst (Biddulph Sands). Both these workings occur on outcrops greater than 50 ha and in close proximity to other outcrops.

3.8.1 Comments after consultation

The BGS originally designated a cut-off point for the extent of silica sand resources of Rough Rock Formation as 50 ha. However, consultation with industry showed that even in areas where Rough Rock outcrop was 25 ha or smaller the formation should still be considered as a resource. Sub-crop of the Rough Rock Formation beneath the Pennine Lower Coal Measures could potentially be economically worked in a number of areas subject to appropriate drilling and assessment.

Mineral Planning Guidance 15, paragraph 53 specifically refers to silica sand as a scarce national resource warranting safeguarding. It states “Silica sand is a scarce resource and MPAs should, as far as possible and in cooperation with other planning authorities, safeguard deposits which are, or may become, of economic importance, against other types of development or other constraints which would be a serious hindrance to their extraction” (DoE 1996).

Given the scarcity and consequent value of the resource, the entire Rough Rock Formation at outcrop has been included as a resource and is shown in Figure 6.
3.9 GYPSUM/ ANHYDRITE

Gypsum (CaSO₄·2H₂O) and anhydrite (CaSO₄) are, respectively, the hydrated and anhydrous forms of calcium sulphate. The former is economically the most important. They occur in nature as beds originally deposited by the evaporation of seawater, but are also derived as by-products 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% gypsum) than most natural gypsum (80%). The amount of natural gypsum extracted in Britain has declined appreciably in recent years due to the availability of substantial amounts of desulphogypsum derived from FGD plants.

In nature, gypsum and anhydrite normally occur as beds or nodular masses up to a few metres thick. Gypsum is formed by the hydration of anhydrite at or near surface, but passes into anhydrite generally at depths greater than 40-50 m, although this depends on local conditions. Anhydrite is, therefore, very much more extensive than gypsum.

When gypsum is ground to a powder and heated at 150° to 165°C, three-quarters of its combined water content is removed to produce hemi-hydrate plaster (CaSO₄·1/2 H₂O), commonly known as ‘Plaster of Paris.’ When this powder is mixed with water the resulting paste will set hard as a result of the water recombining to produce gypsum again. The most important applications of gypsum are, therefore, in the production of plaster and plasterboard and the mineral forms the basis of a large industry producing a range of building products. In contrast anhydrite has more limited uses but large quantities of a mixture of gypsum/anhydrite are used as a retarder in the manufacture of cement.

Staffordshire is one of the few areas in Britain where gypsum/anhydrite is produced. Production is confined to the Fauld Mine, near Tutbury. The output at the mine is now used entirely in the manufacture of cement and consequently material that has a significant proportion of anhydrite is being sought. The resource consists of a single bed (the Tutbury Gypsum) up to 2m thick, which occurs in the upper part of the Triassic Mercia Mudstone Group. It is worked underground using pillar and stall mining which does not normally cause subsidence at the surface. The Gypsum/Anhydrite resource in Staffordshire is shown in Figure 7.

3.9.1 Comments after consultation

Through consultation with British Gypsum, the sole operator of gypsum mines in Staffordshire, it is apparent that due consideration must be given to the long term future of gypsum extraction in the county and that the entire of the known resource must be safeguarded. Gypsum is currently extracted from a single, underground mine at the eastern end of the resource. This mine is slowly developing westward, following a bed that contains a high proportion of anyhdrite. East of the mine the gypsum appears to have largely been removed by dissolution and therefore unlikely to be worked. This area has been removed from the recommended MSA. The Tutbury Gypsum extends over a large area to the west of the mine and whilst its quality is variable, its subsurface extent has been included within the MSA. It is possible that future market demands may necessitate the sinking of a new adit to access the western end of the resource.

3.10 BRICK CLAY

Brick clay is the term used to describe ‘common clay and shale’ and fireclay used in the manufacture of structural clay products, such as facing and engineering bricks, pavers, clay tiles for roofing and cladding, and vitrified clay pipes. Clay and shale may also be used in cement making, as a source of constructional fill, for lining and sealing landfill sites and, rarely, for the manufacture of lightweight aggregate. The Carboniferous Etruria Formation is the principal brick clay resource in Staffordshire. The importance of safeguarding the Etruria Formation is recognised in the Staffordshire and Stoke on Trent Minerals Local Plan (1994 – 2006) by the
designation of the Etruria Formation as a safeguarding area in order to provide a higher level of protection in the planning process than the MCA. The term Mineral Safeguard Area within the Staffordshire and Stoke on Trent Minerals Local Plan (1994 – 2006) referred to areas which “for reasons of scarcity and/or development pressure and/or economic and locational importance, the protection of minerals from the threat of sterilisation by built or other forms of development are seen as a very important planning consideration.” This term should not be confused with the MSA term used within this project. MSAs identify safeguarding areas for all economic minerals because principles of sustainability apply to all natural resources and are described further in section 2.1.

**Etruria Formation**

Staffordshire has the largest output of clay and shale in Britain, production being some 912 thousand tonnes in 2004. The Etruria Formation is the principal clay resource in Staffordshire and one of the most important in Britain. It forms the basis of an extensive brick and tile industry in the Stoke-on-Trent area, in the area to the south of Cannock and near Tamworth. The bulk mineralogy of the clay, i.e. the relative proportions of disordered kaolinite, illite, quartz and iron oxides, and the low levels of impurities, such as carbon, sulphur, soluble salts and, except locally, calcite, makes it suitable for the manufacture of high strength and low water absorption heavy clayware, including high-quality facing and engineering bricks, pavers, and roofing and floor tiles. The characteristically high, but variable, iron content of the Etruria Formation allows the production of a wide range of fired colours. The extent of the Etruria Formation at outcrop is shown in Figure 8. The formation is known to be time-transgressive, being of different ages in different areas. For this reason alone it is unlikely that its mineralogical composition and suitability for brickmaking will be uniform across the whole outcrop.

The outcrop south of Cannock has been extensively exploited and the scope for further development in this area is more limited than Figure 8 would suggest due to structural complexities that have yet to be fully resolved.

### 3.10.1 Comments after consultation

The Etruria Marl mineral safeguard areas in the Staffordshire and Stoke on Trent Mineral Local Plan 1994 - 2006 were designated to cover the entire resource except for those covered by houses, roads or greater than 4 m of overburden (superficial deposits such as glacial till or alluvium). As the pressure on remaining brick clay resources increases, and technology improves, the depth of overburden that can be economically removed to extract the mineral resource increases. After consultation with industry, it was decided that the whole Etruria Formation outcrop should be considered as resource, regardless of the depth of cover. In certain circumstances, industry thought it may also be economical to remove overlying bedrock in order to extract the Etruria Formation, and that this should be taken into considered when determining the areas to safeguard.

### 3.10.2 Generating Brick clay resource map with downdip extension

The resource map in Figure 9 shows the Etruria Formation brick clay resource at outcrop, but also where the interpreted down dip continuation of the resource could be feasible for working based on industry consultation and geological expertise. The down dip extension for each of the outcrop areas was considered and evaluated based on the overlying geology. Many of the areas, such as the area near Hawks Green in the Heath Hayes region, are considered to be faulted and consequently no resource extends beyond the outcrop line. Where there is potentially down dip continuation, a 100 m buffer has been applied to the resource. This assumes that the average angle of dip is 15° and thus takes no consideration of the topography. The downdip extension dataset was used in the creation of the resultant MSA.
3.11 SHALLOW COALS WITH ASSOCIATED FIRECLAYS

Fireclays are non-marine, sedimentary clays consisting essentially of kaolinite, mica and quartz in varying proportions. Fireclays commonly underlie coal seams and the two minerals are normally produced together. The occurrence of fireclays as relatively thin, widely-spaced beds in close association with coal seams also means that surface coal mining operations provide one of the few viable sources of the clay. Fireclay resources are, therefore, with few exceptions, largely coincident with shallow coal resources that are suitable for extraction by surface mining.

In Staffordshire fireclay resources have, therefore, been defined as coincident with shallow coal resources. Areas of primary shallow coal, within which the coal seams are relatively thick and closely spaced, and are therefore the main target for open cast coal extraction have been defined. These areas are thought to contain the best prospects for shallow coal mining and also, by association, fireclay. However, significant areas have already been worked by shallow mining and the coal and fireclay in these will have been removed. For completeness, areas of secondary shallow coal have also been defined in Figure 8. The secondary resource area represents the area which contain open cast coal resources, but in which the coals are generally thinner and less concentrated in vertical and areal distribution.

Fireclays may exhibit relatively low iron contents compared with other clays and are used in the manufacture of buff-coloured facing bricks. It is likely that most fireclays exposed during surface coal mining would be unsuitable for this use because of the presence of impurities, notably iron and carbon. Their suitability for brick manufacture can only be determined after detailed ceramic testing. Coal Measure Mudstones are also associated with coal-bearing strata.

In the Potteries Coalfield, mudstones within the Coal Measures have in the past been extensively used in brick manufacture, and were until recently, at Birchenwood. Similarly, at Kingsley in the Cheadle Coalfield, Coal Measures mudstones were worked for brick manufacture but are now produced for industrial applications.

Whilst a wide range of clays may be used in brick manufacture, modern brickmaking technology is highly dependent on raw materials with consistent and predictable firing characteristics. The suitability of Coal Measures mudstones and fireclays for brick manufacture depends, in part, on their carbon and sulphur contents. Both may lead to firing problems (black coring), and sulphur may also give unacceptable emission levels. In general, carbon and sulphur levels should be less than 1.5 % and 0.2 % respectively, although the ease with which carbon burns out, and blending, may permit some tolerance in these figures. Blending of different clays to give a range of fired colours and aesthetic qualities is an increasingly common feature of the brick industry.

3.11.1 Comments after consultation

In the absence of detailed information on the firing characteristics of Coal Measure fireclays, Figure 8 only indicates the location of the principal primary and secondary shallow coal resources. A more focused assessment will be required to assess whether the fireclays meet a particular specification.

3.12 BUILDING STONE

Natural stone is the traditional building material of Britain and the built environment is perhaps the most visible aspect of our cultural heritage. Production and usage of natural stone has declined since the high point of the industry in the late 19th Century, largely because of competition from cheaper alternatives, such as brick and concrete. However, more recently there has been an increase in interest in natural stone and the prospects for the industry remain buoyant.

A number of formations have historically been worked as building stone in Staffordshire, these include; limestones of the Carboniferous Limestone Group, sandstone outcrops of Millstone Grit
Group, including the Chatsworth Grit, Cheddleton Sandstone, Minn Sandstone and Rough Rock, various sandstones of the Pennine Coal Measures Group, such as the Halesowen Formation and Keele Formation, formations of the Warwickshire Group and well indurated members of the Sherwood Sandstone Group. These formations are shown in figure 10.

3.12.1 Comments after consultation

Although other formations (as shown in Figure 10) may need to be worked in the future in order to restore historic buildings or for characterisation of new builds and extensions to older houses, it is believed that the only building stone resource that needs to be safeguarded for long term commercial extraction is the Hollington Formation. This is the only building stone resource included on the final resource map shown in Figure 11.

3.13 MINERAL SAFEGUARDING AREAS

In order to safeguard a resource in its entirety, and to account for the inexact nature of mapped geological boundaries a buffer can be applied to the resource outline. The use of a buffer can also restrict developments that lie outside the MSA, infringing on the potential winning of resources within the MSA because of close proximity. It can help separate conflicting land uses, such as mineral extraction and housing, and can be planned for in the designation of MSAs. In Wales, The Welsh Assembly Government writes in Minerals Technical Advice Note (Wales) 1: Aggregates (March 2004) that a buffer of 100 m should be adequate around sand and gravel operations and 200 m should be adequate for hard rock operations where blasting takes place. However, no comparable guidance is given in England.

In Staffordshire a 150 m buffer is used for MCAs developed in conjunction with the current Minerals Local Plan. This buffer aimed to protect residents from the noise and dust created by quarrying (Staffordshire County Council 1999) whilst safeguarding the minerals resource. However no consideration is given for the different levels of noise and dust generated by different quarrying methods. Consultation with members of industry in Staffordshire revealed that the quarrying techniques employed to extract different minerals require different stand off limits to protect nearby residents. For example, Limestone as a hard rock resource, generally requires drilling and blasting with explosives before the mineral can be extracted for processing. Quarry operators within the Limestone resource area in Staffordshire currently use a 500 m standoff from residential dwellings when blasting, in order to prevent adverse problems caused by vibration. In contrast, brick clays are generally worked on a smaller scale, using mobile plant and with no need for blasting. This means the standoff distance can be substantially less than those required for aggregate.

This project, through consultation with industry and Staffordshire County Council, agreed that the following minimum buffer limits to the mineral resources in Staffordshire would be used to create the MSAs. These are designed to help protect the mineral resource from sterilisation.

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Resource</th>
<th>Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Rock (generally requires blasting)</td>
<td>Limestone.</td>
<td>500 m</td>
</tr>
<tr>
<td>Soft Rock (requires no blasting)</td>
<td>Sand and Gravel, Coal and Fire clay, Silica sand, Cement shale, Building stone.</td>
<td>250 m</td>
</tr>
<tr>
<td>Clay (uses small excavators)</td>
<td>Brick clay.</td>
<td>50 m</td>
</tr>
<tr>
<td>Underground gypsum mining</td>
<td>Gypsum</td>
<td>0 m</td>
</tr>
</tbody>
</table>

Table 3: Buffer sizes to use for deriving MSAs for each mineral resources.
The use of buffering to help safeguard minerals in the creation of MSAs, created a dataset that crossed county boundaries in some places. The resultant MSA dataset was clipped to the extent of the county. The MSAs for Staffordshire County Council MPA are shown in Figure 12.

4 Delineating Mineral Consultation Areas

4.1 METHODOLOGY

This section of the report describes the process for delineating the MCAs for Staffordshire County Council MPA. The resultant MCAs (shown in Figure 13) will be used by the district authorities and will determine when they should consult with the MPA with regard to a proposed development. The MCAs have been created using the MSA data, which was derived from BGS linework and regional geologist expertise, and through consultation with industry.

4.1.1 Urban areas

Staffordshire County Council MPA required an urban area dataset in order to remove urban areas from within the MSAs to derive MCAs for use by district authorities. For practical reasons, the MPA does not wish to be burdened with an influx of consultations from the district authorities, which may, for example, only constitute an application for a detached development especially when a mineral resource within an urban area is unlikely to be worked because of sterilisation.

Two existing digital (vector) urban area datasets were considered for use in this project. The first was the ODPM’s (now DCLG) 2001 Urban Settlements (previously called Urban Areas) which defines all settlements above 20 ha where the land use is urban in character extracted from the Ordnance Survey (OS) 1:10,000 scale maps. The second was the OS Strategi urban areas dataset (2002) based on mapping at 1:250,000. It was felt that both datasets were too old and in the case of Strategi, too coarse scale, to fully realise urban development that may have taken place in more recent years. The use of OS MasterMap to define urban areas was therefore proposed and the following methodology was derived to capture urban clusters by conducting research and through discussion with Staffordshire County Council.

1. Select all buildings (feature code 10021) from OS MasterMap within a 5 km buffer of the MPA. This ensures that any urban area continuing over MPA boundaries are included in the analysis.
2. Buffer all buildings by 50 m to generate clusters.
3. Dissolve buildings to formulate the clusters where buildings are within 100 m of each other. Note: dissolving may have to be built up using dissolved small subsets and then merged together.
4. Infill interior polygons.
5. Remove buffer effect from the building clusters by using a negative buffer (-25 m). This leaves a 25m buffer around the edge of the outermost buildings to allow for detached development.
6. Extract those polygons that are greater than 200 ha in size to define urban area.

OS MasterMap is the UK Ordnance Surveys flagship large-scale vector dataset. It is comprised of the following nine themes: land area classifications; buildings; roads, tracks and paths; rail; water; terrain and height; heritage and antiquities; structures; and administrative boundaries. Mastermap does not, however, differentiate between urban and rural buildings.
It should be noted that OS MasterMap® is an immensely large dataset and requires much processing power. The final dataset compares well against the ODPM's 2001 Urban Settlements dataset but the derived dataset incorporates the more recent housing developments. The dataset has the following limitations:

- All buildings were considered in the analysis, irrespective of type. This therefore included buildings such as farmhouses, power stations and retail outlets.
- Rivers may separate an urban area into two parts. This may have the undesired effect of not identifying a town, which actually is greater than 20 ha in size, but split across a river, with one or both halves being less than 20 ha in size.
- Interior open spaces which could be used for mineral working e.g. golf courses, recreational grounds, urban parks, will be included in the building clusters polygon.

4.1.2 Current and previously worked planning permissions

Staffordshire County Council decided that current and previously worked areas should be removed from the MCAs on the basis that the MPA does not wish to be burdened with an influx of unnecessary consultations from the district authorities for other development within areas in which the mineral has already been worked. For the purpose of this project, Staffordshire County Council supplied BGS with an updated digital data set showing the mining site area within previously worked planning permissions and current planning permissions. Refusals, licensed underground working areas and other sites that were never worked, were not included in the dataset.

Any MCA polygons that were more than 500m from an existing permitted site and were less than 5 ha in size were removed from the MCA dataset. Staffordshire County Council deemed these to be impractical to implement and potentially uneconomical to work on their own.

5 Data delivery

Paper maps and Adobe PDF documents were provided to Staffordshire County Council showing the mineral resources, MSAs and MCAs within the MPA. ESRI shapefiles delineating the MSAs and MCAs for use in a GIS were also supplied to Staffordshire County Council. The project also processed a licence for Staffordshire County Council to use the licensable BGS mineral resource linework for the county.

6 Conclusions

This study has provided Staffordshire County Council with a clearly defined and delineated set of MSAs and MCAs. The MCAs remain practical to implement, applying criteria to help reduce the amount of potentially unnecessary consultation from district authorities. The project has followed recommendations and guidance, where possible, from the ALSF project titled, Safeguarding Aggregates and the environment is being undertaken by the BGS in partnership with Somerset County Council, Durham County Council and Mineral Resource Planning Associates. The study has also provided the thoughts and suggestions of Staffordshire County Council in relation to MCAs to the ASLF funded project for consideration.
References

Many of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.


Appendix 1  Map Figures
FIGURE 1
Indication of geological sheet age and quality covering Staffordshire
FIGURE 2
Superficial sand and gravel resources of Staffordshire with permitted sites

SAND AND GRAVEL
- **Sub-alluvial deposits**
- **River terrace deposits**
- **Glaciofluvial sand and gravel deposits**
- **Sand and gravel quarries**
FIGURE 3
Bedrock sand resources of Staffordshire with permitted sites

BEDROCK SAND

- Bedrock sand deposits: Triassic Sherwood Sandstone
- Bedrock sand quarries
FIGURE 4
Sand and gravel resources of Staffordshire with permitted sites

SAND AND GRAVEL

- Sub-alluvial deposits
- River terrace deposits
- Glaciofluvial sand and gravel deposits
- Triassic Sherwood Sandstone
- Bedrock deposits
- Sand and gravel quarries

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LIMESTONE
- Limestone
- High purity limestone

CEMENT SHALE
- Cement shale
- Limestone/Cement shale quarry

FIGURE 5
Limestone resources of Staffordshire with permitted sites
FIGURE 6
Silica sand resources of Staffordshire with permitted sites

SILICA SAND

- Outcrop area of Rough Rock Formation
- Silica Sand quarries
FIGURE 8
Clay resources of Staffordshire with permitted sites

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CLAY

Brick Clay
- Outcrop area of Etruria Formation: Principal clay resource
- Fireclay coincident with shallow coal resource

Primary shallow coal resource
Secondary shallow coal resource
Brick clay pits and brickworks
FIGURE 9
Brick clay resources of Staffordshire showing down dip extension and permitted sites

Outcrop area of Etruria Formation: Principal clay resource
Down dip extension of brick clay resource
Brick clay pits and brickworks
FIGURE 10
Building Stone resources of Staffordshire with permitted sites

BUILDING STONE

- Tarporley Siltstone
- Hollington Sandstone Formation
- Bromsgrove Sandstone Formation
- Wildmoor Sandstone
- Halesowen Formation
- Rough Rock
- Pennine Coal Measures Sandstone
- Rough Rock
- Chatsworth Grit
- Minn Sandstones
- Cheddleton Sandstone

Building stone quarries

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FIGURE 11
Hollington Sandstone resources of Staffordshire with permitted sites

BUILDING STONE

- Hollington Sandstone Formation
- Building stone quarries
MINERAL SAFEGUARDING AREAS

- Bedrock sand
- Brick clay
- Building stone
- Cement shale
- Fireclay
- Gypsum
- Limestone
- Silica sand
- Superficial sand and gravel
FIGURE 13
Mineral Consultation Areas in Staffordshire

MINERAL CONSULTATION AREAS
- Bedrock sand
- Brick clay
- Building stone
- Cement shale
- Fireclay
- Gypsum
- Limestone
- Silica sand
- Superficial sand and gravel