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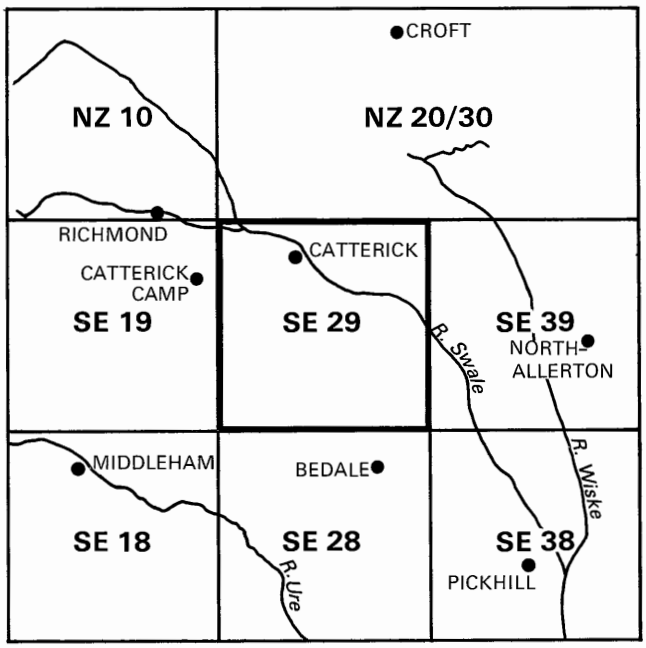


# The sand and gravel resources of the country around Catterick, North Yorkshire

## Description of 1:25 000 sheet SE 29

J. H. Lovell



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The first twelve reports on the assessment of British sand and gravel resources appeared in the Report Series of the Institute of Geological Sciences as a subseries. Report No. 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

Details of published reports appear at the end of this Report.

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## PREFACE

National resources of many industrial minerals may seem so large that stocktaking appears unnecessary, but the demand for minerals and for land for all purposes is intensifying and it has become increasingly clear in recent years that regional assessments of the resources of these minerals should be undertaken. The publication of information about the quantity and quality of deposits over large areas is intended to provide a comprehensive factual background against which planning decisions can be made.

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding the most urgent attention, initially in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. Following a short feasibility project, initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys in 1968. The work is now being financed by the Department of the Environment and is being undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report describes the sand and gravel resources of the country around Catterick, North Yorkshire. The survey was conducted by Mr J. H. Lovell, with some assistance in the drilling programme by Mr R. G. Crofts and Mr D. Thomas. The work is based on six-inch scale geological surveys: the whole of the district was surveyed at this scale by Gunn, Cameron and Lucas between 1854 and 1878; the eastern part was resurveyed by Dr. D. V. Frost, Mr J. G. O. Smart and Mr J. R. Davies in 1978-80.

Mr W. N. Pierce (Land Agent) was responsible for negotiating access to land for drilling. The ready cooperation of landowners, tenants and sand and gravel operators in this work is gratefully acknowledged.

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CONTENTS



**FIGURES**



**MAP**



**TABLES**

# The sand and gravel resources of the country around Catterick, North Yorkshire

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## SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information, and 53 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of the sand and gravel resources of the country around Catterick, North Yorkshire.

All the deposits in the district that might be potentially workable for sand and gravel have been investigated and a simple statistical method has been used to estimate the volume. The reliability of the volume estimates is given at the symmetrical 95 per cent probability level.

The mineral-bearing ground is divided into four resource blocks, containing between 11.2 and 15.1 $km^2$ of sand and gravel. For each block the geology of the deposits is described, and the mineral-bearing area, the mean thickness of overburden and mineral and the mean gradings of the mineral are stated. Detailed borehole data are also given. The geology, the position of the boreholes and the outlines of the resource blocks are shown on the accompanying map.


### Notes

Each borehole registered with the Institute is identified by a four-element code (e.g. SE 29 SE 25). The first two elements define the 10-km square (of the National Grid) in which the borehole is situated; the third element defines a quadrant of that square, and the fourth is the accession number of the borehole. In the text of the report the borehole is normally referred to by the last two elements alone (e.g. SE 25).

All National Grid references in this publication lie within the 100-km square SE unless otherwise stated. Grid references are given to eight figures, accurate to within 10 m, or to six figures for more extensive locations such as farms and quarries.


### Bibliographical reference

LOVELL, J. H. 1982. The sand and gravel resources of the country around Catterick, North Yorkshire. Description of 1:25 000 resource sheet SE 29. **Miner. Assess. Rep. Inst. Geol. Sci.**, No. 120.



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## INTRODUCTION

The survey is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, neither the economic nor the social factors used to decide whether a deposit may be workable in the future can be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher-grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability, which this survey seeks to provide, will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974).

The survey provides information at the 'indicated' level "for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout" (Bureau of Mines and Geological Survey, 1948, p. 15).

It follows that the whereabouts of reserves must still be established and their size and quality proved by the customary detailed exploration and evaluation undertaken by the industry. However, the information provided by this survey should assist in the selection of the best targets for such further work. The following arbitrary physical criteria have been adopted:

a The deposit should average at least 1 m in thickness.
b The ratio of overburden to sand and gravel should be no more than 3:1.
c The proportion of fines (particles passing a 0.063 mm (about $\frac{1}{16}$ mm) mesh B.S. sieve) should not exceed 40 per cent.
d The deposit should lie within 25 m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18 m if no sand and gravel has been proved.

A deposit of sand and gravel that broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

Pre-Pleistocene rocks, which are usually consolidated and devoid of potentially workable sand and gravel, are referred to as 'bedrock'; 'waste' is any material other than bedrock or mineral; 'overburden' is waste that occurs between the surface and an underlying body of mineral.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm, 64 mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and sand, and between sand and gravel grade material, are placed at $\frac{1}{16}$ mm and 4 mm respectively (see Appendix C).

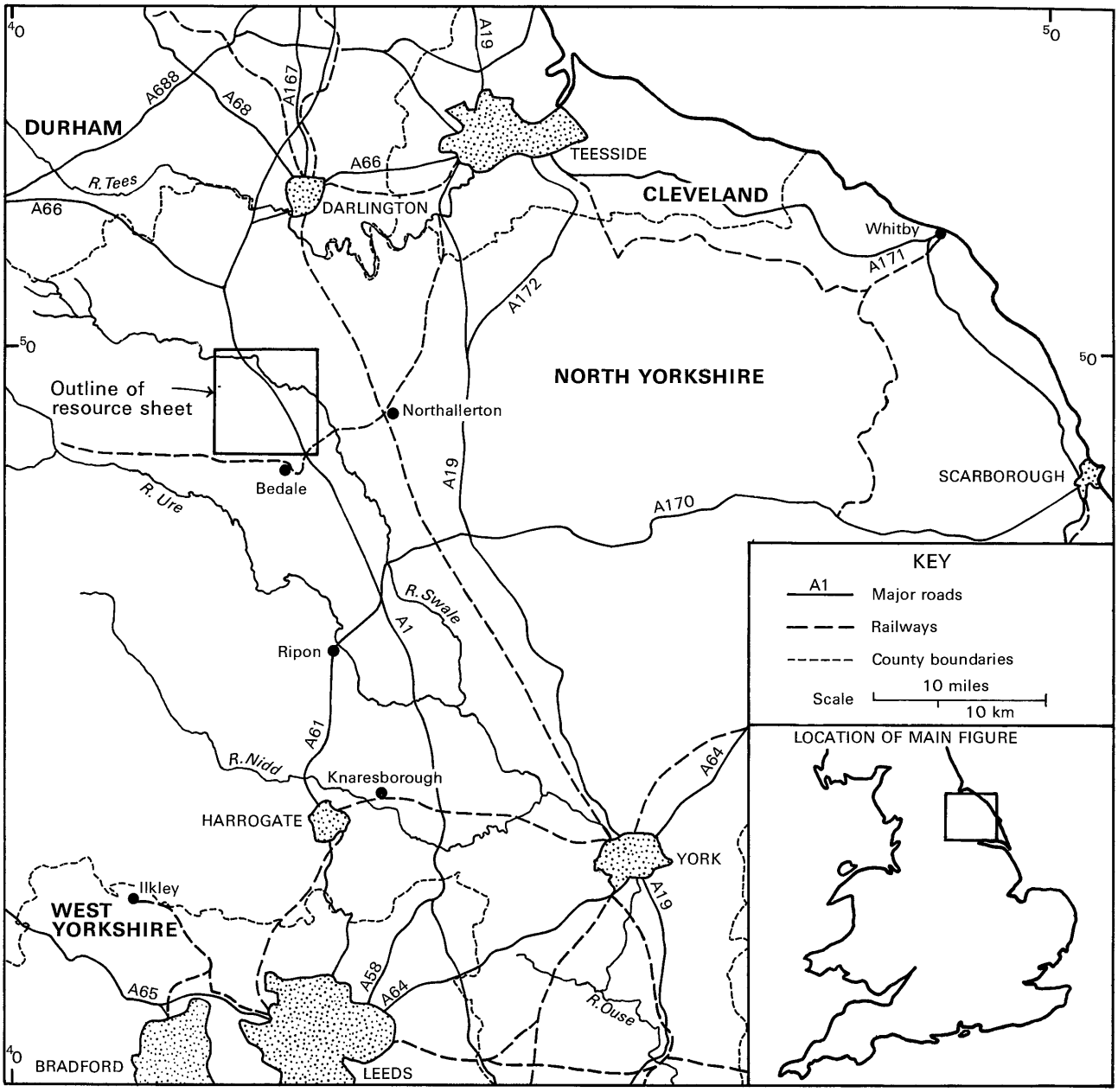



**Figure 1** Sketch map showing the location of the district.

The volume and other characteristics are assessed within resource blocks, each of which, ideally, contains approximately 10 km$^2$ of sand and gravel. No account is taken of any factors, for example roads, villages or land of high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

*It must be emphasised that the assessment applies to the resource block as a whole; valid conclusions cannot be drawn about mineral in parts of a block, except in the immediate vicinity of the actual sample points.*

## DESCRIPTION OF THE DISTRICT

### General

The district (Figure 1) lies in North Yorkshire, between Ripon and Darlington. It straddles the A1 (T) road, the major north-south communication route in north-east England, and is linked by other roads to the Pennine valleys and the east coast. The main London to Edinburgh railway lies a short distance to the east.

Drainage eastwards is effected by the River Swale, which flows across a broad floodplain lying at between 30 and 70 m OD, and its tributaries. Gently undulating ground rises away from the Swale valley to about 168 m OD on the upland flanking the Pennines in the west and to about 70 m OD near Whitwell in the northeast.

The district is predominantly rural, with mixed farming as the major source of employment. There are small industrial estates at Catterick Bridge and Leeming Bar and the extraction of sand and gravel is an important activity at Catterick, Bolton-on-Swale and Great Langton. Small-scale extraction of sand and gravel, limestone, sandstone and brick-clay for local purposes was formerly widespread, particularly in the west and south.

### Geology

The area was originally surveyed on the six-inch scale in 1854-78. The eastern half was mapped in 1978-80 during the resurvey of the Northallerton district (Sheet 42) but the western half has been subjected to only minor revision. The geological sequence is summarised in Table 1, and described briefly below. The 'solid' rocks are

**Table 1** Geological sequence and classification.

| | |
|---|---|
| DRIFT | |
| **Recent and Pleistocene** | Blown Sand |
| | Peat |
| | Lacustrine Alluvium |
| | Alluvial Fan |
| | Alluvium |
| | River Terraces, undifferentiated |
| | Fluvio-glacial Deposits |
| | Glacial Sand and Gravel |
| | Till (Boulder Clay) |
| | Glacial Lake Deposits: Sand |
| | Glacial Lake Deposits: Clay |
| | Morainic Drift |
| SOLID | |
| **Triassic** | Sherwood Sandstone Group |
| **Permian** | Permian Upper Marls (Saliferous Marl) |
| | Upper Magnesian Limestone |
| | Permian Middle Marls |
| | Middle Magnesian Limestone |
| | Lower Magnesian Limestone |
| **Carboniferous** | Namurian (Millstone Grit 'Series') |

largely concealed by drift deposits, but have been proved in a number of boreholes. The base of the Triassic system cannot be readily identified in this area, and is taken at the bottom of the Sherwood Sandstone. The relationships between the drift deposits are illustrated in Figure 2.

SOLID

Carboniferous Rocks of Namurian age (Millstone Grit 'Series') underlie the high western area but are poorly exposed. The Main Limestone at the base is overlain by a series of grey mudstones and pale-coloured felspathic sandstones together with thin coals. In the lower part, thick, bedded cherts and thin shelly limestones are present.

Permian Poorly exposed Permian strata overstep on to an eastward-sloping peneplain of Carboniferous rocks, and thicken eastwards. Although shown undivided on the resource map they consist of a number of formations. The lowest are the Lower and Middle Magnesian Limestones which consist of terrigenous basal breccias and sands, passing up into buff to reddish buff limestones and dolomites which have been much altered by diagenesis. The Permian Middle Marls, which are brick-red and grey contorted mudstones, cross-bedded sandy dolomites and evaporites, separate them from the Upper Magnesian Limestone, a cream to grey dolomite and limestone sequence. Above lie the Permian Upper Marls (Saliferous Marl) which consist of a sequence of red mudstones and sandstones, together with gypsum and anhydrite; they become more sandy upwards, passing into the Sherwood Sandstone Group, and are probably partly Triassic in age.

Solution of the evaporite layers throughout the Permian strata has given rise to a belt of collapsed solution-hollows, many peat-filled, which are aligned along the strike of the sub-drift outcrop.

Triassic Only the basal part of this system is present in the district. It consists of the Sherwood Sandstone, a reddish brown fine to medium-grained sandstone with thin mudstone partings. It frequently contains water under artesian pressure, and is one of the major aquifers in north-east England.

DRIFT

Morainic Drift A ridge of gravelly clay which stands above the level of the surrounding drift south-west of Tunstall [218 958] is thought (Raistrick 1926, p.378) to represent a stage in glacial retreat. Two related parallel ridges occur to the west.

Glacial Lake Deposits: Sand A small area of fine-grained sand overlying laminated clay east of Leeming Bar [287 901] has been mapped under this heading. Similar sands occurring farther south (Giles, 1982) are thought to represent lake shore (or margin) deposits.

Glacial Lake Deposits: Clay Extensive, low-lying, flat marshy areas on Crakehall Ings [265 905] and east of Leeming Bar [287 901] are floored by Glacial Lake Deposits up to 12.0 m thick. These consist chiefly of dark grey to reddish-brown laminated micaceous clays and silts with lenses of fine-grained sand, scattered small pebbles and some thin peat at the surface. Some striated and polished boulders are present, and were probably dropped from floating ice. These deposits were formerly worked for brick clay near Cobshaw Farm [261 917].

Thick sequences of laminated clays with sand lenses underlie Glacial Sand and Gravel in the central area and the fluvial deposits in the Swale valley. They appear to correlate with the lacustrine deposits described above (see Figure 2B).

Till (Boulder Clay) Bedrock is overlain by till of variable thickness across most of the district. At outcrop it ranges in thickness from a veneer to a maximum of 30 m proved from the surface near Hewitson Hill [299 998], but where buried beneath younger deposits it is generally thin. In the west it is a tough, grey to dark brown clay containing pebbles and boulders, predominantly of locally-derived Carboniferous cherts, limestones and sandstones with other far-travelled erratics, for example, Lake District granites. In the east and north-east its composition reflects the underlying geology: it is reddish-brown and contains pebbles of Permian and Triassic dolomites, limestones and sandstones as well as a few Carboniferous and Lower Palaeozoic erratics.

Around Street House [260 935] and north-west of Kirkby Fleetham, patches of till overlie thick sands and laminated clays. They are similar in composition to those described above but are variable in colour, sheared, and appear to be reworked in parts.

Glacial Sand and Gravel Thick, coarse gravels containing pebbles of predominantly local origin but with a small admixture of igneous rocks from the Lake District and the Cheviots are found in the south-west between Patrick Brompton [222 906] and Hackforth [246 933]. They form relatively high, hummocky ground, overlie bouldery clay and laminated clays and probably represent glacial outwash derived chiefly from the north and west. In the south-east, thick sequences of clayey sands, laminated clays and subordinate gravels form a high morainic ridge aligned parallel to the A1 between Leeming Bar [287 901] and St Ann's Cross [266 935]. A few kilometres farther north, around Killerby Hall [260 960], moundy patches of sand and gravel extend this feature. Elsewhere small patches of sand and gravel are associated with till.

Fluvio-glacial Deposits Small patches of sand and gravel form terrace-like features on the flanks of the Glacial Sand and Gravel outcrop north-east of Langthorne [255 918] and south-west of Little Holtby [275 918]. They may indicate or result from fluvial reworking of that deposit.

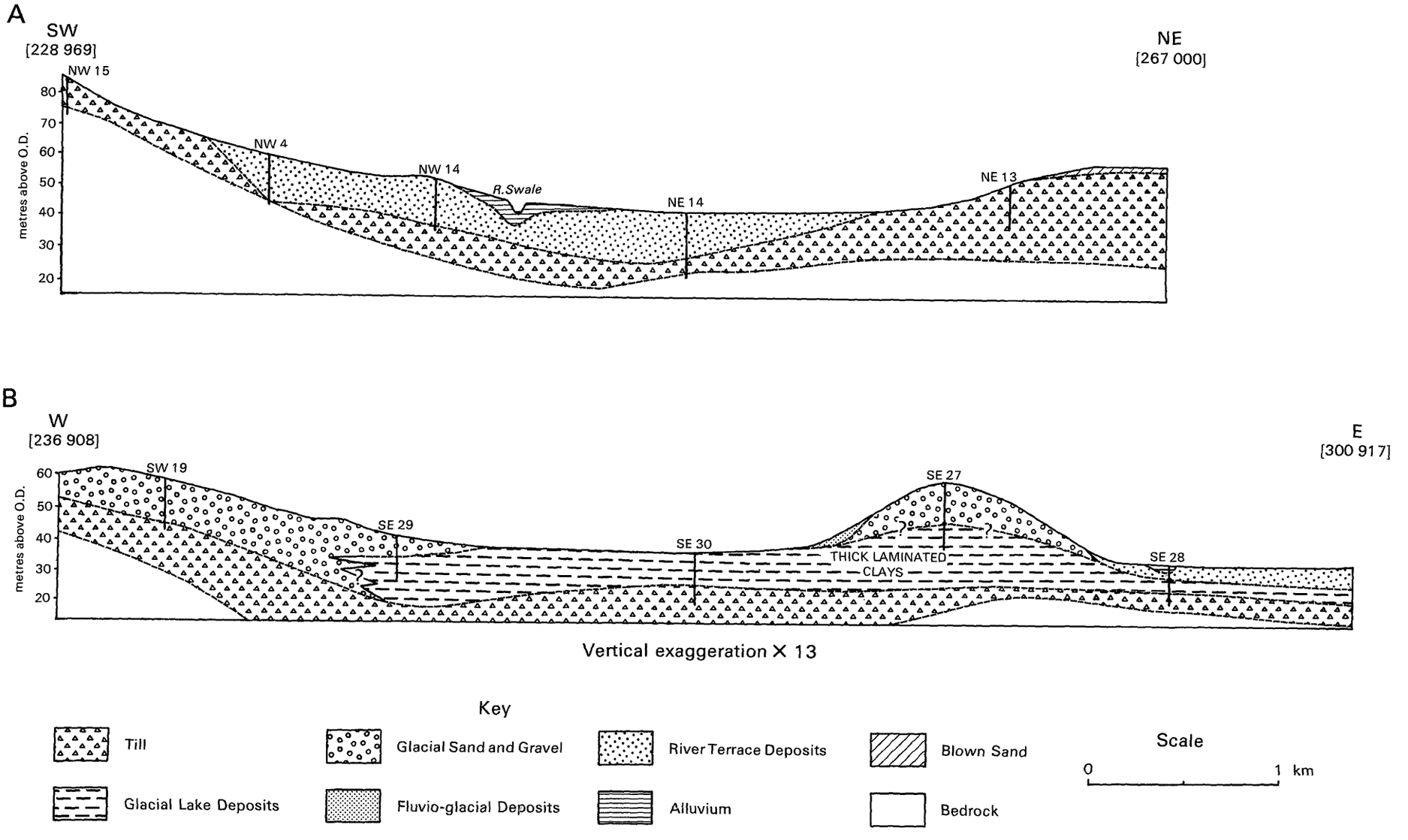



**Figure 2** Generalised sections showing the relationships between the drift deposits (lines of section are shown on the resource map).

River Terraces, undifferentiated Three terraces lying at between 30 and 60 m above OD have been recognised in the Swale valley, but are not differentiated here or on the resource map. They consist of coarse gravels and sands with subordinate clays and silts, and range up to 21 m in thickness. They are a major source of aggregate, especially in the north.

Alluvium and Alluvial Fans Alluvium of the River Swale lies slightly below the level of the terraces, and forms large areas of flat-lying, and in places, marshy ground. It consists mainly of clays and silts, but sand and gravel up to 6.6 m thick has been recorded (borehole NE 19).

Elsewhere alluvium occurs along minor streams, for example Bedale Beck, as well as in peaty hollows. It commonly contains a pale-weathering clay, locally termed 'white marl', which is rich in shell debris.

Small alluvial fans have been mapped north-east of Ellerton Hill [265 984].

Lacustrine Alluvium Patches of soft, silty clay and sand lying at between 45 and 61 m above OD around Killerby Hall [260 960] and north and east of Ellerton Hill [265 984] have been mapped as lacustrine alluvium.

Peat Extensive spreads of peat occur in low hollows around Hackforth Mires [250 938] and Ainderby Mires [257 927]; they probably occupy foundered areas resulting from solution of underlying Permian evaporites. Other small patches of peat occur in the west of the area and north-east of Goskins [255 943].

Blown Sand A few small patches of blown sand have been recorded in the north-east around Rushwood [267 993].

**Composition of the Sand and Gravel Deposits**

The potentially workable sand and gravel deposits in this district are found in the Glacial Sand and Gravel, in the fluvial deposits of the Swale valley and, to a lesser extent, in the Fluvio-glacial Deposits.

Glacial Sand and Gravel Mineral in these deposits occurs both at surface and buried beneath overburden. It has a mean grading of fines 12 per cent, sand 57 per cent and gravel 31 per cent (including 3 per cent cobbles), but shows considerable lateral variation. In the south-west, between Patrick Brompton [220 907] and Rudd Hall [243 949], thick gravels and sandy gravels crop out at the surface and extend north-eastwards beneath till. Maximum mean gravel contents of 60 per cent were recorded in boreholes NE 21 and SW 8. Farther east, Glacial Sand and Gravel occurs at the surface between St. Ann's Cross [266 935] and Leeming Bar [287 901], and beneath overburden between Hook Car Hill [274 958] and West Lowfield [291 949]. Here it consists predominantly of 'clayey' to 'very clayey' sandy gravels and pebbly sands, which are commonly underlain by 'clayey' to 'very clayey' sands. The gravel fraction, which may include up to 14 per cent cobbles, consists chiefly of varying proportions of locally-derived pale to dark grey Carboniferous limestone, some of which may be silicified or dolomitised, and brown to grey Carboniferous sandstone together with a small percentage of angular chert (see Table 2). Quartz, quartzite and Magnesian Limestone (mainly dolomite and dolomitic limestone) constitute only a few per cent of the fraction, while granitic, andesitic and porphyritic rocks from the Lake District or Cheviot areas, mudstones, coals, Lower Palaeozoic grits and greywackes and red Permian and Triassic sandstones and marls are generally present in only 'trace' amounts. Gravel in the 10 to 14 mm size range taken from boreholes NE 23, SW 9 and SW 19 gave aggregate impact values (British Standards Institution, 1975) of 27, 26 and 25 respectively. The sand fraction is predominantly fine to medium grained, but is coarser in the west. It consists of subangular to well rounded quartz grains and, especially in the coarse grade, rock fragments. The fines content ranges widely and reaches a maximum of 37 per cent in the lower part of borehole SE 29. It consists chiefly of brown and grey clay and micaceous silt with some coal debris.

Fluvio-glacial Deposits Deposits mapped under this heading are of limited extent and have been penetrated by only one borehole (SE 21) where they consisted of fine sand. Fluvio-glacial sand and gravel is more extensive in the district to the south and there consists predominantly of sandy gravels (Giles 1982).

Fluvial deposits of the Swale Sands and gravels forming extensive terraces in the Swale valley can readily be classified as 'River Terrace Deposits'. However, similar sands and gravels are also found at a slightly lower level beneath the thin silts and clays of the floodplain. Some of these deposits doubtless correlate with those forming the terraces, but others are probably younger and more properly classified as 'Alluvium'. Owing to their similarity in grading and composition no distinction can be made on the basis of samples taken from IMAU boreholes. On the resource map and in Appendix E, mineral found beneath the floodplain is shown as 'Alluvium', but for assessment purposes it is grouped with the terrace deposits.

**Table 2** Lithological composition of gravel from selected boreholes.

| Borehole | Percentage by weight | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carboniferous | | | Quartz Quartzite | Magnesian Limestone | Lower Palaeozic grits and greywackes | Lake District or Cheviot igneous rocks | Others: mudstone coal etc |
| | Limestone | Chert | Sandstone | | | | | |
| **Fluvial deposits of River Swale** | | | | | | | | |
| NW 13 | 42 | 11 | 43 | 2 | trace | trace | trace | 1 |
| NE 20 | 18 | 3 | 66 | 11 | trace | trace | trace | 1 |
| **Glacial Sand and Gravel** | | | | | | | | |
| NE 23 | 58 | 4 | 35 | trace | trace | trace | trace | 2 |
| SW 9 | 63 | 5 | 30 | 1 | trace | trace | trace | trace |
| SW 19 | 41 | 3 | 47 | trace | 4 | trace | trace | 4 |

**Table 3** The sand and gravel resources of the Catterick district (sheet SE 29).

| Block | Area | | Mean thickness | | | Volume of sand and gravel | | | Mean grading percentage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Block | Mineral | Over-burden | Mineral | Waste | | Limits at the 95% probability level | | Fines $-\frac{1}{16}$ mm | Sand $+\frac{1}{16}$ -4 mm | Gravel +4 mm |
| | $km^2$ | $km^2$ | m | m | m | $m^3 \times 10^6$ | ± % | ± $m^3 \times 10^6$ | | | |
| A | 17.4 | 15.1 | 0.8 | 10.8 | 0.2 | 163 | 30 | 49 | 7 | 41 | 52 |
| B | 12.6 | 11.9 | 1.7 | 5.1 | 1.0 | 61 | 34 | 21 | 13 | 66 | 21 |
| C | 12.6 | 12.0 | 1.1 | 6.8 | 2.1 | 82 | 31 | 27 | 11 | 43 | 46 |
| D | 11.2 | 11.2 | 2.3 | 9.8 | 1.3 | 110 | 30 | 33 | 12 | 66 | 22 |
| **Total** | **53.8** | **50.2** | **1.7** | **8.4** | **1.0** | **421** | **16** | **68** | **10** | **54** | **36** |

Taken together the deposits have a mean grading of fines 10 per cent, sand 48 per cent and gravel 42 per cent (including 3 per cent cobbles). Between Brompton-on-Swale [219 997] and Kirkby Fleetham [285 945] they consist of gravels and sandy gravels with mean pebble and cobble contents ranging up to a maximum of 73 per cent (in borehole NE 15). To the south (downstream), however, the deposits become thinner and finer-grained, and although boreholes SE 15 and 20 penetrated gravel and sandy gravel, other boreholes recorded only 'clayey' to 'very clayey' sands and pebbly sands, with a maximum mean gravel content of 17 per cent (borehole SE 25) and up to a mean of 38 per cent fines (SE 25). The lithological composition of the fines, sand and gravel fractions is similar to that of the Glacial Sand and Gravel. Gravel in the size range 10 to 14 mm from borehole NE 12 gave an aggregate impact value of 26.

**Notes on Workings**

Present-day workings are confined to the Swale valley, where large areas around Catterick, Bolton-on-Swale, North Ellerton and Great Langton are occupied by working pits. Gravel is occasionally dredged from the Swale bed near Kiplin [280 971]. Elsewhere in the district numerous small abandoned pits testify to the former widespread extraction of sand and gravel for local purposes.

**The Map**

The sand and gravel resource map is folded into the pocket at the end of this report. The base map is the Ordnance Survey 1:25 000 Outline Edition in grey, on which the geological data are shown in black and the mineral resource information in shades of red.

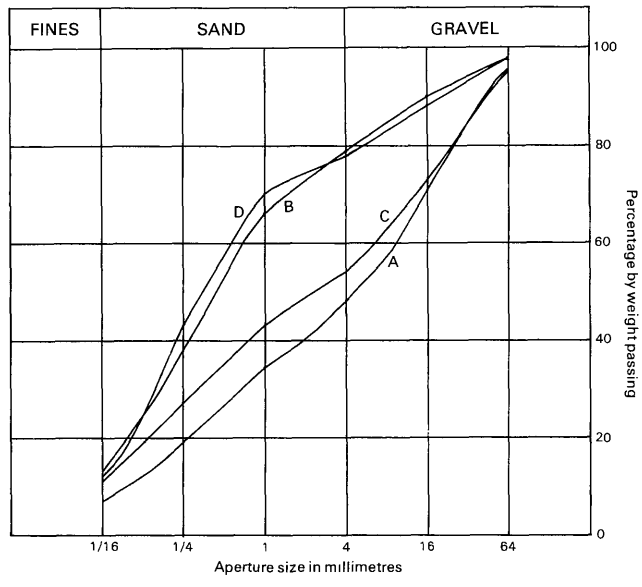
Geological data The geological boundary lines, symbols, etc., shown are taken from sources shown at the foot of the map. The geological boundaries are the best interpretation of the information available at the time of survey. However, it is inevitable that local irregularities and discrepancies will be revealed as new evidence from boreholes and excavations becomes available.

Borehole data, which include the stratigraphic relations, thicknesses and mean particle size distribution of the sand and gravel samples collected during the assessment survey, are also shown on the map.

Mineral resource information The mineral-bearing ground is divided into resource blocks (see Appendix A). Within a resource block the mineral is subdivided into areas where it is exposed, that is where the overburden averages less than 1 m in thickness, and areas where it is present in continuous, or almost continuous spreads beneath overburden.

Areas where bedrock crops out, where boreholes indicate absence of sand and gravel beneath cover and where sand and gravel beneath cover is interpreted to be not potentially workable, are uncoloured on the map; where appropriate, the relevant criterion is noted. In such cases it has been assumed that mineral is absent except in infrequent and relatively minor patches that can neither be outlined nor assessed quantitatively in the context of this survey. Areas of unassessed sand and gravel, for example in built-up areas, are indicated by a red stipple.

The area of the mineral-bearing ground is measured, where possible, from the mapped geological boundary lines. The whole of this area is considered as mineral-




| Resource block | Cumulative percentage by weight passing | | | | | |
|---|---|---|---|---|---|---|
| | 1/16mm | 1/4mm | 1mm | 4mm | 16mm | 64mm |
| A | 7 | 19 | 35 | 48 | 71 | 96 |
| B | 13 | 38 | 66 | 79 | 90 | 98 |
| C | 11 | 27 | 43 | 54 | 73 | 95 |
| D | 12 | 43 | 70 | 78 | 88 | 98 |

**Figure 3** Mean particle size distribution for the assessed thickness of sand and gravel in resource blocks A to D.

**Table 4** Block A: data from IMAU boreholes.

| Borehole | Recorded thickness (m) | | | Mean grading percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Over-burden | Mineral | Waste | Fines $-\frac{1}{16}$ mm | Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm | Medium sand $+\frac{1}{4}$ -1 mm | Coarse sand +1 -4 mm | Fine gravel +4 -16 mm | Coarse gravel +16 -64 mm | Cobbles +64 mm |
| NW 13 | 2.7 | 18.4 | | 6 | 9 | 14 | 16 | 22 | 26 | 7 |
| NW 14 | 0.3 | 14.2 | | 7 | 12 | 16 | 14 | 26 | 21 | 4 |
| NE 12 | 0.4 | 9.5 | 1.2 | 6 | 7 | 16 | 14 | 23 | 29 | 5 |
| NE 14 | 0.6 | 7.2 | 0.7 | 5 | 7 | 22 | 14 | 20 | 27 | 5 |
| NE 15 | 1.4 | 1.6 | | 3 | 4 | 8 | 12 | 18 | 49 | 6 |
| NE 16 | 0.7 | 4.3 | | 23 | 36 | 12 | 4 | 10 | 14 | 1 |
| NE 17 | 0.7 | 20.5 | | 7 | 11 | 17 | 11 | 25 | 25 | 4 |
| NE 18 | 0.8 | 7.6 | | 2 | 4 | 18 | 18 | 31 | 23 | 4 |
| NE 19 | 0.6 | 6.6 | | 3 | 5 | 15 | 12 | 27 | 35 | 3 |
| NE 20 | 0.3 | 4.5 | | 9 | 12 | 13 | 10 | 19 | 32 | 5 |
| NE 26 | 0.8 | 5.4 | 0.3 | 13 | 40 | 22 | 5 | 7 | 11 | 2 |
| **Mean** | | | | **7** | **12** | **16** | **13** | **23** | **25** | **4** |

bearing, even though it may include small areas where sand and gravel is not present or is not potentially workable. Inferred boundaries have been inserted to delimit areas where sand and gravel beneath cover is interpreted to be not potentially workable or absent. Such boundaries (for which a distinctive zigzag symbol is used) are drawn primarily for the purpose of volume estimation. The symbol is intended to indicate an approximate location within a likely zone of occurrence rather than to represent the breadth of the zone, its size being determined only by cartographic considerations. For the purpose of measuring areas the centre line of the symbol is used.

**Results**

The statistical results are summarised in Table 3. Fuller grading particulars are shown in Figures 3 to 7 and Tables 4 to 7.

Accuracy of results For the four blocks, the accuracy of the results at the 95 per cent probability level (that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral) varies between 30 per cent and 34 per cent (Appendix B). However, the true volumes are more likely to be nearer the figure estimated than either of the limits. Moreover, it is probable that roughly the same percentage limits would apply for the statistical estimate of mineral volume within a very much smaller parcel of ground (say 100 hectares) containing similar sand and gravel deposits, if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for quotation of reserves, data from more sample points would be required, even if the area were quite small. This point can be illustrated by considering the whole of the potentially workable sand and gravel in Blocks A to D. The total volume (421 million $m^3$) can be estimated to limits of $\pm$ 16 per cent at the 95 per cent probability level by a calculation based on the data from 45 sample points spread across the four resource blocks. However, it must be emphasised that the quoted volume of mineral has no simple relationship with the amount that could be extracted in practice, as no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of the land for mineral working.

**Notes on Resource Blocks**

The four resource blocks are defined on mainly geological criteria. The fluvial deposits of the Swale valley are included in blocks A and B. The former includes the relatively thick mineral in the northern part of the Swale valley, where it has been extensively worked, while Block B contains the thinner and finer-grained deposits farther downstream. In addition, Block B contains an area of concealed and potentially workable glacial deposits. The remainder of the glacial and fluvio-glacial deposits, both at outcrop and buried beneath overburden, are included in blocks C and D. Extensive areas of till in the west and north-east, and patches of Glacial Lake Deposits on Crakehall Ings [265 906] and north-east of Leeming Bar [287 901] have, except for a small, thin patch of gravel around borehole SW 7, proved to be barren.

Block A Present-day aggregate extraction in the district is confined to block A, where an area of about 2.3 $km^2$ has been worked out, leaving a mineral-bearing area of 15.1 $km^2$. Data from 11 IMAU boreholes (Table

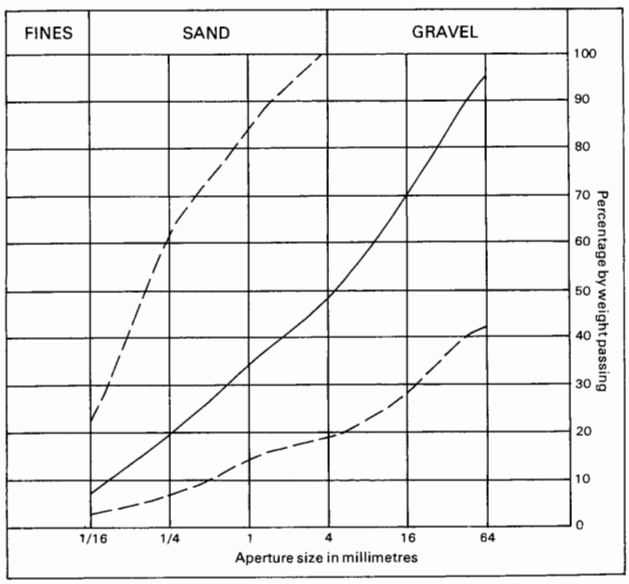



**Figure 4** Grading characteristics of the mineral in Block A; the continuous line represents the weighted mean grading of the mineral, the broken lines denote the envelope within which the mean grading curves for indidual boreholes fall.

**Table 5** Block B: data from IMAU boreholes.

| Borehole | Recorded thickness (m) | | | Mean grading percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Over-burden | Mineral | Waste | Fines $-\frac{1}{16}$ mm | Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm | Medium sand $+\frac{1}{4}$ -1 mm | Coarse sand +1 -4 mm | Fine gravel +4 -16 mm | Coarse gravel +16 -64 mm | Cobbles +64 mm |
| NE 23 | 4.2 | 10.3 | | 3 | 5 | 19 | 29 | 21 | 14 | 9 |
| NE 24 | 0.9 | 6.6 | 5.1 | 16 | 35 | 25 | 9 | 8 | 7 | 0 |
| NE 25 | 9.6 | 5.3 | | 13 | 27 | 43 | 11 | 5 | 1 | 0 |
| SE 14 | 0.6 | 6.5 | | 9 | 11 | 41 | 17 | 11 | 10 | 1 |
| SE 15 | 0.4 | 2.3 | | 8 | 7 | 18 | 15 | 27 | 25 | 0 |
| SE 19 | - | 4.4 | | 13 | 36 | 45 | 4 | 2 | 0 | 0 |
| SE 20 | 1.4 | 2.5 | | 5 | 5 | 25 | 19 | 29 | 17 | 0 |
| SE 24 | 0.6 | 4.4 | | 15 | 26 | 51 | 6 | 2 | 0 | 0 |
| SE 25 | 0.4 | 7.2 | 5.3 | 35 | 36 | 11 | 4 | 6 | 6 | 2 |
| SE 28 | 0.9 | 2.0 | | 6 | 25 | 27 | 16 | 24 | 2 | 0 |
| SE 32 | 0.3 | 4.9 | 0.2 | 14 | 67 | 18 | 1 | 0 | 0 | 0 |
| **Mean** | | | | **13** | **25** | **28** | **13** | **11** | **8** | **2** |

4, Figure 4) and 19 other, mainly confidential, borehole records have been used to assess the block's resources.

Mineral consists largely, and perhaps entirely, of the fluvial deposits of the Swale valley. Glacial Sand and Gravel may be present in the deeper parts of some boreholes, especially in the west, but it cannot be distinguished from the younger deposits. Gravels and sandy gravels predominate, with mean gravel percentages ranging from 20 in borehole NE 26 to a maximum of 73 in NE 15, but generally exceeding 50 per cent. The fines content is normally below 9 per cent but, exceptionally, 23 per cent were recorded in NE 16. Mineral is thickest in the north and west of the block, where a maximum of 20.5 m was recorded in NE 17. The mean mineral thickness is 10.8 m, giving an estimated volume of mineral present of 163 million $m^3 \pm 30$ per cent. The mean grading is fines 7 per cent, sand 41 per cent and gravel 52 per cent (including 4 per cent cobbles).

Overburden, which consists of soil, clay and silt, is generally thin, except in NW 13 where 2.7 m of silt were recorded; it has a mean thickness of 0.8 m. Waste partings were proved in only three boreholes, and consist of clay bands up to 1.2 m in thickness.

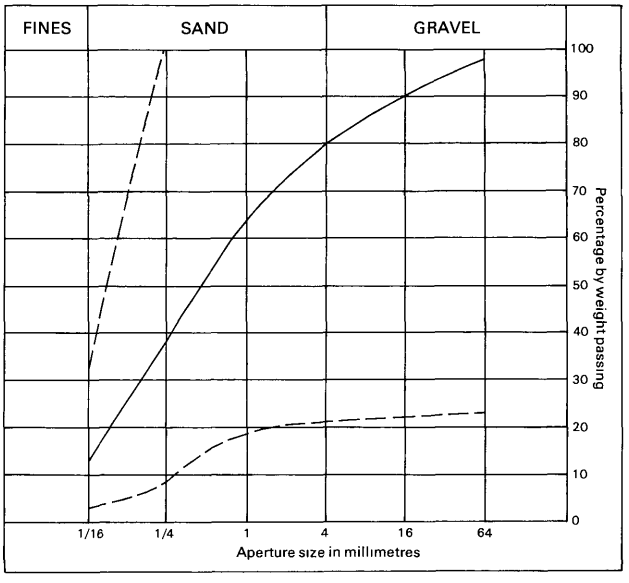



**Figure 5** Grading characteristics of the mineral in Block B. For explanation see Figure 4.

Block B This block is the downstream continuation of block A, and includes 11.9 $km^2$ of mineral-bearing ground. Potentially workable mineral occurs in the Swale fluvial deposits, glacial lake sands, and, largely beneath thick overburden, in the Glacial Sand and Gravel. Data from 11 IMAU boreholes, summarised in Table 5 and Figure 5, and one confidential record have been used in the assessment.

In the north of the block, an area of about 1.9 $km^2$ is underlain by glacial mineral proved in boreholes NE 24 and 25. The former found 1.6 m of 'very clayey' sandy gravel separated by 5.1 m of till from 5.0 m of 'clayey' pebbly sand, while the latter proved 5.3 m of 'clayey' pebbly sand beneath 9.6 m of till. Within the fluvial deposits, gravels and sandy gravels were recorded in boreholes NE 23 and SE 15, 20 and 28, but elsewhere mineral consists predominantly of 'clayey' to 'very clayey' sands and pebbly sands. Proved thicknesses range from 2.0 m in SE 28 to a maximum of 10.3 m in NE 23, with a mean of about 4.9 m.

For the block as a whole, the mean proved mineral thickness is 5.1 m, giving an estimated volume of mineral present of 61 million $m^3 \pm 34$ per cent. Its mean grading is fines 13 per cent, sand 66 per cent and gravel 21 per cent, including 2 per cent cobbles.

Overburden is generally thin, except in boreholes NE 23 and NE 25, where 4.2 and 9.6 m respectively were recorded. Thin waste partings were found in borehole SE 32, and 5.1 and 5.3 m of clay were recorded between mineral deposits in NE 24 and SE 25 respectively.

Block C This block has a mineral bearing area of 12.0 $km^2$. Data from 12 IMAU boreholes and one other were used to assess the resources; data from IMAU boreholes are summarised in Table 6 and Figure 6. Mineral consists chiefly of glacial sand and gravel, with fluvial and fluvio-glacial deposits contributing only minor amounts.

Gravels and sandy gravels, partly 'clayey', predominate in the west of the block, but farther east the deposits are less coarse, and sands may be present, as in boreholes SE 21 and 29. The mean gravel content ranges from 22 to 61 per cent, but is commonly greater than 50 per cent, and fines account for between 6 and 21 per cent of the mineral. The mean grading is fines 11 per cent, sand 43 per cent and gravel 46 per cent, including 5 per cent cobbles. Proved thicknesses range from 2.2 m in borehole SW 17 to 13.3 m in SW 11, although owing to the difficulty of drilling such coarse deposits the base of the mineral was not reached in boreholes SW 11 and 18. The mean proved thickness is 6.8 m, giving an estimated

**Table 6** Block C: data from IMAU boreholes.

| Borehole | Recorded thickness (m) | | | Mean grading percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Over-burden | Mineral | Waste | Fines $-\frac{1}{16}$ mm | Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm | Medium sand $+\frac{1}{4}$ -1 mm | Coarse sand +1 -4 mm | Fine gravel +4 -16 mm | Coarse gravel +16 -64 mm | Cobbles +64 mm |
| SW 8 | 0.6 | 4.2 | | 7 | 9 | 11 | 13 | 21 | 33 | 6 |
| SW 9 | 1.0 | 8.5 | 2.0 | 9 | 12 | 15 | 11 | 21 | 26 | 6 |
| SW 10 | 1.0 | 3.7 | 0.5 | 14 | 10 | 9 | 6 | 20 | 34 | 7 |
| SW 11 | 0.5 | 13.3+ | 3.7 | 6 | 14 | 32 | 16 | 14 | 17 | 1 |
| SW 13 | 2.5 | 6.9 | 4.8 | 6 | 9 | 14 | 13 | 25 | 27 | 6 |
| SW 15 | 2.0 | 5.5 | 4.5 | 13 | 10 | 14 | 12 | 19 | 25 | 7 |
| SW 16 | 1.2 | 9.1 | | 14 | 20 | 17 | 12 | 20 | 16 | 1 |
| SW 17 | 0.4 | 2.2 | 2.3 | 19 | 27 | 13 | 12 | 21 | 8 | 0 |
| SW 18 | 1.0 | 4.3+ | 0.7 | 13 | 10 | 13 | 7 | 18 | 25 | 14 |
| SW 19 | 0.6 | 10.4 | 0.2 | 9 | 10 | 10 | 10 | 22 | 29 | 10 |
| SE 21 | 1.1 | 8.8 | 9.2 | 16 | 40 | 16 | 6 | 12 | 9 | 1 |
| SE 29 | 0.5 | 2.7 | | 21 | 20 | 12 | 8 | 15 | 23 | 1 |
| **Mean** | | | | **11** | **16** | **16** | **11** | **19** | **22** | **5** |

**Table 7** Block D: data from IMAU boreholes.

| Borehole | Recorded thickness (m) | | | Mean grading percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Over-burden | Mineral | Waste | Fines $-\frac{1}{16}$ mm | Fine sand $+\frac{1}{16}-\frac{1}{4}$ mm | Medium sand $+\frac{1}{4}$ -1 mm | Coarse sand +1 -4 mm | Fine gravel +4 -16 mm | Coarse gravel +16 -64 mm | Cobbles +64 mm |
| NE 21 | 5.2 | 8.3 | | 7 | 8 | 13 | 12 | 22 | 34 | 4 |
| NE 22 | 3.3 | 11.0 | | 6 | 9 | 22 | 14 | 21 | 25 | 3 |
| SE 13 | 2.5 | 15.9 | 0.1 | 11 | 30 | 23 | 9 | 14 | 10 | 3 |
| SE 16 | 4.9 | 10.1 | 4.5 | 17 | 24 | 29 | 10 | 10 | 8 | 2 |
| SE 17 | 5.3 | 15.2 | | 10 | 33 | 40 | 5 | 7 | 5 | 0 |
| SE 18 | 2.6 | 10.0 | 1.0 | 10 | 44 | 34 | 6 | 4 | 2 | 0 |
| SE 22 | | Absent | | 5.4+ | | | | | | |
| SE 23 | 1.6 | 13.1 | 6.3 | 23 | 55 | 13 | 2 | 2 | 4 | 1 |
| SE 27 | 0.9 | 12.1 | | 12 | 33 | 37 | 11 | 4 | 3 | 0 |
| SE 31 | 0.8 | 2.1 | | 16 | 56 | 27 | 1 | 0 | 0 | 0 |
| **Mean** | | | | **12** | **31** | **27** | **8** | **10** | **10** | **2** |

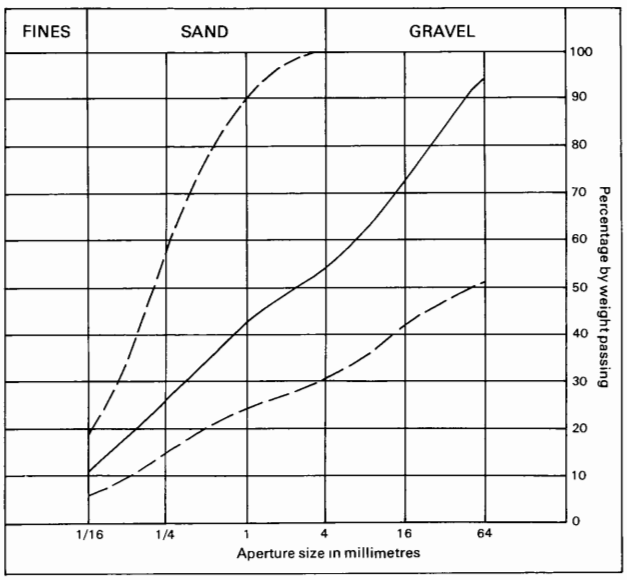



**Figure 6** Grading characteristics of the mineral in Block C. For explanation see Figure 4.

volume of mineral present of 82 million $m^3 \pm 31$ per cent.

Overburden is generally less than 1 m thick and consists mainly of soil and pebbly clay. An area of thicker overburden of uncertain extent around boreholes SW 13, 15 and 16 has been indicated on the resource map by an inferred boundary. The mean overburden thickness is 1.1 m. Waste partings were found in all boreholes except SW 8, 16 and SE 29 and range from a thin clay parting up to a maximum of 9.2 m of silt and clay in SE 21, with a mean thickness for the block as a whole of 2.1 m.

Block D The area of this block is 11.2 $km^2$, all of which is mineral-bearing except for a very small worked-out area. Data from 10 IMAU boreholes and three others have been used to estimate the sand and gravel resources, and details of IMAU boreholes are summarised in Table 7 and Figure 7. Mineral is found in Glacial Sand and Gravel and, to a lesser extent, in Fluvio-glacial Deposits.

In the north-western part of the block Glacial Sand and Gravel occurs for the most part beneath relatively thick overburden. Gravels, partly 'clayey', 8.3 m and 11.0 m thick were proved in boreholes NE 21 and 22

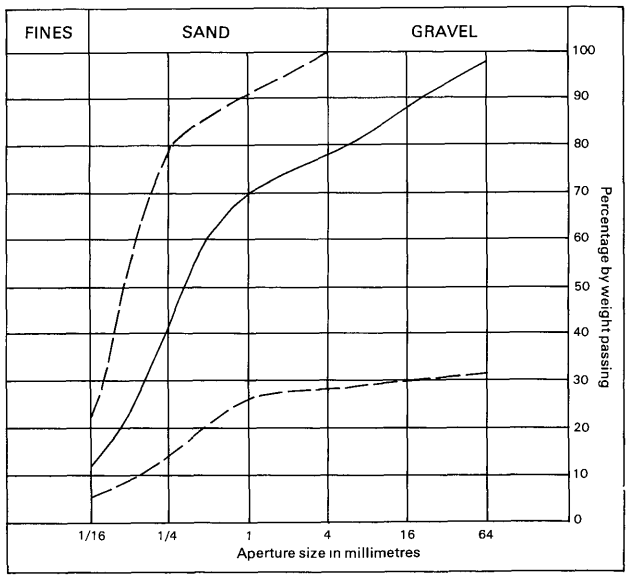



**Figure 7** Grading characteristics of the mineral in Block D. For explanation see Figure 4.

respectively but farther to the west borehole NW 16 proved no mineral, and an inferred boundary has been drawn to indicate the approximate western limit of concealed mineral hereabouts. Southeastwards, gravel becomes less dominant, and boreholes SE 13, 16 and 17 included pebbly sand and, mainly at the base, sands. Proved mineral thicknesses in this part of the block range from 8.3 m (NE 21) to 15.9 m (SE 13), with a mean of about 12 m, although borehole SE 22 had to be abandoned before encountering sand and gravel. Overburden consists of up to 5.3 m of till with a mean thickness of about 4.2 m.

In the south-eastern part of the block, mineral occurs at the surface in the Glacial Sand and Gravel and Fluvioglacial Deposits. It consists predominantly of 'clayey' to 'very clayey' sands and pebbly sands with only subordinate gravel, and ranges in thickness from 2.1 m (in SE 21) to 13.1 m (in SE 23). Overburden, consisting chiefly of clay, is generally thin but ranges up to 2.6 m in thickness in borehole SE 18, with a mean of about 1.4 m.

For the block as a whole, the mean thickness of mineral is 9.8 m, and the mean grading is fines 12 per cent, sand 66 per cent and gravel 22 per cent, including 2 per cent cobbles. The estimated volume of mineral present is 110 million $m^3 \pm 30$ per cent. Overburden has a mean thickness of 2.3 m. Waste partings, which consist mainly of silty clay were found in a number of boreholes; they range in thickness from 0.1 m to 6.3 m but the mean thickness of waste in the block is only 1.3 m.

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WP/KW/LKW

## APPENDIX A

### FIELD AND LABORATORY PROCEDURES

Trial and error during initial studies of the complex and variable glacial deposits of East Anglia and Essex showed that an absolute minimum of five sample points evenly distributed across the sand and gravel are needed to provide a worthwhile statistical assessment, but that, where possible, there should be not less than ten. Sample points are any points for which adequate information exists about the nature and thickness of the deposit and may include boreholes other than those drilled during the survey and exposures. In particular, the cooperation of sand and gravel operators ensures that boreholes are not drilled where reliable information is already available; although this may be used in the calculations, it is held confidentially by the Institute and cannot be disclosed.

The mineral shown on each 1:25 000 sheet is divided into resource blocks. The arbitrary size selected is a compromise to meet the aims of the survey by providing sufficient sample points in each block. As far as possible the block boundaries are determined by geological boundaries so that, for example, glacial and river terrace gravels are separated. Otherwise division is by arbitrary lines, which may bear no relationship to the geology. The blocks are drawn provisionally before drilling begins.

A reconnaissance of the ground is carried out to record any exposures and inquiries are made to ascertain what borehole information is available. Borehole sites are then selected to provide an even pattern of sample points at a density of approximately one per square kilometre. However, because broad trends are independently overlain by smaller-scale characteristically random variations, it is unnecessary to adhere to a square grid pattern. Thus such factors as ease of access and the need to minimise disturbance to land and the public are taken into account in siting the holes; at the same time it is necessary to guard against the possibility that ease of access (that is, the positions of roads and farms) may reflect particular geological conditions, which may bias the drilling results.

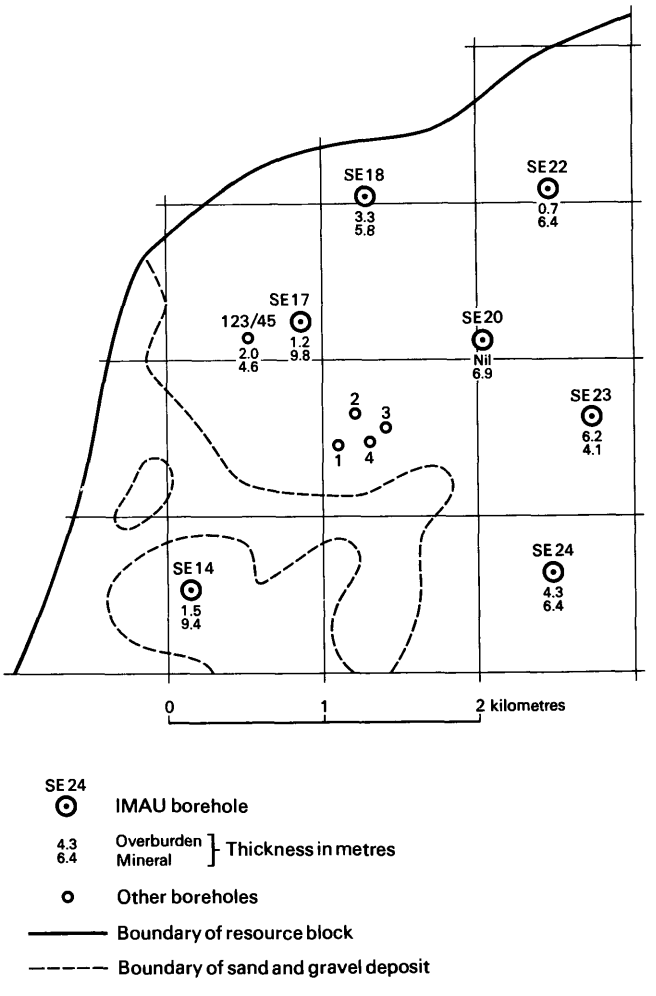
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites of difficult access). Shell and auger rigs have proved to be almost ideal.

The rigs are modified to enable deposits above the water table to be drilled 'dry', instead of with water added to facilitate the drilling, to minimise the amount of material drawn in from outside the limits of the hole. The samples thus obtained are representative of the in-situ grading, and satisfy one of the most important aims of the survey. Below the water table the rigs are used conventionally, although this may result in the loss of some of the fines fraction and the pumping action of the bailer tends to draw unwanted material into the hole from the sides or the bottom.

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel, or at every 1 m (3.3 ft) depth. The samples, each weighing between 25 and 45 kg (55 and 100 lb), are despatched in heavy-duty polythene bags to a laboratory for grading. The grading procedure is based on B.S. 1337 (British Standards Institution, 1967). Random checks of the accuracy of the grading are made in the Institute's laboratories.

All data, including mean grading analysis figures calculated for the total thickness of the mineral, are entered on standard record sheets, abbreviated copies of which are reproduced in Appendix E.

Detailed records may be consulted at the appropriate offices of the Institute, upon application to the Head, Industrial Minerals Assessment Unit.




Example of resource block assessment: map of a fictitious block

## APPENDIX B

## STATISTICAL PROCEDURE

### Statistical assessment

1 A statistical assessment is made of an area of mineral greater than 2 km$^2$, if there are at least five evenly spaced boreholes in the resource block (for smaller areas, see Paragraph 12 below).

2 The simple methods used in the calculations are consistent with the amount of data provided by the survey (Hull, 1981). Conventional symmetrical confidence limits are calculated for the 95 per cent probability level, that is, on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral.

3 The volume estimate ($V$) for the mineral in a given block is the product of two variables, the sampled areas ($A$) and the mean thickness ($\bar{l}_m$) calculated from the individual thicknesses at the sample points. The standard deviations for these variables are related such that

$$S_V = \sqrt{(S_A^2 + S_{\bar{l}_m}^2)} \qquad [1]$$

4 The above relationship may be transposed such that

$$S_V = S_{\bar{l}_m} \sqrt{(1 + S_A^2 / S_{\bar{l}_m}^2)} \qquad [2]$$

From this it can be seen that as $S_A^2 / S_{\bar{l}_m}^2$ tends to 0, $S_V$ tends to $S_{\bar{l}_m}$.

If, therefore, the standard deviation for area is small with respect to that for thickness, the standard deviation for volume approximates to that for mean thickness.

5 Given that the number of approximately evenly spaced sample points in the sampled area is $n$ with mineral thickness measurements $l_{m_1}, l_{m_2}, \ldots l_{m_n}$, then the best estimate of mean thickness, $\bar{l}_m$, is given by

$$\Sigma\ (l_{m_1} + l_{m_2} \ldots l_{m_n}) / n .$$

For groups of closely spaced boreholes a discretionary weighting factor may be applied to avoid bias (see note on weighting below). The standard deviation for mean thickness $S_{\bar{l}_m}$, expressed as a proportion of the mean thickness, is given by

$$S_{\bar{l}_m} = (1/\bar{l}_m) \sqrt{\ [\Sigma (l_m - \bar{l}_m)^2/(n-1)]}$$

where $l_m$ is any value in the series $l_{m_1}$ to $l_{m_n}$.

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of a deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are small relative to those in thickness. The relationship $S_A / S_{\bar{l}_m} \leqq 0.\dot{3}$ is assumed in all cases. It follows from Equation [2] that

$$S_{\bar{l}_m} \leqq S_V \leqq 1.05\, S_{\bar{l}_m} \qquad [3]$$

7 The limits on the estimate of mean thickness of mineral, $L_{\bar{l}_m}$, may be expressed in absolute units

$\pm (t/\sqrt{n}) \times S_{\bar{l}_m}$ or as a percentage

$\pm (t/\sqrt{n}) \times S_{\bar{l}_m} \times (100/\bar{l}_m)$ per cent, where t is Student's t at the 95 per cent probability level for $(n-1)$ degrees of freedom, evaluated by reference to statistical tables. (In applying Student's t it is assumed that the measurements are distributed normally).

8 Values of t at the 95 per cent probability level for values of $n$ up to 20 are as follows:

| $n$ | t | $n$ | t |
|---|---|---|---|
| 1 | infinity | 11 | 2.228 |
| 2 | 12.706 | 12 | 2.201 |
| 3 | 4.303 | 13 | 2.179 |
| 4 | 3.182 | 14 | 2.160 |
| 5 | 2.776 | 15 | 2.145 |
| 6 | 2.571 | 16 | 2.131 |
| 7 | 2.447 | 17 | 2.120 |
| 8 | 2.365 | 18 | 2.110 |
| 9 | 2.306 | 19 | 2.101 |
| 10 | 2.262 | 20 | 2.093 |

(from Table 12 in *Biometrika Tables for Statisticians*, Volume 1, Second Edition, Cambridge University Press, 1962). When $n$ is greater than 20, 1.96 is used (the value of t when n is infinity).

9 In calculating confidence limits for volume, $L_V$, the following inequality, corresponding to Equation [3], is applied:

$$L_{\bar{l}_m} \leqq L_V \leqq 1.05\, L_{\bar{l}_m}.$$

10 In summary, for values of $n$ between 5 and 20, $L_V$ is calculated as

$$[(1.05 \times t)/\bar{l}_m] \times [\sqrt{\Sigma (l_m - \bar{l}_m)^2/n\ (n-1)}] \times 100$$

per cent,

and when $n$ is greater than 20, as

$$[(1.05 \times 1.96)/\bar{l}_m] \times [\sqrt{\Sigma (l_m - \bar{l}_m)^2/n\,(n-1)}] \times 100$$

per cent.

11 The application of this procedure to a fictitious area is illustrated in the accompanying Figure and example of a block calculation.

### Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.25 km$^2$ and 2 km$^2$, an assessment is inferred on the basis of geological and topographical information, usually supported by the data from one or two boreholes. The volume of mineral is calculated as the product of the area, measured from field data, and the estimated thickness. Confidence limits are not calculated.

13 In some cases a resource block may include an area left uncoloured on the map, within which mineral (as defined) is interpreted to be generally absent. If there is reason to believe that some mineral may be present, an inferred assessment may be made.

14 No assessment is attempted for an isolated area of mineral less than 0.25 km$^2$.

15 Note on weighting The thickness of a deposit at any point may be governed solely by the position of the point in relation to a broad trend. However, most sand and gravel deposits also exhibit a random pattern of local, and sometimes considerable, variation in thickness. Thus the distribution of sample points needs to be only approximately regular and in estimating the mean thickness only simple weighting is necessary. In practice, equal weighting can often be applied to thicknesses at all sample points. If, however, there is a distinctly unequal distribution of points, bias is avoided by dividing the sampled area into broad zones, to each of which a value roughly proportional to its area is assigned. This value is then shared between the data points with the zone as the weighting factor.

**Block calculation**

Scale: 1:25 000
Block: Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

Confidence limits of the estimate of mineral volume at the 95 per cent probability level: ± 20 per cent
That is, the volume of mineral (with 95 per cent probability): 54 ± 11 million m³

Thickness estimate (measurements in metres)
$l_o$= overburden thickness $l_m$ = mineral thickness

| Sample point | Weighting $w$ | Overburden $l_o$ | Overburden $wl_o$ | Mineral $l_m$ | Mineral $wl_m$ | Remarks |
|---|---|---|---|---|---|---|
| SE 14 | 1 | 1.5 | 1.5 | 9.4 | 9.4 | IMAU boreholes |
| SE 18 | 1 | 3.3 | 3.3 | 5.8 | 5.8 | |
| SE 20 | 1 | nil | - | 6.9 | 6.9 | |
| SE 22 | 1 | 0.7 | 0.7 | 6.4 | 6.4 | |
| SE 23 | 1 | 6.2 | 6.2 | 4.1 | 4.1 | |
| SE 24 | 1 | 4.3 | 4.3 | 6.4 | 6.4 | |
| SE 17 | ½ | 1.2 | 1.6 | 9.8 | 7.2 | Hydrogeology Unit record |
| 123/45 | ½ | 2.0 | | 4.6 | | |
| 1 | ¼ | 2.7 | 2.6 | 7.3 | 5.8 | Close group of four boreholes (commercial) |
| 2 | ¼ | 4.5 | | 3.2 | | |
| 3 | ¼ | 0.4 | | 6.8 | | |
| 4 | ¼ | 2.8 | | 5.9 | | |
| Totals | $\Sigma w = 8$ | $\Sigma wl_o = 20.2$ | | $\Sigma wl_m = 52.0$ | | |
| Means | | $\overline{wl}_o = 2.5$ | | $\overline{wl}_m = 6.5$ | | |

Calculation of confidence limits

| $wl_m$ | $\lvert(wl_m - \overline{wl}_m)\rvert$ | $(wl_m - \overline{wl}_m)^2$ |
|---|---|---|
| 9.4 | 2.9 | 8.41 |
| 5.8 | 0.7 | 0.49 |
| 6.9 | 0.4 | 0.16 |
| 6.4 | 0.1 | 0.01 |
| 4.1 | 2.4 | 5.76 |
| 6.4 | 0.1 | 0.01 |
| 7.2 | 0.7 | 0.49 |
| 5.8 | 0.7 | 0.49 |

$\Sigma(wl_m - \overline{wl}_m)^2 = 15.82$

$n = 8$

$t = 2.365$

$L_V$ is calculated as

$1.05\,(t/\overline{wl}_m)\,\sqrt{[\Sigma(wl_m - \overline{wl}_m)^2/\,n(n-1)]} \times 100$

$= 1.05 \times (2.365/6.5)\,\sqrt{[15.82/(8 \times 7)]} \times 100$

$= 20.3$

$\simeq 20$ per cent.

**APPENDIX C**

**CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL**

For the purposes of assessing resources of sand and gravel a classification should take account of economically important characteristics of the deposit, in particular the absolute content of fines and the ratio of sand to gravel.

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (< $\frac{1}{16}$ mm) and coarser than pebbles (> 64 mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system, a modified binary classification based on Willman (1942) has been adopted.

When the fines content exceeds 40 per cent the material is considered to be not potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel but qualified in the light of the fines content, as follows: less than 10 per cent fines - no qualification; 10 per cent or more but less than 20 per cent fines - 'clayey'; 20 to 40 per cent fines - 'very clayey'.

The term 'clay' (as written, with single quote marks) is used to describe all material passing $\frac{1}{16}$ mm. Thus it has no mineralogical significance and includes particles falling within the size range of silt. The normal meaning applies to the term clay where it does not appear in single quotation marks.

The ratio of sand to gravel defines the boundaries between sand, pebbly sand, sandy gravel and gravel (at 19:1, 3:1 and 1:1).

Thus it is possible to classify the mineral into one of twelve descriptive categories (see the accompanying Figure). The procedure is as follows:

1 Classify according to the ratio of sand to gravel.
2 Describe the fines.

For example, a deposit grading 11 per cent gravel, 70 per cent sand and 19 per cent fines is classified as 'clayey' pebbly sand. This short description is included in the borehole log (see Appendix D)

Many differing proposals have been made for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1947). As Archer (1970a, b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$-mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology (see the accompanying table), which is used in the Report.

The fairly wide intervals in the scale are consistent with the general level of accuracy of the qualitative assessments of the resource blocks. Three sizes of sand are recognised, fine ($+\frac{1}{16}$ -$\frac{1}{4}$ mm), medium ($+\frac{1}{4}$ -1 mm) and coarse (+1 -4 mm). The boundary at 16 mm distinguishes a range of finer gravel (+4 -16 mm), often characterised by abundance of worn tough pebbles of vein quartz, from larger pebbles, often of notably different materials. The boundary at 64 mm distinguishes pebbles from cobbles. The term 'gravel' is used loosely to denote both pebble-sized and cobble-sized material.

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standards Institution, 1967). In this report the grading is tabulated on the borehole record sheets (Appendix E), the intercepts corresponding with the simple geometric scale $\frac{1}{16}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

Each bulk sample is described, subjectively, by a geologist at the borehole site. Being based on visual examination, the description of the grading is inexact, the accuracy depending on the experience of the observer. The descriptions recorded are modified, as necessary, when the laboratory results become available.

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'flint and quartz' indicates roughly equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constitutents are referred to as 'trace'.

The terms used in the field to describe the degree of rounding of particles, which is concerned with the sharpness of the edges and corners of a clastic fragment and not the shape (after Pettijohn, 1975), are as follows.

Angular: showing little or no evidence of wear; sharp edges and corners.

Subangular: showing definite effects of wear. Fragments still have their original form but edges and corners begin to be rounded off.

Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. Original grain shape is still distinct.

Rounded: original faces almost completely destroyed, but some comparatively flat surfaces may still remain. All original edges and corners have been smoothed off to rather broad curves. Original shape is still apparent.

Well rounded: not original faces, edges or corners left. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

Classification of gravel, sand and fines

| Size limits | Grain-size description | Qualification | Primary classification |
|---|---|---|---|
| | Cobble | | |
| 64 mm | | | |
| | | Coarse | Gravel |
| 16 mm | Pebble | | |
| | | Fine | |
| 4 mm | | | |
| | | Coarse | |
| 1 mm | | | |
| | Sand | Medium | Sand |
| $\frac{1}{4}$ mm | | | |
| | | Fine | |
| $\frac{1}{16}$ mm | | | |
| | Fines (silt and clay) | | Fines |

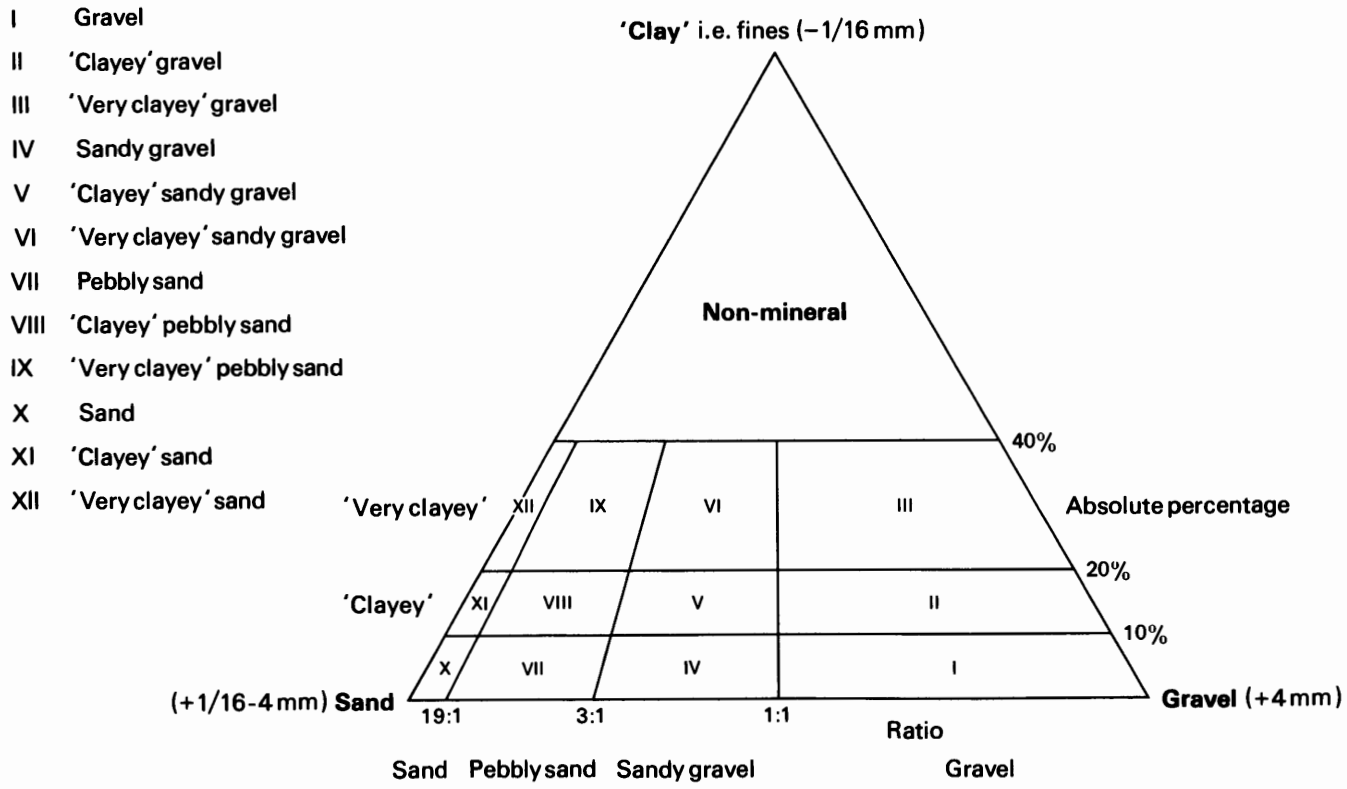



Diagram showing the descriptive categories used in the classification of sand and gravel

## APPENDIX D

## EXPLANATION OF THE BOREHOLE RECORDS

### Annotated fictitious example

**CK 66 NW 5**[1] **6191 6962**[2] **Northfields**[3] **Block B**

Surface level +49.7 m[4]
Water struck at +45.9 m[5]
October 1972[6]

Overburden[7] 2.8 m
Mineral 5.4 m
Waste 1.1 m
Mineral 1.4 m
Bedrock 0.7 m+[8]

**LOG**

| Geological classification | Lithology[9] | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.2 | 0.2 |
| Alluvium | Clay, silty, dark brown | 2.6 | 2.8 |
| River Terrace Deposits | **a** Gravel<br>Gravel: fine to coarse, with cobbles towards base, angular to rounded; flint and limestone with ironstone and some quartz and chalk<br>Sand: medium with coarse and some fine, quartz and limestone | 5.4 | 8.2 |
| Boulder Clay | Clay, sandy and pebbly, red-brown | 1.1 | 9.3 |
| Glacial Sand and Gravel | **b** Sand, 'clayey' in part: fine, subangular to rounded, quartz with some coal | 1.4 | 10.7 |
| Lias | Mudstone, blue-grey, fossiliferous | 0.7+ | 11.4 |

**GRADING**[10]

| | Mean for deposit percentages | | | Depth below surface (m) | percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 5 | 46 | 49 | 2.8-3.9 | 20 | 14 | 62 | 2 | 2 | 0 | 0 |
| | | | | 3.8-4.8 | 2 | 2 | 12 | 18 | 42 | 24 | 0 |
| | | | | 4.8-5.8 | 1 | 3 | 24 | 13 | 35 | 24 | 0 |
| | | | | 5.8-6.8 | 0 | 4 | 21 | 20 | 26 | 29 | 0 |
| | | | | 6.8-8.2 | 4 | 3 | 23 | 10 | 23 | 30 | 7 |
| | | | | **Mean** | **5** | **5** | **28** | **13** | **25** | **22** | **2** |
| **b** | 5 | 95 | 0 | 9.3-10.3 | 3 | 73 | 23 | 1 | 0 | 0 | 0 |
| | | | | 10.3-10.7 | 9 | 85 | 5 | 1 | 0 | 0 | 0 |
| | | | | **Mean** | **5** | **77** | **17** | **1** | **0** | **0** | **0** |
| **a+b** | **5** | **56** | **39** | **Mean** | **5** | **20** | **26** | **10** | **20** | **17** | **2** |

The numbered paragraphs below correspond with the annotations given on the specimen record opposite.

1 Borehole Registration Number
Each Industrial Minerals Assessment Unit (IMAU) borehole is identified by a Registration Number. This consists of two statements.

a The number of the 1:25 000 sheet on which the borehole lies, here CK 66.

b The quarter of the 1:25 000 sheet on which the borehole lies and the number of the borehole in a series for that quarter, here NW 5.

Thus the full Registration Number is CK 66 NW 5.

2 National Grid Reference
All National Grid References fall in the 100 km square identified by the first two letters of the Registration Number. Grid references are given to eight figures, accurate to within 10 m.

3 Location
The position of the borehole is generally referred to the nearest named locality on the 1:25 000 base map and the resource block in which the borehole lies is stated.

4 Surface level
The surface level at the borehole site is given in metres.

5 Groundwater conditions
If groundwater was present the level at which it was encountered is normally given (in metres relative to Ordnance Datum).

6 Type of drill and date of drilling
All boreholes were drilled by a shell and auger rig using 254 mm and 203 mm diameter casing. The month and year of completion of drilling are stated.

7 Overburden, mineral, waste and bedrock
Mineral is sand and gravel which, as part of a deposit, falls within the arbitrary definition of potentially workable material (see p. 1). Bedrock is the 'formation', 'country rock' or 'rock head' below which potentially workable sand and gravel will not be found. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8 The plus sign (+) indicated that the base of the deposit was not reached during drilling.

9 Lithological description
When sand and gravel is recorded a general description based on the grading characteristics (for details see Appendix C) is followed by more detailed particulars of the gravel and/or sand fraction. Where more than one bed of mineral is recognised each is designated by a letter, e.g. **a, b,** etc. The description of other deposits is based on visual examination in the field.

10 Grading data
A continuous series of bulk samples is taken throughout the thickness of sand and gravel. A new sample is commenced whenever there is an appreciable lithological change or at every 1 m of depth.

For each bulk sample the percentages of fines ($-\frac{1}{16}$ mm), fine sand ($+\frac{1}{16}$-$\frac{1}{4}$ mm), medium sand ($+\frac{1}{4}$-1 mm), coarse sand (+1-4 mm), fine gravel (+4-16 mm), coarse gravel (+16-64 mm) and cobble gravel (+64 mm) are stated.

The mean grading of groups of samples making up an identified bed of mineral are also given in detail and in summary. Where more than one bed is recognised the mean grading for the whole of the mineral in the borehole may be given. Where necessary, in calculating mean gradings, data for individual samples are weighted by the thickness represented. If, exceptionally, grading results are not available for a sample, an attempt may be made to estimate the grading by comparing the grading and field descriptions of adjacent samples with the sample in question. Such estimates are shown in square brackets. Alternatively, in calculating means, the sample may be allotted the mean grading of other samples in the deposit.

Fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures commonly suggests that in borehole samples the proportion of sand may be higher and the proportion of fines and coarse gravel may be lower.

**APPENDIX E**

**INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS**

**SE 29 NW 12** **2154 9851** **Catterick Road**

Surface level +79.8 m
Water seepage at +78.3 m
December 1979

Waste 7.0 m
Bedrock 0.1 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill and topsoil | 0.4 | 0.4 |
| Till | Clay, sandy, brown, pebbly and with pale grey silt stringers to 3.1 m, but grey and with boulders of chert and sandstone below | 6.6 | 7.0 |
| Namurian | Sandstone, pale grey, fine-grained, micaceous | 0.1+ | 7.1 |

**SE 29 NW 13** **2340 9863** **Catterick Racecourse** **Block A**

Surface level +59.6 m
Water struck at +47.4 m
November 1979

Overburden 2.7 m
Mineral 18.4 m
Waste 3.9 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| River Terrace, undifferentiated | Soil, thin, sandy, on light brown to moderate yellowish brown, soft, sandy silt with sand pockets and small Carboniferous sandstone and limestone pebbles | 2.7 | 2.7 |
| | Gravel<br>Gravel: fine and coarse with cobbles, subangular to well rounded; black and grey chert and limestone with some quartz, greywacke,red sandstone, Magnesian Limestone and Lake District igneous rocks<br>Sand: fine, medium and coarse, rounded to well rounded; quartz and rock fragments | 18.4 | 21.1 |
| Till | Clay, dark grey, hard, silty, with pebbles of chert, sandstone and mudstone | 3.9+ | 25.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| 6 | 39 | 55 | 2.7-3.7 | 11 | 8 | 5 | 7 | 15 | 33 | 21 |
| | | | 3.7-4.7 | 7 | 6 | 4 | 10 | 27 | 39 | 7 |
| | | | 4.7-5.7 | 11 | 14 | 11 | 11 | 19 | 19 | 15 |
| | | | 5.7-6.7 | 7 | 8 | 9 | 11 | 25 | 38 | 2 |
| | | | 6.7-7.7 | 8 | 9 | 13 | 13 | 27 | 26 | 4 |
| | | | 7.7-8.7 | 8 | 10 | 11 | 13 | 25 | 25 | 8 |
| | | | 8.7-9.7 | 7 | 9 | 13 | 10 | 24 | 35 | 2 |
| | | | 9.7-10.7 | 6 | 8 | 12 | 8 | 25 | 40 | 1 |
| | | | 10.7-11.7 | 9 | 15 | 13 | 12 | 19 | 30 | 2 |
| | | | 11.7-12.7 | 5 | 8 | 11 | 12 | 23 | 35 | 6 |
| | | | 12.7-13.7 | 2 | 7 | 17 | 10 | 21 | 39 | 4 |
| | | | 13.7-14.7 | 2 | 6 | 22 | 23 | 20 | 24 | 3 |
| | | | 14.7-15.7 | 4 | 7 | 20 | 27 | 20 | 17 | 5 |
| | | | 15.7-16.7 | 3 | 3 | 11 | 29 | 23 | 18 | 13 |
| | | | 16.7-17.7 | 3 | 4 | 16 | 26 | 22 | 16 | 13 |
| | | | 17.7-18.7 | 2 | 7 | 21 | 27 | 25 | 18 | 0 |
| | | | 18.7-19.7 | 3 | 8 | 19 | 22 | 17 | 20 | 11 |
| | | | 19.7-21.1 | 6 | 19 | 21 | 20 | 16 | 15 | 3 |
| | | | **Mean** | **6** | **9** | **14** | **16** | **22** | **26** | **7** |

**SE 29 NW 14** **2482 9721** **Castle Hills** **Block A**

Surface level +50.5 m
Water struck at +43.7 m
July 1979

Overburden 0.3 m
Mineral 14.2 m
Waste 2.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, silty, sandy | 0.3 | 0.3 |
| River Terrace undifferentiated | Gravel, with thin clay bands at around 6 m and 8 m<br>Gravel: fine and coarse, with some cobbles, subangular to well rounded; cream and brown sandstone and quartzite, black and pale grey chert and limestone with some quartz, red sandstone and Lake District granites and andesites<br>Sand: fine, medium and coarse, subrounded to well-rounded; quartz and rock fragments with some mica and coal debris | 14.2 | 14.5 |
| Till | Clay, reddish brown to 15 m, dark grey below, sandy in part; pebbles and boulders of cherty limestone, quartzite and sandstone | 2.5+ | 17.0 |
| | Borehole abandoned on limestone boulder | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 7 | 42 | 51 | 0.3-1.3 | 3 | 21 | 19 | 9 | 29 | 13 | 6 |
| | | | 1.3-2.3 | 10 | 14 | 10 | 8 | 29 | 29 | 0 |
| | | | 2.3-3.3 | 15 | 20 | 14 | 7 | 28 | 16 | 0 |
| | | | 3.3-4.3 | 15 | 30 | 13 | 9 | 18 | 15 | 0 |
| | | | 4.3-5.3 | 9 | 15 | 21 | 10 | 20 | 18 | 7 |
| | | | 5.3-6.3 | 13 | 18 | 35 | 9 | 14 | 11 | 0 |
| | | | 6.3-7.3 | 9 | 9 | 16 | 12 | 29 | 25 | 0 |
| | | | 7.3-8.3 | 4 | 10 | 18 | 16 | 28 | 23 | 1 |
| | | | 8.3-9.3 | 5 | 4 | 16 | 18 | 25 | 22 | 10 |
| | | | 9.3-10.3 | 7 | 8 | 17 | 17 | 24 | 23 | 4 |
| | | | 10.3-11.3 | 4 | 6 | 14 | 27 | 28 | 15 | 6 |
| | | | 11.3-12.3 | 3 | 4 | 12 | 18 | 32 | 25 | 6 |
| | | | 12.3-13.3 | 3 | 4 | 12 | 26 | 25 | 22 | 8 |
| | | | 13.3-14.5 | 2 | 2 | 10 | 7 | 34 | 32 | 13 |
| | | | **Mean** | **7** | **12** | **16** | **14** | **26** | **21** | **4** |

**SE 29 NW 15** **2282 9690** **Prospect Hill**

Surface level +88.3 m
Water not struck
December 1979

Waste 8.2 m
Bedrock 0.1 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, brown | 0.3 | 0.3 |
| Till | Clay, brown to 2.0 m, dark grey below, stiff, sandy and with pebbles of sandstone, quartzite and limestone | 7.9 | 8.2 |
| Magnesian Limestone | Limestone and dolomite, cream, with evaporite veins | 0.1+ | 8.3 |

**SE 29 NW 16** **2389 9584** **Appleton Cottages**

Surface level +77.4 m
Water not struck
October 1979

Waste 11.6 m
Bedrock 0.4 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill | 0.7 | 0.7 |
| Till | Clay, olive-brown and weathered to 1.3 m, grey and silty to 9.3 m, dark brown and hard below; pebbles of cherty limestone, sandstone and, below 9.3 m, Magnesian Limestone | 10.9 | 11.6 |
| Magnesian Limestone | Limestone, dolomitic, cream, hard | 0.4+ | 12.0 |

**SE 29 NE 12** **2539 9852** **Bolton Cross** **Block A**

Surface level +51.1 m
Water struck at +45.2 m
December 1979

Overburden 0.4 m
Mineral 8.0 m
Waste 1.2 m
Mineral 1.5 m
Waste 10.4 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, gravelly, clayey at base | 0.4 | 0.4 |
| River Terrace undifferentiated | **a** Gravel<br>Gravel: fine and coarse, with some cobbles, rounded; brown and white sandstone and quartzite and black and grey cherty limestone with some quartz, Magnesian Limestone and red sandstone<br>Sand: medium, coarse and fine, subangular to rounded; quartz and rock fragments | 8.0 | 8.4 |
| Till | Clay, greyish red to moderate reddish brown, hard, with pebbles of sandstone and quartzite | 1.2 | 9.6 |
| Glacial Sand and Gravel | **b** Sandy gravel<br>Gravel: fine and coarse; as above but with some pale grey mudstone and greywacke<br>Sand: coarse and medium with some fine; as above | 1.5 | 11.1 |
| Till | Clay, dark grey, hard, with pebbles and boulders of chert, limestone, cream and brown sandstone and, less commonly , Magnesian Limestone and red sandstone | 10.4+ | 21.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| **a** | 6 | 33 | 61 | 0.4-2.2 | 9 | 7 | 9 | 6 | 16 | 41 | 12 |
| | | | | 2.2-3.2 | 11 | 8 | 7 | 11 | 23 | 29 | 11 |
| | | | | 3.2-4.2 | 7 | 7 | 9 | 11 | 27 | 30 | 9 |
| | | | | 4.2-5.2 | 8 | 13 | 25 | 16 | 25 | 18 | 1 |
| | | | | 5.2-6.2 | 8 | 13 | 16 | 15 | 28 | 20 | 0 |
| | | | | 6.2-7.2 | 1 | 3 | 15 | 11 | 25 | 45 | 0 |
| | | | | 7.2-8.4 | 2 | 3 | 19 | 16 | 21 | 34 | 5 |
| | | | | **Mean** | **6** | **7** | **14** | **12** | **23** | **32** | **6** |
| **b** | 6 | 54 | 40 | 9.6-11.1 | 6 | 8 | 22 | 24 | 19 | 20 | 1 |
| **a+b** | **6** | **37** | **57** | **Mean** | **6** | **7** | **16** | **14** | **23** | **29** | **5** |

**SE 29 NE 13** **2654 9923** **Rushwood**

Surface level +56.3 m
Water seepage at bottom of hole
December 1979

Waste 16.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, brown | 0.4 | 0.4 |
| Till | Clay, brown to reddish brown to 7.7 m, dark grey below, partly silty, with pebbles and, below 7.7 m, boulders of chert, sandstone and limestone | 16.1+ | 16.5 |
| | Borehole abandoned on limestone boulder | | |

**SE 29 NE 14** **2605 9754** **Toft Hill** **Block A**

Surface level +42.8 m
Water level +42.0 m
December 1979

Overburden 0.6 m
Mineral 2.8 m
Waste 0.7 m
Mineral 4.4 m
Waste 5.8 m
Bedrock 0.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.6 | 0.6 |
| River Terrace, undifferentiated | **a** Gravel<br>Gravel: coarse with fine and some cobbles, mainly rounded; quartzite and limestone with some chert and sporadic Lake District igneous rocks, quartz and red sandstone | 2.8 | 3.4 |
| | Clay, moderate red, darkening to grey on exposure to air, poorly laminated, micaeous, and with small sandstone and limestone pebbles | 0.7 | 4.1 |
| | **b** Sandy gravel<br>Gravel: fine and coarse with some cobbles; as above but with high proportion of reddened Carboniferous limestone<br>Sand: mainly medium; as above | 4.4 | 8.5 |
| Till | Clay, dark brown to dark grey, stiff, silty and sandy below 13.3 m; boulders of limestone and sandstone | 5.8 | 14.3 |
| Sherwood Sandstone Group | Sandstone, red, hard | 0.2+ | 14.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| a | 3 | 26 | 71 | 0.6-1.6 | 4 | 6 | 7 | 10 | 14 | 41 | 18 |
| | | | | 1.6-3.4 | 3 | 2 | 9 | 18 | 27 | 37 | 4 |
| | | | | **Mean** | **3** | **3** | **8** | **15** | **22** | **40** | **9** |
| b | 6 | 53 | 41 | 4.1-5.3 | 9 | 17 | 39 | 15 | 14 | 6 | 0 |
| | | | | 5.3-6.3 | 5 | 8 | 34 | 13 | 20 | 20 | 0 |
| | | | | 6.3-7.3 | 3 | 5 | 35 | 15 | 20 | 22 | 0 |
| | | | | 7.3-8.5 | 6 | 6 | 14 | 12 | 24 | 31 | 7 |
| | | | | **Mean** | **6** | **9** | **30** | **14** | **19** | **20** | **2** |
| a+b | **5** | **43** | **52** | **Mean** | **5** | **7** | **22** | **14** | **20** | **27** | **5** |

**SE 29 NE 15** **2694 9778** **Ellerton Bridge** **Block A**

Surface level +43.3 m
Water level +40.8 m
December 1979

Overburden 1.4 m
Mineral 1.6 m
Waste 7.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, thin, on moderate yellowish brown, soft, micaceous pebbly clay | 1.4 | 1.4 |
| River Terrace, undifferentiated | Gravel<br>Gravel: coarse with fine and some cobble, rounded; black chert and limestone and brown and cream sandstone and quartzite<br>Sand: coarse with medium and fine, rounded; quartz and rock fragments | 1.6 | 3.0 |
| Till | Clay, dark grey, silty, with pebbles of limestone and sandstone | 7.0+ | 10.0 |
| | Borehole abandoned on boulder | | |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| | 3 | 24 | 73 | 1.4-3.0 | 3 | 4 | 8 | 12 | 18 | 49 | 6 |

**SE 29 NE 16** **2832 9703** **Kiplin Beck** **Block A**

Surface level +38.2 m
Water level +33.2 m
November 1979

Overburden 0.7 m
Mineral 4.3 m
Waste 9.7 m
Bedrock 0.3 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, clayey, on pale brown, micaceous, sandy clay | 0.7 | 0.7 |
| River Terrace, undifferentiated | 'Clayey' sandy gravel on 'very clayey' sand<br>Gravel: fine and coarse with some cobble; black chert and grey and brown sandstone and quartzite with some red sandstone<br>Sand: mainly fine, rounded; quartz and rock fragments<br>Fines: brown to reddish brown silt | 4.3 | 5.0 |
| ?Glacial Lake Deposits | Clay, greyish red to brownish grey, silty, laminated in parts, with small pebbles of chert and red and brown sandstone | 5.0 | 10.0 |
| Till | Clay, dark to pale grey, weathered at top, laminated below 11.6 m; stringers of reddish brown sandy silt and sandstone and chert pebbles | 4.7 | 14.7 |
| Sherwood Sandstone Group | Sandstone, red | 0.3+ | 15.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 23 | 52 | 25 | 0.7-2.5 | 14 | 10 | 13 | 8 | 23 | 30 | 2 |
| | | | 2.5-3.5 | 23 | 49 | 17 | 2 | 3 | 4 | 2 |
| | | | 3.5-5.0 | 35 | 55 | 9 | 1 | 0 | 0 | 0 |
| | | | **Mean** | **23** | **36** | **12** | **4** | **10** | **14** | **1** |

**SE 29 NE 17** **2537 9672** **Catterick airfield** **Block A**

Surface level +47.5 m
Water level +42.9 m
July 1979

Overburden 0.7 m
Mineral 20.5 m
Waste 0.8 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, pebbly | 0.7 | 0.7 |
| River Terrace, undifferentiated | **a** 'Clayey', sandy gravel<br>Gravel: fine and coarse, well rounded; black cherty limestone and brown and cream sandstone and quartzite with sporadic purple and greenish grey sandstone and coal<br>Sand: fine and medium with some coarse, subrounded; quartz and rock fragments<br>Fines: bands of reddish brown silt and pebbly clay | 10.0 | 10.7 |
| | **b** Gravel<br>Gravel: fine and coarse with some cobble; components as above but with sporadic pebbles of Magnesian Limestone and Lake District igneous rocks<br>Sand: fine, medium and coarse; as above | 10.5 | 21.2 |
| Till | Clay, dark grey, stiff, with pebbles of sandstone and cherty limestone | 0.8+ | 22.0 |
| | Borehole abandoned on dark grey limestone boulder | | |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 11 | 47 | 42 | 0.7-1.7 | 12 | 14 | 18 | 7 | 27 | 22 | 0 |
| | | | | 1.7-2.7 | 9 | 12 | 16 | 10 | 26 | 27 | 0 |
| | | | | 2.7-3.3 | 10 | 16 | 20 | 10 | 29 | 15 | 0 |
| | | | | 3.3-3.7 | 11 | 45 | 27 | 5 | 11 | 1 | 0 |
| | | | | 3.7-4.7 | 13 | 16 | 14 | 9 | 29 | 19 | 0 |
| | | | | 4.7-5.7 | 11 | 21 | 17 | 7 | 21 | 22 | 1 |
| | | | | 5.7-6.7 | 7 | 10 | 13 | 8 | 25 | 34 | 3 |
| | | | | 6.7-7.7 | 8 | 28 | 21 | 9 | 15 | 19 | 0 |
| | | | | 7.7-8.7 | 23 | 20 | 18 | 10 | 17 | 12 | 0 |
| | | | | 8.7-9.7 | 8 | 12 | 26 | 12 | 23 | 19 | 0 |
| | | | | 9.7-107 | 7 | 11 | 32 | 21 | 18 | 11 | 0 |
| | | | | **Mean** | **11** | **17** | **20** | **10** | **22** | **19** | **1** |
| **b** | 3 | 30 | 67 | 10.7-11.7 | 3 | 6 | 18 | 16 | 25 | 27 | 5 |
| | | | | 11.7-12.7 | 2 | 4 | 10 | 8 | 25 | 41 | 10 |
| | | | | 12.7-13.7 | 4 | 6 | 19 | 11 | 24 | 33 | 3 |
| | | | | 13.7-14.7 | 3 | 6 | 13 | 6 | 22 | 44 | 6 |
| | | | | 14.7-15.7 | 5 | 11 | 22 | 6 | 25 | 22 | 9 |
| | | | | 15.7-16.7 | 1 | 2 | 8 | 17 | 36 | 30 | 6 |
| | | | | 16.7-17.7 | 2 | 4 | 11 | 13 | 30 | 33 | 7 |
| | | | | 17.7-18.7 | 1 | 4 | 14 | 13 | 26 | 37 | 5 |
| | | | | 18.7-19.7 | 1 | 3 | 11 | 11 | 23 | 39 | 12 |
| | | | | 19.7-20.7 | 5 | 5 | 11 | 8 | 23 | 38 | 10 |
| | | | | 20.7-21.2 | 2 | 3 | 16 | 17 | 30 | 30 | 2 |
| | | | | **Mean** | **3** | **5** | **14** | **11** | **26** | **34** | **7** |
| **a+b** | **7** | **39** | **54** | **Mean** | **7** | **11** | **17** | **11** | **25** | **25** | **4** |

**SE 29 NE 18** **2666 9649** **Killerby Hall** **Block A**

Surface level +40.8 m
Water struck at +39.4 m
November 1979

Overburden 0.8 m
Mineral 7.6 m
Waste 7.2 m
Bedrock 0.1 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy, clayey | 0.8 | 0.8 |
| Alluvium | Gravel<br>Gravel: fine and coarse with some cobbles in upper part, subrounded to well rounded; black chert and limestone and brown quartzite and sandstone with some red sandstone and Magnesian Limestone<br>Sand: mainly medium and coarse, rounded; quartz and rock fragments | 7.6 | 8.4 |
| Till | Clay, dark grey, hard, with pebbles of red and brown sandstone, Carboniferous limestone, Magnesian Limestone, quartzite and mudstone | 7.2 | 15.6 |
| Magnesian Limestone | Limestone, cream, hard, with calcite veins | 0.1+ | 15.7 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 2 | 40 | 58 | 0.8-1.8 | 1 | 4 | 9 | 19 | 26 | 28 | 13 |
| | | | 1.8-2.8 | 3 | 4 | 12 | 18 | 31 | 25 | 7 |
| | | | 2.8-3.8 | 3 | 5 | 13 | 17 | 22 | 31 | 9 |
| | | | 3.8-4.8 | 2 | 5 | 27 | 20 | 16 | 30 | 0 |
| | | | 4.8-5.8 | 2 | 4 | 18 | 23 | 39 | 14 | 0 |
| | | | 5.8-6.8 | 1 | 1 | 2 | 6 | 63 | 27 | 0 |
| | | | 6.8-7.8 | 1 | 4 | 33 | 21 | 29 | 12 | 0 |
| | | | 7.8-8.4 | 3 | 4 | 32 | 19 | 25 | 14 | 3 |
| | | | **Mean** | **2** | **4** | **18** | **18** | **31** | **23** | **4** |

**SE 29 NE 19** **2771 9679** **Kiplin** **Block A**

Surface level +37.6 m
Water level +36.1 m
December 1979

Overburden 0.6 m
Mineral 6.6 m
Waste 1.0 m
Bedrock 0.3 m+

## LOG

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, silty | 0.6 | 0.6 |
| Alluvium | Gravel<br>Gravel: fine and coarse with some cobbles in upper part, well rounded; limestone, chert, sandstone and quartzite with some Lake District igneous rock and Magnesian Limestone<br>Sand: mainly medium and coarse, rounded; quartz and rock fragments | 6.6 | 7.2 |
| Till | Clay, reddish brown to dark grey, stiff, silty, pebbly | 1.0 | 8.2 |
| Sherwood Sandstone Group | Sandstone, red | 0.3+ | 8.5 |

## GRADING

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 3 | 32 | 65 | 0.6-1.6 | 2 | 4 | 9 | 8 | 21 | 50 | 6 |
| | | | 1.6-2.6 | 6 | 9 | 13 | 10 | 40 | 37 | 11 |
| | | | 2.6-3.6 | 1 | 4 | 12 | 13 | 30 | 39 | 1 |
| | | | 3.6-4.6 | 2 | 3 | 20 | 13 | 29 | 33 | 0 |
| | | | 4.6-5.6 | 3 | 5 | 26 | 15 | 34 | 17 | 0 |
| | | | 5.6-6.6 | 3 | 6 | 13 | 13 | 33 | 32 | 0 |
| | | | 6.6-7.2 | 5 | 6 | 16 | 17 | 26 | 29 | 1 |
| | | | **Mean** | **3** | **5** | **15** | **12** | **27** | **35** | **3** |

**SE 29 NE 20** **2921 9602** **North Lowfield** **Block A**

Surface level +35.4 m
Water level +31.6 m
November 1979

Overburden 0.3 m
Mineral 4.5 m
Waste 8.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy, pale brown | 0.3 | 0.3 |
| Alluvium | Gravel<br>Gravel: fine and coarse with some cobbles, rounded to well rounded; cherty limestone and iron-stained sandstone<br>Sand: fine, medium and coarse, subrounded; quartz and rock fragments | 4.5 | 4.8 |
| ?Glacial Lake Deposits | Clay, moderate brown to dark yellowish brown, stiff, laminated and micaceous; sporadic small chert pebbles | 6.4 | 11.2 |
| | Clay, dark grey, silty, laminated, soft | 0.2 | 11.4 |
| Till | Clay, dark grey, stiff, with pebbles of angular sandstone, chert and limestone. Towards base contains much angular red sandstone and mudstone | 1.6+ | 13.0 |
| | Borehole abandoned because of obstruction | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 9 | 35 | 56 | 0.3-1.3 | 20 | 23 | 21 | 5 | 11 | 18 | 2 |
| | | | 1.3-2.3 | 8 | 13 | 14 | 9 | 17 | 31 | 8 |
| | | | 2.3-3.3 | 7 | 12 | 7 | 14 | 23 | 34 | 3 |
| | | | 3.3-4.8 | 3 | 4 | 10 | 11 | 25 | 41 | 6 |
| | | | **Mean** | **9** | **12** | **13** | **10** | **19** | **32** | **5** |

**SE 29 NE 21** **2506 9583** **Leases Lane** **Block D**

Surface level +57.1 m
Water not struck
November 1979

Overburden 5.2 m
Mineral 8.3 m
Waste 5.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, sandy | 0.5 | 0.5 |
| Till | Clay, dark grey to dark brown, hard, sandy in parts, with polished boulders of Carboniferous limestone, chert and sandstone and some mudstone pebbles | 4.7 | 5.2 |
| Glacial Sand and Gravel | Gravel<br>Gravel: fine and coarse with some cobbles, angular to rounded; Carboniferous sandstone, quartzite and cherty limestone with some quartz and Lake District volcanic rock<br>Sand: mainly medium and coarse, rounded; quartz and rock fragments | 8.3 | 13.5 |
| Till | Clay, mid- to dark grey, hard, sandy in parts, with rounded cobbles and pebbles of cherty limestone and sandstone | 5.5+ | 19.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 7 | 33 | 60 | 5.2-6.2 | 14 | 12 | 16 | 15 | 21 | 19 | 3 |
| | | | 6.2-7.2 | 13 | 14 | 13 | 14 | 23 | 23 | 0 |
| | | | 7.2-8.2 | 4 | 6 | 5 | 6 | 22 | 48 | 9 |
| | | | 8.2-9.2 | 11 | 10 | 11 | 10 | 21 | 32 | 5 |
| | | | 9.2-10.2 | 6 | 6 | 7 | 9 | 21 | 46 | 5 |
| | | | 10.2-11.2 | 4 | 6 | 16 | 12 | 26 | 34 | 2 |
| | | | 11.2-12.2 | 4 | 7 | 17 | 13 | 19 | 33 | 7 |
| | | | 12.2-13.5 | 3 | 6 | 16 | 17 | 22 | 32 | 4 |
| | | | **Mean** | **7** | **8** | **13** | **12** | **22** | **34** | **4** |

**SE 29 NE 22** **2545 9519** **East Appleton** **Block D**

Surface level +49.4 m
Water level not recorded
October 1979

Overburden 3.3 m
Mineral 11.0 m
Waste 7.7 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| Till | Clay, olive-brown, sandy, with some limestone and sandstone pebbles | 3.3 | 3.3 |
| Glacial Sand and Gravel | Gravel<br>Gravel: fine and coarse with some cobbles, rounded; Carboniferous Limestone and sandstone with some shale and Permo-Triassic sandstone and mudstone<br>Sand: mainly medium and coarse, subangular to rounded; quartz and rock fragments | 11.0 | 14.3 |
| Till | Clay, brown, silty, weakly laminated and stone-free to 14.8 m, dark grey and hard, with pebbles of sandstone, quartz and limestone below | 7.7+ | 22.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 6 | 45 | 49 | 3.3-4.3 | 17 | 16 | 8 | 9 | 15 | 26 | 9 |
| | | | 4.3-5.3 | 19 | 17 | 8 | 9 | 14 | 25 | 8 |
| | | | 5.3-5.8 | 18 | 17 | 10 | 12 | 18 | 17 | 8 |
| | | | 5.8-6.8 | 10 | 9 | 11 | 15 | 25 | 29 | 1 |
| | | | 6.8-7.8 | 4 | 6 | 15 | 14 | 29 | 30 | 2 |
| | | | 7.8-8.8 | 2 | 2 | 15 | 17 | 30 | 29 | 5 |
| | | | 8.8-9.8 | 2 | 4 | 32 | 15 | 18 | 23 | 6 |
| | | | 9.8-10.8 | 2 | 9 | 31 | 19 | 20 | 19 | 0 |
| | | | 10.8-11.8 | 1 | 13 | 46 | 11 | 10 | 18 | 1 |
| | | | 11.8-12.8 | 2 | 8 | 34 | 17 | 18 | 21 | 0 |
| | | | 12.8-14.3 | 2 | 5 | 22 | 18 | 26 | 25 | 2 |
| | | | **Mean** | **6** | **9** | **22** | **14** | **21** | **25** | **3** |

**SE 29 NE 23** **2604 9595** **Killerby Hall** **Block B**

Surface level +42.1 m
Water level +41.4 m
November 1979

Overburden 4.2 m
Mineral 10.3 m
Waste 9.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, brown, sandy | 0.4 | 0.4 |
| Lacustrine Alluvium | Peat, dark grey, silty | 1.4 | 1.8 |
| | Silt, white to 3.6 m, dark grey and organic below, soft, sandy in parts; contains fresh water gastropods and ostracods | 2.4 | 4.2 |
| River Terraces, undifferentiated | Gravel and sandy gravel<br>Gravel: fine and coarse with some cobbles, angular to well rounded; brown, white and grey Carboniferous sandstone and quartzite and black and grey limestone and chert with some reddened limestone and sporadic quartz, Lake District volcanic and granitic rocks and Magnesian Limestone<br>Sand: mainly coarse and medium, subrounded to well rounded; quartz and rock fragments with some mica and coal | 10.3 | 14.5 |
| | Silt, grey to dark grey, soft, sandy | 2.0 | 16.5 |
| Till | Clay, dark grey, hard, silty towards base, with pebbles of sandstone, limestone and chert | 5.2 | 21.7 |
| | Silt, dark grey, micaceous, with fine sand lenses; some black cherty limestone cobbles below 23 m | 2.3+ | 24.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 3 | 53 | 44 | 4.2-5.2 | 5 | 6 | 9 | 13 | 26 | 35 | 6 |
| | | | 5.2-6.2 | 4 | 6 | 17 | 24 | 19 | 20 | 10 |
| | | | 6.2-7.2 | 5 | 6 | 21 | 26 | 15 | 15 | 12 |
| | | | 7.2-8.2 | 1 | 2 | 6 | 27 | 12 | 22 | 30 |
| | | | 8.2-9.2 | 1 | 2 | 16 | 36 | 21 | 13 | 11 |
| | | | 9.2-10.2 | 4 | 8 | 24 | 30 | 16 | 12 | 6 |
| | | | 10.2-11.2 | 3 | 4 | 11 | 30 | 28 | 12 | 12 |
| | | | 11.2-12.2 | 2 | 4 | 26 | 26 | 24 | 13 | 5 |
| | | | 12.2-13.2 | 2 | 5 | 40 | 26 | 21 | 4 | 0 |
| | | | 13.2-14.5 | 4 | 12 | 20 | 38 | 25 | 1 | 0 |
| | | | **Mean** | **3** | **5** | **19** | **29** | **21** | **14** | **9** |

**SE 29 NE 24** **2753 9559** **Hook Carr Hill** **Block B**

Surface level +51.8 m
Water struck at +50.3 m
January 1980

Overburden 0.9 m
Mineral 1.6 m
Waste 5.1 m
Mineral 5.0 m
Waste 9.9 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, thin, sandy, on pale brown to yellowish orange clay with sand pockets and small rounded sandstone pebbles | 0.9 | 0.9 |
| Glacial Sand and Gravel | **a** 'Very clayey' sandy gravel<br>Gravel: fine and coarse, rounded; black limestone and brown and grey sandstone<br>Sand: fine, medium and coarse, subangular; quartz and rock fragments<br>Fines: yellowish brown micaceous clay | 1.6 | 2.5 |
| Till | Clay, moderate to greyish brown, hard, with small pebbles of cherty limestone and sandstone; becomes darker towards base, with larger pebbles | 5.1 | 7.6 |
| Glacial Sand and Gravel | **b** 'Clayey' pebbly sand<br>Gravel: fine and coarse, rounded; black cherty limestone and brown, greenish and red sandstone with some quartz and shale<br>Sand: fine and medium with some coarse, well rounded; quartz and rock fragments including some coal<br>Fines: reddish brown silt | 5.0 | 12.6 |
| ?Glacial Lake Deposits | Clay, reddish brown, silty, poorly laminated, with lenses of fine, micaceous sand | 9.9+ | 22.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| **a** | 25 | 40 | 35 | 0.9-2.5 | 25 | 18 | 9 | 13 | 18 | 17 | 0 |
| b | 14 | 77 | 9 | 7.6-9.6 | 28 | 66 | 5 | 1 | 0 | 0 | 0 |
| | | | | 9.6-10.6 | 3 | 15 | 42 | 17 | 13 | 10 | 0 |
| | | | | 10.6-12.6 | 5 | 26 | 50 | 9 | 5 | 5 | 0 |
| | | | | **Mean** | **14** | **39** | **30** | **8** | **5** | **4** | **0** |
| **a+b** | **16** | **69** | **15** | **Mean** | **16** | **35** | **25** | **9** | **8** | **7** | **0** |

**SE 29 NE 25** **2858 9504** **Kirkby Wood** **Block B**

Surface level +49.1 m
Water struck at +35.1 m
November 1979

Overburden 9.6 m
Mineral 5.3 m
Waste 0.6 m
Bedrock 0.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, clayey | 0.4 | 0.4 |
| Till | Clay, moderate brown with vertical grey joints and pebbles of sandstone, quartzite, limestone and quartz; less stony and with greenish red silty bands below 5.3 m | 9.2 | 9.6 |
| Glacial Sand and Gravel | 'Clayey' pebbly sand<br>Gravel: fine, rounded; sandstone and limestone with some quartzite<br>Sand: medium and fine with some coarse, subangular to sub-rounded; quartz and rock fragments including some coal<br>Fines: brown silt | 5.3 | 14.9 |
| Till | Clay, olive-black with pebbles of limestone and sandstone | 0.6 | 15.5 |
| Sherwood Sandstone Group | Sandstone, dark reddish brown, medium-grained, poorly cemented | 0.2+ | 15.7 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 13 | 81 | 6 | 9.6-10.6 | 20 | 18 | 34 | 19 | 9 | 0 | 0 |
| | | | 10.6-11.6 | 9 | 15 | 32 | 26 | 11 | 7 | 0 |
| | | | 11.6-12.6 | 9 | 28 | 53 | 7 | 3 | 0 | 0 |
| | | | 12.6-13.6 | 16 | 38 | 39 | 6 | 1 | 0 | 0 |
| | | | 13.6-14.9 | 12 | 33 | 53 | 1 | 1 | 0 | 0 |
| | | | **Mean** | **13** | **27** | **43** | **11** | **5** | **1** | **0** |

**SE 29 NE 26** **2977 9522** **North Lowfield** **Block A**

Surface level +31.2 m
Water struck at +30.0 m
November 1979

Overburden 0.8 m
Mineral 2.2 m
Waste 0.3 m
Mineral 3.2 m
Waste 5.5 m
?Bedrock -

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy, peaty | 0.3 | 0.3 |
| Alluvium | Clay, yellowish brown, micaceous | 0.5 | 0.8 |
| | a Gravel<br>Gravel: fine and coarse, subangular to rounded; sandstone and some limestone with occasional Lake District volcanic rocks and Magnesian Limestone<br>Sand: medium with fine and coarse, subangular to subrounded; quartz and rock fragments including some coal | 2.2 | 3.0 |
| | Clay, reddish brown to grey, stiff, silty, with polished chert and sandstone pebbles | 0.3 | 3.3 |
| | 'Clayey' sand<br>Sand: mainly fine, subrounded; quartz and rock fragments<br>Fines: reddish brown silt | 3.2 | 6.5 |
| ?Glacial Lake Deposits | Clay, reddish brown, silty, laminated | 3.8 | 10.3 |
| Till | Clay, dark grey, with pebbles of dark grey limestone and cream and red sandstone; increasing proportion of angular red sandstone pebbles and red sand towards base | 1.7 | 12.0 |
| Sherwood Sandstone Group | Sandstone, red | - | 12.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| a | 5 | 45 | 50 | 0.8-1.8 | 7 | 7 | 12 | 13 | 26 | 34 | 1 |
| | | | | 1.8-3.0 | 4 | 15 | 35 | 9 | 10 | 21 | 6 |
| | | | | **Mean** | **5** | **11** | **24** | **10** | **17** | **29** | **4** |
| b | 19 | 81 | 0 | 3.3-6.5 | 19 | 60 | 20 | 10 | 0 | 0 | 0 |
| **a+b** | **13** | **67** | **20** | **Mean** | **13** | **40** | **22** | **5** | **7** | **11** | **2** |

**SE 29 SW 7** **2253 9408** **Hornby Castle**

Surface level +96.0 m
Water level +81.7 m
June 1979

Overburden 0.6 m
Mineral 1.6 m
Waste 16.8 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, pale brown, sandy | 0.3 | 0.3 |
| | Clay, brown, sandy, pebbly | 0.3 | 0.6 |
| Glacial Sand and Gravel | 'Clayey' sandy gravel<br>Gravel: mainly fine, subangular to well rounded; chert, sandstone and limestone with some shale<br>Sand: mainly medium and fine, subangular to rounded; quartz and rock fragments<br>Fines: brownish silt | 1.6 | 2.2 |
| Till | Clay, brown, sandy and pebbly to 4.4 m, becomes medium to dark grey, hard, silty, with sand lenses, and boulders and pebbles of grey chert and limestone, cream sandstone and quartzite and purplish and red sandstone | 16.8+ | 19.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 11 | 55 | 34 | 0.6-1.6 | 8 | 14 | 31 | 11 | 22 | 14 | 0 |
| | | | 1.6-2.2 | 16 | 22 | 25 | 7 | 18 | 8 | 4 |
| | | | **Mean** | **11** | **17** | **29** | **9** | **21** | **12** | **1** |

**SE 29 SW 8** **2344 9411** **Hornby Castle** **Block C**

Surface level +66.0 m
Water level +63.3 m
December 1979

Overburden 0.6 m
Mineral 4.2 m
Waste 6.9 m
?Bedrock -

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, dark brown, clayey, on thin brown sandy clay | 0.6 | 0.6 |
| Glacial Sand and Gravel | Gravel<br>Gravel: fine and coarse with some cobbles, subangular to rounded; cream quartzite and sandstone and black chert and limestone with some quartz, Lake District volcanic rocks and Magnesian Limestone<br>Sand: fine, medium and coarse, rounded; quartz and rock fragments | 4.2 | 4.8 |
| Till | Clay, brown and sandy at top becoming dark grey, with boulders of quartzite and cherty limestone | 6.9 | 11.7 |
| ?Namurian | Limestone, hard, dark grey - ?bedrock | - | 11.7 |
| | Borehole abandoned owing to lack of progress | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 7 | 33 | 60 | 0.6-1.6 | 12 | 8 | 7 | 9 | 18 | 41 | 5 |
| | | | 1.6-2.6 | 8 | 11 | 9 | 11 | 19 | 30 | 12 |
| | | | 2.6-3.6 | 3 | 9 | 10 | 10 | 25 | 33 | 10 |
| | | | 3.6-4.8 | 4 | 7 | 16 | 18 | 22 | 33 | 0 |
| | | | **Mean** | **7** | **9** | **11** | **13** | **21** | **33** | **6** |

**SE 29 SW 9** **2460 9470** **Gyll Hall** **Block C**

Surface level +52.0 m
Water level +47.7 m
October 1979

Overburden 1.0 m
Mineral 1.3 m
Waste 1.4 m
Mineral 4.2 m
Waste 0.6 m
Mineral 3.0 m
Bedrock 2.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 1.0 | 1.0 |
| Glacial Sand and Gravel | **a** 'Clayey' pebbly sand<br>Gravel: fine and coarse, rounded; chert, sandstone and quartzite<br>Sand: fine and medium, rounded; quartz and rock fragments<br>Fines: yellowish brown silt | 1.3 | 2.3 |
| Till | Clay, yellowish brown to dark grey, stiff, sandy, with rounded and striated pebbles of limestone and sandstone | 1.4 | 3.7 |
| Glacial Sand and Gravel | **b** Gravel<br>Gravel: fine and coarse with some cobbles, subangular to well rounded; dark grey cherty limestone, quartzite and sandstone, with some quartz and red sandstone<br>Sand: fine, medium and coarse, rounded; quartz and rock fragments | 4.2 | 7.9 |
| Till | Clay, dark grey, stiff, with chert, limestone and sandstone pebbles | 0.6 | 8.5 |
| Glacial Sand and Gravel | **c** Gravel, as above, but with high proportion of Magnesian Limestone | 3.0 | 11.5 |
| Magnesian Limestone | Limestone, cream to brown, dolomitic, with calcite-filled vugs | 2.5+ | 14.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 19 | 62 | 19 | 1.0-2.3 | 19 | 34 | 22 | 6 | 11 | 6 | 2 |
| **b** | 9 | 38 | 53 | 3.7-4.7 | 15 | 17 | 15 | 12 | 20 | 17 | 4 |
| | | | | 4.7-5.7 | 14 | 11 | 9 | 7 | 22 | 32 | 5 |
| | | | | 5.7-6.7 | 5 | 6 | 11 | 10 | 29 | 37 | 2 |
| | | | | 6.7-7.9 | 4 | 4 | 30 | 19 | 25 | 17 | 1 |
| | | | | **Mean** | **9** | **9** | **17** | **12** | **24** | **26** | **3** |
| **c** | 6 | 28 | 66 | 8.5-9.5 | 7 | 9 | 9 | 13 | 22 | 34 | 6 |
| | | | | 9.5-10.5 | 4 | 5 | 8 | 12 | 23 | 30 | 18 |
| | | | | 10.5-11.5 | 6 | 9 | 9 | 9 | 21 | 32 | 14 |
| | | | | **Mean** | **6** | **7** | **9** | **12** | **22** | **31** | **13** |
| **a+b+c** | **9** | **38** | **53** | **Mean** | **9** | **12** | **15** | **11** | **21** | **26** | **6** |

**SE 29 SW 10** **2382 9372** **Hornby Castle** **Block C**

Surface level +55.6 m
Water not struck
June 1979

Overburden 1.0 m
Mineral 1.7 m
Waste 0.5 m
Mineral 2.0 m
Waste 5.3 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, brown, on stiff, pebbly, brown clay | 1.0 | 1.0 |
| Glacial Sand and Gravel | **a** 'Clayey' gravel<br>Gravel: fine and coarse with some cobbles, well rounded; chert, limestone and sandstone<br>Sand: fine, medium and coarse, subangular to well rounded; quartz and rock fragments<br>Fines: brown | 1.7 | 2.7 |
| Till | Clay, moderate brown, very sandy, hard, with pebbles of limestone, chert and quartzite | 0.5 | 3.2 |
| Glacial Sand and Gravel | **b** 'Clayey' gravel<br>Gravel: coarse with fine and some cobble; as above<br>Sand: as above<br>Fines: brown clay bands | 2.0 | 5.2 |
| Till | Clay, moderate brown at top, dark grey below, silty; some sand lenses, pebbles and boulders of cherty limestone, quartzite and sandstone | 5.3+ | 10.5 |
| | Borehole abandoned on boulders | | |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 11 | 33 | 56 | 1.0-2.0 | 11 | 13 | 11 | 7 | 21 | 32 | 5 |
| | | | | 2.0-2.7 | 11 | 13 | 13 | 10 | 25 | 26 | 2 |
| | | | | **Mean** | **11** | **13** | **12** | **8** | **23** | **30** | **3** |
| **b** | 15 | 18 | 67 | 3.2-4.3 | 18 | 11 | 6 | 5 | 18 | 31 | 11 |
| | | | | 4.3-5.2 | 13 | 6 | 5 | 4 | 19 | 42 | 11 |
| | | | | **Mean** | **15** | **8** | **6** | **4** | **18** | **38** | **11** |
| **a+b** | **14** | **25** | **61** | **Mean** | **14** | **10** | **9** | **6** | **20** | **34** | **7** |

**SE 29 SW 11** **2497 9402** **Goskins Plantation** **Block C**

Surface level +45.4 m
Water level +44.9 m
January 1980

Overburden 0.5 m
Mineral 5.8 m
Waste 1.0 m
Mineral 1.3 m
Waste 2.7 m
Mineral 6.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, peaty, black, on pale grey clay with organic debris | 0.5 | 0.5 |
| Glacial Sand and Gravel | **a** Gravel<br>Gravel: fine and coarse with cobbles in parts, angular to well rounded; black chert and limestone and brown and grey sandstone with some Magnesian Limestone, quartz, red sandstone and Lake District igneous rocks<br>Sand: mainly medium and coarse, rounded; quartz and rock fragments | 5.8 | 6.3 |
| Till | Clay, dark grey, hard, with angular pebbles of sandstone and limestone | 1.0 | 7.3 |
| Glacial Sand and Gravel | **b** 'Clayey' sand, mainly medium, rounded; quartz and rock fragments | 1.3 | 8.6 |
| Till | Clay, brownish grey, soft, with angular pebbles of sandstone, quartzite and grey and cream limestone | 2.7 | 11.3 |
| Glacial Sand and Gravel | **c** Pebbly sand<br>Gravel: fine and coarse with cobbles in parts; as above<br>Sand: medium with fine and coarse; as above | 6.2+ | 17.5 |
| | Borehole abandoned because of rising sand | | |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 4 | 46 | 50 | 0.5-1.5 | 8 | 7 | 22 | 10 | 21 | 32 | 0 |
| | | | | 1.5-2.5 | 5 | 9 | 23 | 13 | 21 | 29 | 0 |
| | | | | 2.5-3.5 | 1 | 4 | 20 | 17 | 23 | 35 | 0 |
| | | | | 3.5-4.5 | 2 | 4 | 20 | 20 | 24 | 22 | 8 |
| | | | | 4.5-5.5 | 4 | 14 | 31 | 23 | 17 | 11 | 0 |
| | | | | 5.5-6.3 | 2 | 9 | 10 | 13 | 26 | 37 | 3 |
| | | | | **Mean** | **4** | **8** | **22** | **16** | **21** | **27** | **2** |
| **b** | 11 | 85 | 4 | 7.3-8.6 | 11 | 24 | 55 | 6 | 2 | 2 | 0 |
| **c** | 7 | 72 | 21 | 11.3-12.3 | 9 | 11 | 26 | 27 | 9 | 18 | 0 |
| | | | | 12.3-13.3 | 5 | 12 | 40 | 26 | 9 | 8 | 0 |
| | | | | 13.3-14.3 | 5 | 12 | 47 | 25 | 9 | 2 | 0 |
| | | | | 14.3-16.2 | 10 | 29 | 34 | 11 | 9 | 3 | 4 |
| | | | | 16.2-17.5 | 5 | 16 | 29 | 13 | 16 | 21 | 0 |
| | | | | **Mean** | **7** | **18** | **35** | **19** | **10** | **10** | **1** |
| **a+b+c** | **6** | **62** | **32** | **Mean** | **6** | **14** | **32** | **16** | **14** | **17** | **1** |

**SE 29 SW 12** **2234 9213** **Arbour Hill**

Surface level +81.6 m
Water level not recorded
January 1980

Waste 9.0 m
?Bedrock -

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, clayey, pebbly | 0.4 | 0.4 |
| Till | Clay, brown to grey, hard, sandy, with pebbles and boulders of Carboniferous sandstone and limestone | 8.6 | 9.0 |
| ?Namurian | Limestone, dark grey, crinoidal, ?bedrock | - | 9.0 |
| | Borehole abandoned owing to lack of progress | | |

**SE 29 SW 13** **2412 9217** **Hollow Moor Lane** **Block C**

Surface level +56.8 m
Water level +51.8 m
October 1979

Overburden 2.5 m
Mineral 1.2 m
Waste 0.3 m
Mineral 2.3 m
Waste 4.5 m
Mineral 3.4 m
Waste 2.8 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.2 | 0.2 |
| | Clay, pale brown, stiff, sandy, with patches of dark grey clay, pebbles and cobbles of limestone and quartzite | 2.3 | 2.5 |
| Glacial Sand and Gravel | **a** 'Very clayey' gravel<br>Gravel: fine and coarse, rounded; sandstone, quartzite and limestone<br>Sand: fine, medium and coarse, rounded; quartz<br>Fines: brown silt | 1.2 | 3.7 |
| Till | Clay, dark grey, with limestone pebbles | 0.3 | 4.0 |
| Glacial Sand and Gravel | **b** Gravel<br>Gravel: fine and coarse with some cobbles; as above<br>Sand: coarse with fine and medium; as above | 2.3 | 6.3 |
| Till | Clay, dark grey, sandy, with pebbles of chert, limestone, quartz and red sandstone | 4.5 | 10.8 |
| Glacial Sand and Gravel | **c** Gravel<br>Gravel: fine and coarse; as above<br>Sand: fine, medium and coarse; as above | 3.4 | 14.2 |
| Till | Clay, dark grey, hard, with pebbles and boulders of limestone and sandstone | 2.8+ | 17.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| a | 20 | 39 | 41 | 2.5-3.7 | 20 | 17 | 11 | 11 | 26 | 15 | 0 |
| b | 4 | 34 | 62 | 4.0-5.4 | 5 | 8 | 7 | 11 | 28 | 25 | 16 |
| | | | | 5.4-6.3 | 3 | 5 | 10 | 29 | 28 | 23 | 2 |
| | | | | **Mean** | **4** | **7** | **9** | **18** | **27** | **24** | **11** |
| c | 2 | 37 | 61 | 10.8-11.8 | 3 | 7 | 9 | 8 | 29 | 44 | 0 |
| | | | | 11.8-12.8 | 3 | 7 | 16 | 11 | 21 | 31 | 11 |
| | | | | 12.8-14.2 | 1 | 10 | 26 | 12 | 20 | 26 | 5 |
| | | | | **Mean** | **2** | **8** | **18** | **11** | **23** | **33** | **5** |
| **a+b+c** | **6** | **36** | **58** | **Mean** | **6** | **9** | **14** | **13** | **25** | **27** | **6** |

**SE 29 SW 14** **2102 9155** **Carnaby House**

Surface level +87.1 m
Water level +81.6 m
February 1980

Waste 6.1 m
?Bedrock 0.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| Till | Clay, pale brown and soft to 1.4 m, dark grey and stiff below; pebbles of Carboniferous limestone, sandstone and chert | 6.1 | 6.1 |
| ?Namurian | Limestone, dark grey, shelly - ?bedrock | 0.2+ | 6.3 |

**SE 29 SW 15** **2367 9160** **Hunter's Hill** **Block C**

Surface level +55.6 m
Water standing at ground level
January 1980

Overburden 2.0 m
Mineral 3.6 m
Waste 1.3 m
Mineral 0.8 m
Waste 3.2 m
Mineral 1.1 m
?Bedrock 2.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, reddish brown, clayey | 0.6 | 0.6 |
| | Clay, reddish brown, sandy, organic to 1.2 m, becomes pebbly below | 1.4 | 2.0 |
| Glacial Sand and Gravel | **a** 'Clayey' gravel<br>Gravel: coarse and fine with some cobbles, rounded; chert, limestone, sandstone and quartzite<br>Sand: fine, medium and coarse, rounded; quartz and rock fragments<br>Fines: brown silt | 3.6 | 5.6 |
| Till | Clay, brownish grey, stiff, pebbly | 1.3 | 6.9 |

| | | | |
|---|---|---|---|
| Glacial Sand and Gravel | **b** Gravel<br>Gravel: fine and coarse with some cobbles; as above<br>Sand: coarse with fine and medium; as above | 0.8 | 7.7 |
| Till | Clay, dark grey, hard, with rounded and striated pebbles of cherty limestone and sandstone | 3.2 | 10.9 |
| Glacial Sand and Gravel | **c** Sandy gravel<br>Gravel: fine and coarse, angular to rounded; sandstone with some limestone, chert and quartz<br>Sand: mainly medium , subrounded; quartz and rock fragments | 1.1 | 12.0 |
| ?Namurian | Sandstone, grey, fine to medium-grained, felspathic, friable: ?bedrock or large erratic | 2.0+ | 14.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 16 | 28 | 56 | 2.0-3.4 | 33 | 14 | 6 | 8 | 11 | 24 | 4 |
| | | | | 3.4-4.4 | 5 | 5 | 9 | 14 | 19 | 29 | 19 |
| | | | | 4.4-5.6 | 7 | 5 | 8 | 14 | 29 | 32 | 5 |
| | | | | **Mean** | **16** | **8** | **8** | **12** | **19** | **29** | **8** |
| **b** | 6 | 33 | 61 | 6.9-7.7 | 6 | 8 | 9 | 16 | 24 | 29 | 8 |
| **c** | 7 | 69 | 24 | 10.9-12.0 | 7 | 19 | 41 | 9 | 11 | 13 | 0 |
| **a+b+c** | **13** | **36** | **51** | **Mean** | **13** | **10** | **14** | **12** | **19** | **25** | **7** |

**SE 29 SW 16** **2482 9162** **West Farm** **Block C**

Surface level +51.8 m
Water level +46.3 m
September 1979

Overburden 1.2 m
Mineral 9.1 m
Waste 9.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill | 0.7 | 0.7 |
| | Clay, sandy, pebbly | 0.5 | 1.2 |
| Glacial Sand and Gravel | 'Clayey' sandy gravel<br>Gravel: fine and coarse, angular to rounded; cherty limestone, quartzite and sandstone with some quartz and granitic and andesitic rocks<br>Sand: fine, medium and coarse, subangular to well rounded; quartz and rock fragments<br>Fines: grey clay bands | 9.1 | 10.3 |
| Till | Clay, dark grey, stiff, with striated boulders of sandstone and cherty limestone | 9.2+ | 19.5 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Fines | Sand | | | Gravel | | |
| Fines | Sand | Gravel | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 14 | 49 | 37 | 1.2-2.2 | 35 | 27 | 8 | 10 | 11 | 9 | 0 |
| | | | 2.2-3.4 | 13 | 19 | 13 | 8 | 20 | 23 | 4 |
| | | | 3.4-5.4 | 16 | 17 | 21 | 9 | 23 | 14 | 0 |
| | | | 5.4-7.4 | 17 | 24 | 19 | 9 | 17 | 14 | 0 |
| | | | 7.4-8.4 | 4 | 22 | 19 | 11 | 27 | 17 | 0 |
| | | | 8.4-9.4 | 7 | 16 | 15 | 25 | 25 | 12 | 0 |
| | | | 9.4-10.3 | 5 | 10 | 17 | 20 | 25 | 22 | 1 |
| | | | **Mean** | **14** | **20** | **17** | **12** | **20** | **16** | **1** |

**SE 29 SW 17** **2155 9029** **Patrick Brompton** **Block C**

Surface level +61.8 m
Water level +61.8 m
January 1980

Overburden 0.4 m
Mineral 1.2 m
Waste 2.3 m
Mineral 1.0 m
Waste 2.6 m
Bedrock 1.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, pale brown, sandy | 0.4 | 0.4 |
| Glacial Sand and Gravel | **a** 'Very clayey' pebbly sand<br>Gravel: fine, rounded sandstone<br>Sand: mainly fine, rounded; quartz and rock fragments | 1.2 | 1.6 |
| | Clay, grey, stiff, laminated, sandy in parts | 2.3 | 3.9 |
| | **b** Gravel<br>Gravel: mainly fine, rounded; cherty limestone, sandstone and quartzite<br>Sand: mainly medium and coarse, subangular to rounded; quartz and rock fragments | 1.0 | 4.9 |
| Till | Clay, brown, sandy, soft | 2.6 | 7.5 |
| Namurian | Sandstone, pale grey, friable, with carbonaceous and micaceous layers | 1.5+ | 9.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 32 | 64 | 4 | 0.4-1.6 | 32 | 47 | 12 | 5 | 4 | 0 | 0 |
| **b** | 3 | 40 | 57 | 3.9-4.9 | 3 | 5 | 14 | 21 | 40 | 17 | 0 |
| **a+b** | **19** | **52** | **29** | **Mean** | **19** | **27** | **13** | **12** | **21** | **8** | **0** |

**SE 29 SW 18** **2283 9045** **High Mill Farm** **Block C**

Surface level +61.4 m
Water level +58.6 m
June 1979

Overburden 1.0 m
Mineral 1.3 m
Waste 0.7 m
Mineral 3.0 m+

## LOG

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, thin, on brownish yellow, soft micaceous clay | 1.0 | 1.0 |
| Glacial Sand and Gravel | **a** 'Very clayey' gravel<br>Gravel: fine, coarse and cobble, rounded; limestone, sandstone and quartzite with some shale<br>Sand: mainly medium and fine, subangular to rounded; quartz with some rock fragments<br>Fines: greyish silt | 1.3 | 2.3 |
| | Clay, dark grey to brown, soft, sandy, with polished pebbles and cobbles of limestone, chert, sandstone, quartzite and ironstone | 0.7 | 3.0 |
| | **b** Gravel<br>Gravel: as above<br>Sand: fine, medium and coarse; as above | 3.0+ | 6.0 |
| | Borehole abandoned on boulder | | |

## GRADING

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 30 | 33 | 37 | 1.0-2.3 | 30 | 11 | 17 | 5 | 11 | 16 | 10 |
| **b** | 6 | 28 | 66 | 3.0-4.0 | 8 | 10 | 8 | 6 | 28 | 28 | 12 |
| | | | | 4.0-5.0 | 7 | 7 | 6 | 4 | 14 | 33 | 29 |
| | | | | 5.0-6.0 | 4 | 11 | 20 | 12 | 20 | 27 | 6 |
| | | | | **Mean** | **6** | **9** | **12** | **7** | **21** | **29** | **16** |
| **a+b** | **13** | **30** | **57** | **Mean** | **13** | **10** | **13** | **7** | **18** | **25** | **14** |

**SE 29 SW 19** **2404 9068** **Burtree House** **Block C**

Surface level +56.1 m
Water level +47.9 m
July 1979

| | |
|---|---|
| Overburden | 0.6 m |
| Mineral | 3.9 m |
| Waste | 0.1 m |
| Mineral | 1.6 m |
| Waste | 0.1 m |
| Mineral | 4.9 m |
| Waste | 2.8 m+ |

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil on brown, sandy, pebbly clay | 0.6 | 0.6 |
| Glacial Sand and Gravel | Gravel, 'clayey' in upper part and with 0.1 m bands of pebbly clay at 4.5 m and 6.2 m<br>Gravel: fine and coarse with some cobbles, mainly well rounded; chert, limestone, sandstone and quartzite<br>Sand: fine, medium and coarse, angular to subrounded; quartz and rock fragments | 10.6 | 11.2 |
| Till | Clay, dark grey, stiff, with pebbles and boulders of cherty limestone, quartzite and sandstone | 2.8+ | 14.0 |
| | Borehole abandoned on limestone boulder | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 15 | 28 | 57 | 0.6-1.6 | 11 | 16 | 10 | 8 | 16 | 29 | 10 |
| | | | 1.6-2.6 | 11 | 16 | 10 | 8 | 19 | 27 | 9 |
| | | | 2.6-3.6 | 20 | 13 | 7 | 7 | 19 | 20 | 14 |
| | | | 3.6-4.5 | 17 | 7 | 6 | 5 | 25 | 28 | 12 |
| | | | 4.5-4.6 | Clay band | | | | | | |
| | | | 4.6-5.6 | 6 | 7 | 6 | 6 | 24 | 36 | 15 |
| | | | 5.6-6.2 | 5 | 6 | 5 | 7 | 25 | 31 | 21 |
| | | | 6.2-6.3 | Clay band | | | | | | |
| | | | 6.3-7.5 | 8 | 8 | 8 | 9 | 21 | 37 | 9 |
| | | | 7.5-8.5 | 6 | 9 | 8 | 9 | 28 | 33 | 7 |
| | | | 8.5-9.5 | 7 | 12 | 20 | 21 | 25 | 15 | 0 |
| | | | 9.5-10.5 | 2 | 4 | 12 | 19 | 21 | 30 | 12 |
| | | | 10.5-11.2 | 5 | 12 | 21 | 13 | 24 | 21 | 4 |
| | | | **Mean** | **9** | **10** | **10** | **10** | **22** | **29** | **10** |

**SE 29 SE 13** **2649 9482** **Glebe Farm** **Block D**

Surface level +50.4 m
Water level +41.2 m
October 1979

Overburden 2.5 m
Mineral 9.3 m
Waste 0.1 m
Mineral 6.6 m
Waste 4.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.2 | 0.2 |
| Till | Clay, brown, sandy and pebbly | 2.3 | 2.5 |
| Glacial Sand and Gravel | **a** 'Very clayey' pebbly sand<br>Gravel: fine and coarse, rounded; limestone and sandstone<br>Sand: fine, medium and coarse, angular to rounded; quartz and rock fragments<br>Fines: brownish grey silt and clay | 3.7 | 6.2 |
| | **b** Gravel, partly 'clayey'<br>Gravel: fine and coarse with some cobbles, well rounded; quartz, sandstone and limestone with sporadic granite<br>Sand: fine, medium and coarse; as above | 5.6 | 11.8 |
| | Silt, greyish red, soft, sandy | 0.1 | 11.9 |
| | **c** Sand, few pebbles in upper part: mainly fine, rounded; quartz and rock fragments including a little coal | 6.6 | 18.5 |
| ?Glacial Lake Deposits | Silt, reddish grey, soft, laminated and micaceous, with fine sand partings | 4.0+ | 22.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}$ -1 | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 25 | 57 | 18 | 2.5-4.3 | 35 | 20 | 10 | 11 | 13 | 11 | 0 |
| | | | | 4.3-6.2 | 15 | 24 | 34 | 15 | 7 | 5 | 0 |
| | | | | **Mean** | **25** | **22** | **22** | **13** | **10** | **8** | **0** |
| **b** | 7 | 30 | 63 | 6.2-7.2 | 11 | 14 | 19 | 10 | 9 | 14 | 23 |
| | | | | 7.2-8.2 | 12 | 9 | 12 | 15 | 18 | 24 | 10 |
| | | | | 8.2-9.2 | 11 | 9 | 11 | 14 | 19 | 26 | 10 |
| | | | | 9.2-10.2 | 4 | 2 | 7 | 15 | 45 | 24 | 3 |
| | | | | 10.2-11.8 | 1 | 4 | 9 | 8 | 50 | 25 | 3 |
| | | | | **Mean** | **7** | **7** | **11** | **12** | **31** | **23** | **9** |
| **c** | 6 | 92 | 4 | 11.9-13.9 | 5 | 26 | 53 | 11 | 5 | 0 | 0 |
| | | | | 13.9-15.9 | 7 | 63 | 30 | 0 | 0 | | |
| | | | | 15.9-18.5 | 7 | 71 | 22 | 0 | 0 | | |
| | | | | **Mean** | **6** | **55** | **35** | **3** | **1** | | |
| **a+b+c** | **11** | **62** | **27** | **Mean** | **11** | **30** | **23** | **9** | **14** | **10** | **3** |

**SE 29 SE 14** **2825 9438** **Kirkby Fleetham** **Block B**

Surface level +39.6 m
Water level +34.6 m
November 1979

Overburden 0.6 m
Mineral 6.5 m
Waste 13.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, pale brown, pebbly, clayey at base | 0.6 | 0.6 |
| River Terrace, undifferentiated | Pebbly sand, 'clayey' at top and base<br>Gravel: fine and coarse with some cobbles, subangular to rounded; sandstone and limestone<br>Sand: mainly medium, rounded; quartz and rock fragments, including coal, with some mica<br>Fines: brown silt | 6.5 | 7.1 |
| Glacial Lake Deposits | Clay, dark yellowish brown, weakly laminated, with thin silt bands | 13.5+ | 20.5 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 9 | 69 | 22 | 0.6-1.4 | 17 | 12 | 49 | 10 | 9 | 3 | 0 |
| | | | 1.4-2.6 | 7 | 7 | 41 | 32 | 8 | 5 | 0 |
| | | | 2.6-3.6 | 9 | 7 | 17 | 19 | 23 | 24 | 1 |
| | | | 3.6-4.4 | 7 | 5 | 28 | 22 | 16 | 19 | 3 |
| | | | 4.4-5.4 | 7 | 19 | 49 | 10 | 8 | 7 | 0 |
| | | | 5.4-6.4 | 3 | 12 | 57 | 10 | 6 | 9 | 3 |
| | | | 6.4-7.1 | 15 | 14 | 48 | 12 | 9 | 2 | 0 |
| | | | **Mean** | **9** | **11** | **41** | **17** | **11** | **10** | **1** |

**SE 29 SE 15** **2914 9405** **South Lowfield Farm** **Block B**

Surface level +30.6 m
Water level +29.6 m in gravel, artesian flow from bedrock
November 1979

Overburden 0.4 m
Mineral 2.3 m
Waste 6.2 m
Bedrock 0.3 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.4 | 0.4 |
| Alluvium | Gravel<br>Gravel: fine and coarse, subangular to rounded; sandstone and limestone with trace of quartz<br>Sand: mainly medium and coarse, subangular to sub-rounded; quartz and rock fragments | 2.3 | 2.7 |
| ?Glacial Lake Deposits | Clay, brown to reddish brown, stiff, poorly laminated | 5.8 | 8.5 |
| Till | Clay, dark grey, hard, stony | 0.4 | 8.9 |
| Sherwood Sandstone Group | Sandstone, red, hard, micaceous | 0.3+ | 9.2 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| 8 | 40 | 52 | 0.4-1.4 | 14 | 11 | 24 | 14 | 23 | 14 | 0 |
| | | | 1.4-2.7 | 4 | 4 | 14 | 16 | 27 | 34 | 1 |
| | | | **Mean** | **8** | **7** | **18** | **15** | **27** | **25** | **0** |

**SE 29 SE 16** **2607 9329** **Bowbridge Lane** **Block D**

Surface level +52.8 m
Water level +43.3 m
September 1979

| | |
|---|---|
| Overburden | 4.9 m |
| Mineral | 0.9 m |
| Waste | 1.2 m |
| Mineral | 4.8 m |
| Waste | 0.9 m |
| Mineral | 0.8 m |
| Waste | 0.2 m |
| Mineral | 2.5 m |
| Waste | 2.2 m |
| Mineral | 1.1 m |
| Waste | 6.5 m+ |

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy, pebbly, clayey at base | 0.7 | 0.7 |
| Till | Clay, brown to 2.0 m, grey below, stiff, sandy and with pebbles of sandstone, limestone and quartzite | 4.2 | 4.9 |
| Glacial Sand and Gravel | **a** 'Very clayey' sandy gravel<br>Gravel: fine and coarse, rounded; sandstone and limestone<br>Sand: fine and medium with coarse, rounded; quartz and rock fragments | 0.9 | 5.8 |
| Till | Clay, dark grey, hard | 1.2 | 7.0 |
| Glacial Sand and Gravel | **b** 'Very clayey' sandy gravel: as above | 4.8 | 11.8 |
| | Clay, dark grey | 0.9 | 12.7 |
| | **c** 'Clayey' pebbly sand<br>Gravel: fine; as above<br>Sand: medium with fine and coarse; as above | 0.8 | 13.5 |
| | Clay, dark grey, soft, silty | 0.2 | 13.7 |
| | **d** Pebbly sand; as above | 2.5 | 16.2 |
| ?Glacial Lake Deposits | Silt, dark grey | 2.2 | 18.4 |
| Glacial Sand and Gravel | **e** Sand with few pebbles: mainly medium, rounded; quartz and rock fragments, including some coal, with some mica | 1.1 | 19.5 |
| ?Glacial Lake Deposits | Silt, brown, soft, laminated, micaceous, becoming grey and sandy towards base | 6.5+ | 26.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| a | 28 | 45 | 27 | 4.9-5.8 | 28 | 21 | 15 | 9 | 13 | 12 | 2 |
| b | 24 | 50 | 26 | 7.0-8.0 | 18 | 32 | 16 | 15 | 10 | 9 | 0 |
| | | | | 8.0-9.4 | 23 | 19 | 7 | 7 | 13 | 25 | 6 |
| | | | | 9.4-10.4 | 21 | 26 | 10 | 4 | 17 | 17 | 5 |
| | | | | 10.4-11.8 | 30 | 33 | 26 | 10 | 1 | 0 | 0 |
| | | | | **Mean** | **24** | **26** | **15** | **9** | **10** | **13** | **3** |
| c | 12 | 82 | 6 | 12.7-13.5 | 12 | 27 | 39 | 16 | 6 | 0 | 0 |
| d | 7 | 74 | 19 | 13.7-14.7 | 4 | 13 | 33 | 21 | 27 | 2 | 0 |
| | | | | 14.7-16.2 | 9 | 22 | 50 | 6 | 8 | 5 | 0 |
| | | | | **Mean** | **7** | **19** | **43** | **12** | **15** | **4** | **0** |
| e | 6 | 90 | 4 | 18.4-19.5 | 6 | 19 | 63 | 8 | 4 | 0 | 0 |
| **a to e** | **17** | **63** | **20** | **Mean** | **17** | **24** | **29** | **10** | **10** | **8** | **2** |

**SE 29 SE 17** **2692 9362** **Tickergate Lane** **Block D**

Surface level +52.9 m
Water level +46.1 m
October 1979

Overburden 5.3 m
Mineral 15.2 m
Waste 4.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, mid-brown, silty | 0.3 | 0.3 |
| Till | Clay, mottled brown and grey, with pale grey silt stringers, leached areas and coal debris; appears reworked | 3.2 | 3.5 |
| | Clay, grey-brown, laminated, micaceous, sandy in parts, with cobbles of cherty limestone and sandstone | 1.8 | 5.3 |
| Glacial Sand and Gravel | a Sandy gravel, 'very clayey' in upper part<br>Gravel: fine and coarse with some cobbles, subangular to rounded; cherty limestone, sandstone and quartzite<br>Sand: medium and fine with some coarse, rounded; quartz and rock fragments<br>Fines: brown micaceous silt | 7.0 | 12.3 |
| | b Sand: fine and medium, rounded; quartz and rock fragments | 8.2 | 20.5 |
| ?Glacial Lake Deposits | Silt, brownish grey, very sandy; some coal debris | 4.5+ | 25.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 13 | 60 | 27 | 5.3-6.3 | 17 | 14 | 20 | 9 | 18 | 19 | 3 |
| | | | | 6.3-7.3 | 24 | 22 | 20 | 11 | 14 | 9 | 0 |
| | | | | 7.3-8.3 | 24 | 26 | 20 | 9 | 13 | 8 | 0 |
| | | | | 8.3-9.3 | 16 | 34 | 38 | 6 | 4 | 2 | 0 |
| | | | | 9.3-10.3 | 8 | 11 | 22 | 12 | 24 | 21 | 2 |
| | | | | 10.3-11.3 | 3 | 6 | 36 | 18 | 22 | 15 | 0 |
| | | | | 11.3-12.3 | 2 | 15 | 62 | 10 | 9 | 2 | 0 |
| | | | | **Mean** | **13** | **19** | **30** | **11** | **15** | **11** | **1** |
| **b** | 7 | 93 | 0 | 12.3-13.6 | 6 | 36 | 58 | 0 | 0 | 0 | 0 |
| | | | | 13.6-15.6 | 2 | 37 | 60 | 1 | 0 | 0 | 0 |
| | | | | 15.6-17.6 | 4 | 28 | 64 | 3 | 0 | 1 | 0 |
| | | | | 17.6-20.5 | 14 | 68 | 18 | 0 | 0 | 0 | 0 |
| | | | | **Mean** | **7** | **45** | **47** | **1** | **0** | **0** | **0** |
| **a+b** | **10** | **78** | **12** | **Mean** | **10** | **33** | **40** | **5** | **7** | **5** | **0** |

**SE 29 SE 18** **2747 9333** **Tickergate Lane** **Block D**

Surface level +53.7 m
Water struck at +41.7 m
October 1979

| | |
|---|---|
| Overburden | 2.6 m |
| Mineral | 6.0 m |
| Waste | 0.8 m |
| Mineral | 0.7 m |
| Waste | 0.2 m |
| Mineral | 3.3 m |
| Waste | 8.4 m+ |

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.2 | 0.2 |
| Glacial Sand and Gravel | Clay, yellowish brown, sandy, with cobbles of limestone and sandstone below 0.7 m | 2.4 | 2.6 |
| | **a** Pebbly sand<br>Gravel: mainly fine, rounded to subangular; chert, limestone, sandstone and quartzite<br>Sand: medium with fine and coarse, rounded; quartz and rock fragments | 3.7 | 6.3 |
| | **b** Sand: fine and medium, rounded; quartz and rock fragments, including coal, with some mica | 2.3 | 8.6 |
| | Silt, brownish grey, sandy, laminated | 0.8 | 9.4 |
| | **c** 'Clayey' sand with 0.2 m silt band at 10.3 m<br>Sand: mainly fine, rounded; quartz and rock fragments<br>Fines: greyish brown micaceous silt bands | 4.2 | 13.6 |
| ?Glacial Lake Deposits | Silt, greyish brown to reddish brown, laminated, micaceous and sandy, with scattered polished chert pebbles | 8.3+ | 22.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| a | 8 | 76 | 16 | 2.6-4.3 | 9 | 31 | 42 | 12 | 3 | 3 | 0 |
| | | | | 4.3-5.3 | 8 | 10 | 26 | 21 | 24 | 11 | 0 |
| | | | | 5.3-6.3 | 7 | 11 | 23 | 21 | 17 | 1 | 0 |
| | | | | **Mean** | **8** | **20** | **39** | **17** | **12** | **4** | **0** |
| b | 7 | 93 | 0 | 6.3-8.6 | 7 | 43 | 49 | 1 | | | |
| c | 10 | 90 | 0 | 9.4-10.1 | 17 | 50 | 33 | 0 | | | |
| | | | | 10.1-10.3 | Silt band | | | | | | |
| | | | | 10.3-12.3 | 14 | 76 | 10 | 0 | | | |
| | | | | 12.3-13.6 | 8 | 58 | 34 | 0 | | | |
| | | | | **Mean** | **10** | **66** | **24** | **0** | | | |
| **a+b+c** | **10** | **84** | **6** | **Mean** | **10** | **44** | **34** | **6** | **4** | **2** | |

**SE 29 SE 19** **2849 9326** **Little Fencote** **Block B**

Surface level +37.3 m
Water level +31.3 m
July 1979

Mineral 4.4 m
Waste 18.1 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| River Terrace, undifferentiated | 'Clayey' sand, with a few polished chert pebbles: fine and medium, subangular to well rounded; quartz and rock fragments including some coal | 4.4 | 4.4 |
| | Fines: reddish brown micaceous silt | | |
| ?Glacial Lake Deposits | Clay, reddish brown, laminated in parts, micaceous, silty, stone free and with lenses of fine quartz sand | 7.0 | 11.4 |
| | Clay, reddish brown to grey, laminated, soft, micaceous | 9.5 | 20.9 |
| Till | Clay, dark grey to brown, stiff, with sandstone and chert pebbles | 1.6+ | 22.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| | 13 | 85 | 2 | 0.0-2.0 | 11 | 43 | 38 | 4 | 4 | 0 | 0 |
| | | | | 2.0-3.0 | 19 | 20 | 54 | 6 | 1 | 0 | 0 |
| | | | | 3.0-4.4 | 12 | 37 | 48 | 3 | 0 | 0 | 0 |
| | | | | **Mean** | **13** | **36** | **45** | **4** | **2** | **0** | **0** |

**SE 29 SE 20** **2970 9317** **Scruton Grange** **Block B**

Surface level +29.5 m
Water level +26.5 m
November 1979

Overburden 1.4 m
Mineral 2.5 m
Waste 15.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil | 0.4 | 0.4 |
| Alluvium | Clay, yellowish grey mottled; some small rounded sandstone pebbles | 1.0 | 1.4 |
| River Terrace, undifferentiated | Sandy gravel<br>Gravel: fine and coarse, well rounded; limestone, chert and sandstone<br>Sand: medium and coarse, angular; quartz and rock fragments | 2.5 | 3.9 |
| Glacial Lake Deposits | Silty clay, dark yellowish brown, soft and with few pebbles of sandstone to 8.0 m; greyish red and laminated to 14.5 m; moderate brown below | 15.2+ | 19.1 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 5 | 49 | 46 | 1.4-2.4 | 4 | 5 | 24 | 16 | 31 | 20 | 0 |
| | | | 2.4-3.9 | 6 | 6 | 26 | 21 | 26 | 15 | 0 |
| | | | **Mean** | **5** | **5** | **25** | **19** | **29** | **17** | **0** |

**SE 29 SE 21** **2564 9230** **Holtby Hall** **Block C**

Surface level +40.3 m
Water level +30.2 m
August 1979

| | |
|---|---|
| Overburden | 1.1 m |
| Mineral | 2.0 m |
| Waste | 8.9 m |
| Mineral | 1.2 m |
| Waste | 0.3 m |
| Mineral | 5.6 m |
| Waste | 3.4 m+ |

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.2 | 0.2 |
| ?Glacial Lake Deposits or Fluvio-glacial Deposits | Clay, ochreous, soft, sandy | 0.9 | 1.1 |
| | **a** 'Very clayey' sand<br>Sand: fine, rounded; quartz and rock fragments including some coal<br>Fines: grey micaceous silt bands | 2.0 | 3.1 |
| | Silt and clay, grey, micaceous, laminated in parts, with lenses of fine sand | 5.2 | 8.3 |
| ?Till | Clay, dark grey, soft, with pebbles of limestone and sandstone | 3.7 | 12.0 |
| Glacial Sand and Gravel | **b** Gravel<br>Gravel: fine and coarse with some cobbles, rounded to well rounded; cherty limestone, sandstone and quartzite<br>Sand: fine, medium and coarse, rounded; quartz and rock fragments | 1.2 | 13.2 |
| | Clay, dark grey, pebbly | 0.3 | 13.5 |
| | **c** Sandy gravel, with thin clay band at 17.8 m<br>Gravel: fine and coarse; as above<br>Sand: mainly fine and medium; as above | 4.3 | 17.8 |
| | **d** 'Very clayey' sand: fine; quartz and rock fragments | 1.3 | 19.1 |
| Till | Clay, mainly dark grey, hard, silty towards base; pebbles of chert, limestone and sandstone | 3.4+ | 22.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}$ -1 | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 28 | 72 | 0 | 1.1-3.1 | 28 | 62 | 9 | 1 | | | |
| **b** | 4 | 30 | 66 | 12.0-13.2 | 4 | 6 | 9 | 15 | 28 | 31 | 7 |
| **c** | 9 | 62 | 29 | 13.5-14.5 | 4 | 17 | 25 | 8 | 20 | 22 | 4 |
| | | | | 14.5-15.5 | 10 | 23 | 35 | 9 | 14 | 9 | 0 |
| | | | | 15.5-16.5 | 12 | 32 | 24 | 5 | 19 | 8 | 0 |
| | | | | 16.5-17.8 | 10 | 41 | 16 | 11 | 16 | 6 | 0 |
| | | | | **Mean** | **9** | **29** | **25** | **8** | **17** | **11** | **1** |
| **d** | 34 | 66 | 0 | 17.8-19.1 | 34 | 62 | 3 | 1 | | | |
| **a+b+c +d** | **16** | **62** | **22** | **Mean** | **16** | **40** | **16** | **6** | **12** | **9** | **1** |

**SE 29 SE 22** **2689 9254** **Holtby Hall** **Block D**

Surface level +47.9 m
Water level +43.1 m
September 1979

Waste 5.4 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy, pebbly | 0.4 | 0.4 |
| Till | Clay, ochreous at top, grey below, sandy; cobbles of cherty limestone and sandstone | 5.0+ | 5.4 |

**SE 29 SE 23** **2736 9229** **Carr Hill** **Block D**

Surface level +63.5 m
Water level +61.9 m
January 1980

Overburden 1.6 m
Mineral 2.0 m
Waste 6.2 m
Mineral 3.2 m
Waste 0.1 m
Mineral 7.9 m
Waste 3.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill | 1.0 | 1.0 |
| | Clay, yellowish brown, soft, sandy, with small pebbles | 0.6 | 1.6 |
| Glacial Sand and Gravel | **a** 'Very clayey' gravel<br>Gravel: coarse, fine and some cobbles, rounded; chert, limestone, sandstone and quartzite with some quartz and Magnesian Limestone<br>Sand: fine with some medium and coarse, angular; quartz and rock fragments | 2.0 | 3.6 |
| | Clay, brownish grey, sandy, hard, with bands of gravel | 6.2 | 9.8 |
| | **b** Sand, 'clayey' and pebbly in upper part<br>Gravel: mainly coarse, subangular; as above<br>Sand: mainly fine, rounded; as above | 3.2 | 13.0 |
| | Clay, yellowish brown, micaceous, sandy | 0.1 | 13.1 |
| | **c** 'Very clayey' sand: mainly fine, rounded; quartz and rock fragments | 7.9 | 21.0 |
| ?Glacial Lake Deposits | Clay, moderate brown to brownish grey, stiff in parts, laminated, micaceous, some sandy partings | 3.0+ | 24.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| a | 36 | 29 | 35 | 1.6-2.6 | 35 | 20 | 7 | 5 | 10 | 17 | 6 |
| | | | | 2.6-3.6 | 38 | 13 | 7 | 5 | 10 | 18 | 9 |
| | | | | **Mean** | **36** | **17** | **7** | **5** | **10** | **18** | **7** |
| b | 9 | 83 | 8 | 9.8-10.8 | 15 | 28 | 27 | 6 | 6 | 18 | 0 |
| | | | | 10.8-13.0 | 6 | 70 | 23 | 1 | 0 | 0 | 0 |
| | | | | **Mean** | **9** | **57** | **24** | **2** | **2** | **6** | **0** |
| c | 25 | 75 | 0 | 13.1-15.4 | 9 | 66 | 23 | 2 | | | |
| | | | | 15.4-17.4 | 41 | 55 | 4 | 0 | | | |
| | | | | 17.4-21.0 | 26 | 69 | 5 | 0 | | | |
| | | | | **Mean** | **25** | **64** | **10** | **1** | | | |
| **a+b+c** | **23** | **70** | **7** | **Mean** | **23** | **55** | **13** | **2** | **2** | **4** | **1** |

**SE 29 SE 24** **2853 9216** **Fence Dike Lane** **Block B**

Surface level +35.5 m
Water level +30.5 m
August 1979

Overburden 0.6 m
Mineral 4.4 m
Waste 6.0 m
Bedrock 0.3 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill | 0.6 | 0.6 |
| River Terrace, undifferentiated | 'Clayey' to 'very clayey' sand, partly pebbly<br>Gravel: fine, rounded; limestone, sandstone and quartz<br>Sand: mainly medium, subangular to rounded; quartz and rock fragments including some coal<br>Fines: brown silt and clay | 4.4 | 5.0 |
| Glacial Lake Deposits | Clay, brown, weakly laminated, stone-free; some sandy partings and lenses | 5.4 | 10.4 |
| Till | Clay, grey to brown, sandy, with pebbles of limestone and sandstone | 0.6 | 11.0 |
| Sherwood Sandstone Group | Sandstone, brick red, fine-grained, poorly cemented | 0.3+ | 11.3 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| | 15 | 83 | 2 | 0.6-1.3 | 27 | 5 | 47 | 19 | 2 | 0 | 0 |
| | | | | 1.3-2.3 | 18 | 17 | 50 | 10 | 5 | 0 | 0 |
| | | | | 2.3-3.3 | 10 | 29 | 60 | 1 | 0 | 0 | 0 |
| | | | | 3.3-4.3 | 9 | 43 | 48 | 0 | 0 | 0 | 0 |
| | | | | 4.3-5.0 | 12 | 30 | 58 | 0 | 0 | 0 | 0 |
| | | | | **Mean** | **15** | **26** | **51** | **6** | **2** | **0** | **0** |

**SE 29 SE 25** **2952 9226** **Lucky Barn** **Block B**

Surface level +34.6 m
Water struck at +26.6 m
August 1979

Overburden 0.4 m
Mineral 1.1 m
Waste 5.3 m
Mineral 6.1 m
Waste 3.9 m
Bedrock 0.9 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.4 | 0.4 |
| River Terrace, undifferentiated | **a** 'Very clayey' pebbly sand<br>Gravel: fine, rounded; limestone and sandstone with some chert<br>Sand: mainly medium, subangular to well rounded; quartz and rock fragments<br>Fines: pale grey and reddish brown stringers of peaty clay | 1.1 | 1.5 |
| | Clay, moderate brown to medium dark grey, ochreous and micaceous at top, stiff, sandy; a few small pebbles below 5.5 m | 5.3 | 6.8 |
| | **b** 'Very clayey' sandy gravel<br>Gravel: fine and coarse with some cobbles, rounded; Carboniferous limestone, sandstone and quartzite with some chert and red and greenish Permo-Triassic and Lower Palaeozoic sandstone and siltstone<br>Sand: fine, rounded; quartz and rock fragments<br>Fines: brown to grey micaceous silt stringers | 6.1 | 12.9 |
| Till | Clay, reddish brown, stiff, with pebbles of chert, sandstone, quartzite and Magnesian Limestone | 3.9 | 16.8 |
| Sherwood Sandstone Group | Sandstone, brick red, medium-grained | 0.9+ | 17.7 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| **a** | 21 | 74 | 5 | 0.4-1.5 | 21 | 23 | 44 | 7 | 5 | 0 | 0 |
| b | 38 | 45 | 17 | 6.8-7.8 | 50 | 28 | 5 | 4 | 6 | 7 | 0 |
| | | | | 7.8-8.8 | 35 | 43 | 5 | 4 | 7 | 6 | 0 |
| | | | | 8.8-9.8 | 40 | 34 | 4 | 3 | 6 | 5 | 8 |
| | | | | 9.8-10.8 | 35 | 41 | 4 | 2 | 6 | 7 | 5 |
| | | | | 10.8-11.8 | 31 | 43 | 7 | 5 | 5 | 5 | 4 |
| | | | | 11.8-12.9 | 36 | 35 | 6 | 5 | 8 | 10 | 0 |
| | | | | **Mean** | **38** | **36** | **5** | **4** | **7** | **7** | **3** |
| **a+b** | **35** | **51** | **14** | **Mean** | **35** | **36** | **11** | **4** | **6** | **6** | **2** |

**SE 29 SE 26** **2572 9150** **Cobshaw Lane**

Surface level +40.1 m
Water struck at +38.1 m
August 1979

Waste 18.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.3 | 0.3 |
| Glacial Lake Deposits | Sand, 'very clayey', fine | 0.4 | 0.7 |
| | Clay and silt, yellowish brown to grey, becoming darker and laminated with depth, jointed, very sandy from 2.0 m to 4.0 m | 11.5 | 12.2 |
| Till | Clay, dark grey, stiff, with pebbles of chert, sandstone and limestone | 5.8+ | 18.0 |

**SE 29 SE 27** **2789 9144** **Leases Hall** **Block D**

Surface level +62.3 m
Water level +53.3 m
January 1980

Waste 0.9 m
Mineral 6.0 m
Waste 0.1 m
Mineral 6.0 m
Waste 9.5 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Made ground | 0.9 | 0.9 |
| Glacial Sand and Gravel | **a** Pebbly sand<br>Gravel: mainly fine, but coarse at top, subangular; chert and sandstone<br>Sand: fine and medium with some coarse at base, rounded; quartz and rock fragments | 6.0 | 6.9 |
| | Clay, reddish brown, micaceous, sandy | 0.1 | 7.0 |
| | **b** 'Clayey' sand<br>Sand: fine and medium, subrounded; quartz and rock fragments including some coal<br>Fines: reddish brown silt | 6.0 | 13.0 |
| ?Glacial Lake Deposits | Clay, dark reddish brown to brownish grey, soft, silty and laminated; some sandy partings | 9.5+ | 22.5 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| **a** | 8 | 80 | 12 | 0.9-2.0 | 12 | 28 | 18 | 6 | 9 | 27 | |
| | | | | 2.0-4.0 | 10 | 34 | 51 | 2 | 1 | 2 | |
| | | | | 4.0-6.9 | 6 | 16 | 35 | 34 | 9 | 0 | |
| | | | | **Mean** | **8** | **24** | **37** | **19** | **6** | **6** | |
| **b** | 16 | 83 | 1 | 7.0-9.0 | 28 | 30 | 36 | 5 | 1 | | |
| | | | | 9.0-11.0 | 4 | 59 | 34 | 3 | | | |
| | | | | 11.0-13.0 | 15 | 38 | 45 | 2 | | | |
| | | | | **Mean** | **16** | **42** | **38** | **3** | **1** | | |
| **a+b** | **12** | **81** | **7** | **Mean** | **12** | **33** | **37** | **11** | **4** | **3** | **0** |

**SE 29 SE 28** **2905 9159** **Moor House Farm** **Block B**

Surface level +32.6 m
Water level +27.7 m
October 1979

Overburden 0.9 m
Mineral 2.0 m
Waste 7.4 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, brown, sandy | 0.9 | 0.9 |
| Alluvium | Sandy gravel<br>Gravel: fine, rounded; sandstone and limestone<br>Sand: fine, medium and coarse, subangular to rounded; quartz and rock fragments | 2.0 | 2.9 |
| ?Glacial Lake Deposits | Clay, brown, soft, laminated | 4.4 | 7.3 |
| Till | Clay, dark grey, hard, with pebbles of Carboniferous chert, sandstone and limestone, and towards base, soft, red Triassic sandstone | 3.0+ | 10.3 |
| | Borehole abandoned on boulder | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| 6 | 68 | 26 | 0.9-2.9 | 6 | 25 | 27 | 16 | 24 | 2 | 0 |

**SE 29 SE 29** **2525 9040** **Kirk Bridge** **Block C**

Surface level +42.7 m
Water level +39.7 m
August 1979

Overburden 0.5 m
Mineral 2.7 m
Waste 11.0 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.5 | 0.5 |
| Glacial Sand and Gravel | 'Very clayey' sandy gravel<br>Gravel: fine and coarse with some cobbles at top; limestone and sandstone with traces of igneous rocks<br>Sand: fine with medium and coarse, angular to sub-rounded; quartz and rock fragments<br>Fines: greyish silt and clay | 2.7 | 3.2 |
| ?Glacial Lake Deposits | Clay, grey and dark grey, soft, laminated, with sandy partings | 11.0+ | 14.2 |
| | Borehole abandoned because of excessive water inflow | | |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | +1 -4 | +4 -16 | +16 -64 | +64 mm |
| 21 | 40 | 39 | 0.5-1.3 | 15 | 10 | 11 | 11 | 20 | 30 | 3 |
| | | | 1.3-2.5 | 15 | 15 | 14 | 8 | 19 | 29 | 0 |
| | | | 2.5-3.2 | 37 | 40 | 11 | 5 | 4 | 3 | 0 |
| | | | **Mean** | **21** | **20** | **12** | **8** | **15** | **23** | **1** |

**SE 29 SE 30** **2683 9062** **Crakehall Ings Lane**

Surface level +36.5 m
Water at ground level
January 1980

Waste 18.2 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Fill | 0.6 | 0.6 |
| Glacial Lake Deposits | Clay, greyish brown to dark grey, soft, micaceous, laminated, with traces of carbonaceous material and shrinkage cracks. Becomes sandy, jointed and with occasional chert pebbles below 4.0 m | 8.4 | 9.0 |
| Till | Clay, moderate brown to dark grey, hard, with rounded and striated pebbles and boulders of cherty limestone | 9.2+ | 18.2 |

**SE 29 SE 31** **2865 9056** **Farfield House** **Block D**

Surface level +35.4 m
Water struck at +32.9 m
October 1979

Overburden 0.8 m
Mineral 2.1 m
Waste 10.4 m
Bedrock 0.7 m+

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, dark brown, sandy, peaty | 0.8 | 0.8 |
| Glacial Sand and Gravel | 'Clayey' sand: mainly fine, subangular to rounded; quartz | 2.1 | 2.9 |
| Glacial Lake Deposits | Clay, greyish red to grey, silty, laminated in parts | 9.0 | 11.9 |
| Till | Clay, grey, hard, partly sandy, with rounded pebbles of limestone, chert and sandstone | 1.4 | 13.3 |
| Sherwood Sandstone Group | Sandstone, red, micaceous | 0.7+ | 14.0 |

**GRADING**

| Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| 16 | 84 | 0 | 0.8-1.8 | 10 | 54 | 36 | 0 | | | |
| | | | 1.8-2.9 | 21 | 59 | 18 | 2 | | | |
| | | | **Mean** | **16** | **56** | **27** | **1** | | | |

**SE 29 SE 32** **2962 9056** **Blow Houses** **Block B**

Surface level +34.2 m
Water level +32.0 m
November 1979

| | |
|---|---|
| Overburden | 0.3 m |
| Mineral | 1.5 m |
| Waste | 0.2 m |
| Mineral | 3.4 m |
| Waste | 5.1 m |
| Bedrock | 0.5 m+ |

**LOG**

| Geological classification | Lithology | Thickness m | Depth m |
|---|---|---|---|
| | Soil, sandy | 0.3 | 0.3 |
| River Terrace, undifferentiated | **a** 'Clayey' sand: mainly fine, rounded, quartz and rock fragments | 1.5 | 1.8 |
| | Clay, reddish grey, soft, micaceous | 0.2 | 2.0 |
| | **b** 'Clayey' sand: as above | 3.4 | 5.4 |
| Glacial Lake Deposits | Clay, reddish grey, soft, micaceous, laminated in parts | 4.1 | 9.5 |
| Till | Clay, grey, hard, with pebbles of grey limestone, red sandstone and black shale | 1.0 | 10.5 |
| Sherwood Sandstone Group | Sandstone, red, hard | 0.5+ | 11.0 |

**GRADING**

| | Mean for deposit percentages | | | Depth below surface (m) | Percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fines | Sand | Gravel | | Fines | Sand | | | Gravel | | |
| | | | | | $-\frac{1}{16}$ | $+\frac{1}{16}-\frac{1}{4}$ | $+\frac{1}{4}-1$ | $+1-4$ | $+4-16$ | $+16-64$ | $+64$ mm |
| **a** | 21 | 78 | 1 | 0.3-1.8 | 21 | 59 | 18 | 1 | 1 | 0 | 0 |
| **b** | 11 | 89 | 0 | 2.0-3.0 | 12 | 59 | 27 | 1 | 1 | 0 | 0 |
| | | | | 3.0-5.4 | 11 | 74 | 15 | 0 | 0 | 0 | 0 |
| | | | | **Mean** | **11** | **71** | **18** | **0** | **0** | **0** | **0** |
| **a+b** | **14** | **86** | **0** | **Mean** | **14** | **67** | **18** | **1** | **0** | **0** | **0** |

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**Reports of the Institute of Geological Sciences**

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E. F. P. Nickless.
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2 The sand and gravel resources of the country around Witham, Essex: Resource sheet TL 81. H. J. E. Haggard.
Report 72/6 ISBN 0 11 880588 6 £1.20

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R. Allender and S. E. Hollyer.
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**Mineral Assessment Reports**

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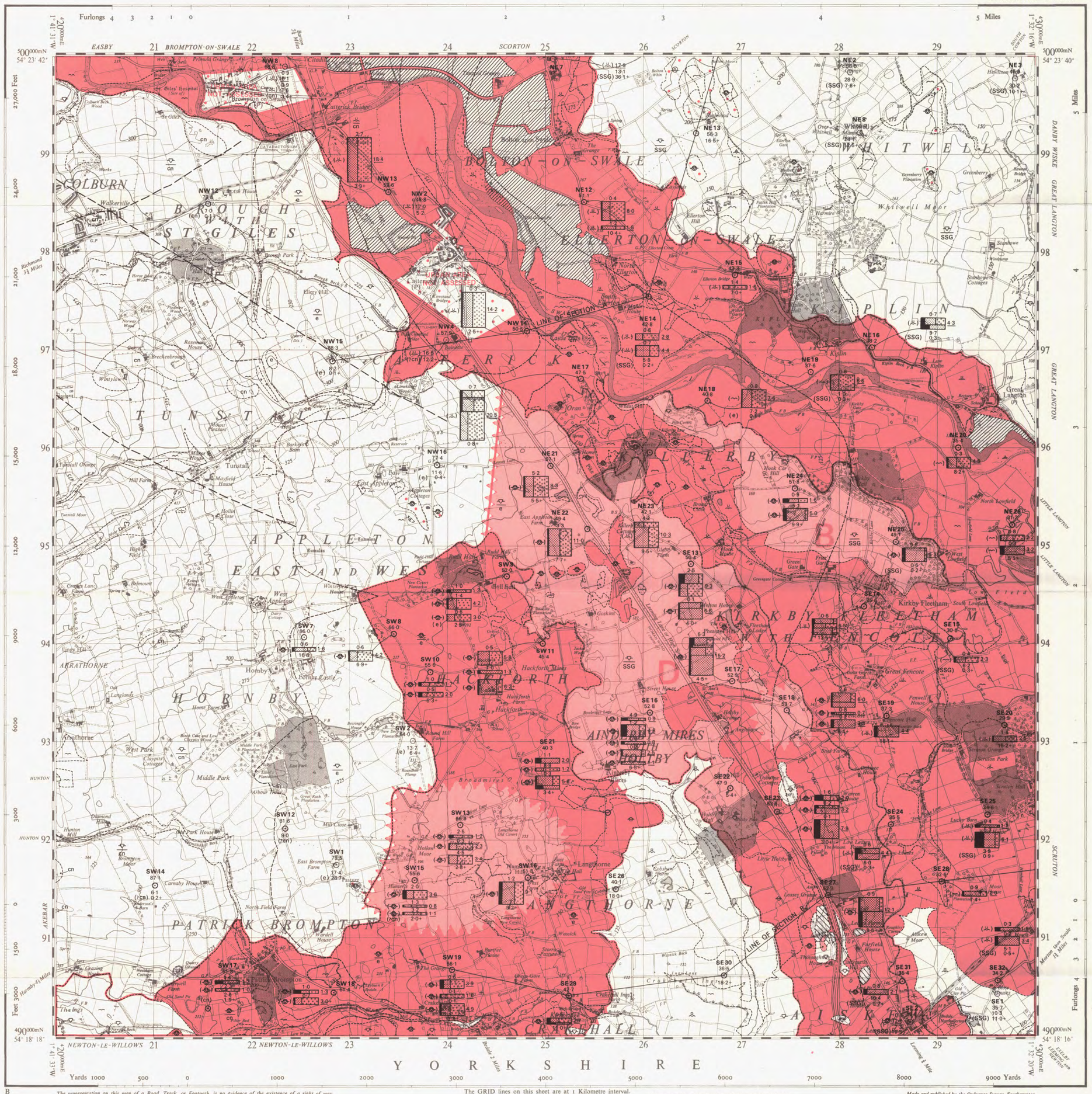
INSTITUTE OF GEOLOGICAL SCIENCES
INDUSTRIAL MINERALS ASSESSMENT UNIT

# THE SAND & GRAVEL RESOURCES OF SHEET SE 29 (CATTERICK, NORTH YORKSHIRE)

Scale 1:25 000 or about 2½ Inches to 1 Mile

ORDNANCE SURVEY
SHEET SE 29
PROVISIONAL EDITION




## THE SAND & GRAVEL RESOURCES OF SHEET SE 29 (CATTERICK, NORTH YORKSHIRE)

120

*This map should be read in conjunction with the accompanying Report which contains details of the assessment of resources.*

### EXPLANATION OF SYMBOLS AND ABBREVIATIONS

**DRIFT**

- **Blown Sand** BS-13
- **Peat** P-1
- **Lacustrine Alluvium** LA-10
- **Alluvial Fan** AF-4
- **Alluvium** -sand, silt and clay A-72
- **River Terraces, undifferentiated** -sand and gravel in varying proportions RT-29
- **Fluvio-glacial Deposits** -terrace-like deposits of variable composition FL-23
- **Glacial Sand and Gravel** - sand and gravel in varying proportions, clayey in parts GS-78
- **Till (Boulder Clay)** -stiff, brown or grey, bouldery clay TL-16
- **Glacial Lake Deposits:Sand** -fine-grained sand GL-11
- **Glacial Lake Deposits:Clay** -laminated, micaceous clay and silt, some peat and sand GL-12
- **Morainic Drift** - gravelly clay MD-2

RECENT AND PLEISTOCENE

**SOLID**

- SSG **Sherwood Sandstone Group** -red-brown, fine-medium grained sandstone
- e **Permian, undivided** -dolomitic limestones, marls and evaporites
- cn **Namurian** -limestones, cherts, sandstones, mudstones and thin coals

PERMO-TRIASSIC

CARBONIFEROUS

- **Made ground** MG-2
- **Worked out areas (sand and gravel)** WO-12

**BOUNDARY LINES**

- Geological boundary, Drift
- Geological boundary, Solid
- Fault, crossmark indicates downthrow side
- Inferred boundary between recognised categories of deposits
- Resource Block boundary

Broken lines denote uncertainty

**BOREHOLE DATA**

**SITE LOCATIONS**

- Industrial Minerals Assessment Unit (I.M.A.U.) Boreholes
- Other Boreholes

**I.M.A.U. BOREHOLES**

Borehole Registration Number — SE 25
Borehole Site — 34·6 Surface level in metres above O.D. (Newlyn)
Grading Diagram — 0·4 Overburden; 1·1 Mineral (sand and gravel); 5·5 Waste; 6·1 Mineral (sand and gravel)
Geological Classification — (SSG) 3·9 Bedrock; 0·9+
Thicknesses in metres

Note:
(i) Figures underlined denote thicknesses used in the assessment of resources.
(ii) The + sign indicates that the base of the deposit was not reached.
(iii) The Geological Classification is given only for mineral and bedrock.

**Borehole Registration Number**

Each I.M.A.U. borehole is identified by a Registration Number, e.g. **SE 25.** The letters refer to the quarter sheet and the figures to the I.G.S. serial number for that quarter. The unique designation for borehole **SE 25** is **SE 29 SE 25.**

**Grading Diagrams**

Each grading diagram shows the mean particle-size distribution in a distinct deposit of mineral.

Sand (+1/16mm-4mm) | Fines (−1/16mm) | Gravel (+4mm)

The height of the diagram is proportional to the mineral thickness.

The widths of the divisions show the proportions of **Fines, Sand** and **Gravel** but small amounts of gravel may be omitted or exaggerated.

**OTHER BOREHOLES**

The layout of information is the same as for I.M.A.U. boreholes, although data available may not be as comprehensive. They are registered in the same series.

**CATEGORIES OF DEPOSITS**

- **Exposed mineral, assessed** CAT-E2
- **Continuous or almost continuous spreads of mineral beneath overburden** CAT-C1
- **Sand and gravel either not potentially workable (see Report) or absent** CAT-A2
- **Sand and gravel not assessed** CAT-N1

**RESOURCE BLOCKS**

For the purpose of assessment the mineral is divided into Resource Blocks (see Report). Each is designated by a letter.

Detailed records may be consulted on application to the Director at the appropriate offices of the Institute of Geological Sciences.

Horizontal sections showing the general relationships between the drift deposits along the lines of section A and B constitute Figure 2 of the report.

Made and published by the Ordnance Survey, Southampton, for the Institute of Geological Sciences, Natural Environment Research Council.

*The representation on this map of a Road, Track, or Footpath, is no evidence of the existence of a right of way.*

*Original geological survey on the six-inch scale by W. Gunn, A. G. Cameron and J. Lucas in 1854-1878.*
*Eastern half resurveyed by D. V. Frost, J. G. O. Smart (District Geologist) and J. R. Davies 1978-1980.*

*Sand and Gravel survey by J. H. Lovell 1979-1980*
*R. G. Thurrell, Head, Industrial Minerals Assessment Unit.*

*1:25 000 Sand and Gravel Resource Sheet published 1982.*
G. M. Brown, D.Sc., F.R.S., *Director, Institute of Geological Sciences.*
*1100/82*

The GRID lines on this sheet are at 1 Kilometre interval.
*Heights are in feet above Mean Sea Level at Newlyn.*
*Heights of Bench Marks and Trigonometrical Stations may be obtained on application to the Director General, Ordnance Survey.*
*Contours values are in feet.*
*1 square inch on this map represents 99·639 acres on the ground.*

Compiled from 6" sheets last fully revised 1911-32.
Other partial systematic revision 1932-51 has been incorporated.
Major roads revised 1963.

*Made and published by the Ordnance Survey, Southampton.*
*Reprinted with addition of new major roads 1965.*

*Data quoted for an individual borehole refer strictly to that site; reliable conclusions cannot be drawn about the thickness and grading elsewhere in the deposit, particularly in material as variable as sand and gravel. However, estimates of the volume and mean grading of the mineral as a whole in each Resource Block are given in the Report.*

| | | |
|---|---|---|
| NZ10 | NZ20 | NZ30 |
| SE19 | SE29 (41, 42, 51, 52) | SE39 |
| SE18 | SE28 | SE38 |

*Diagram showing the relation of the National Grid 1:25 000 sheets with One-Inch and 1:50 000 Geological Sheets 41, 42, 51 and 52.*