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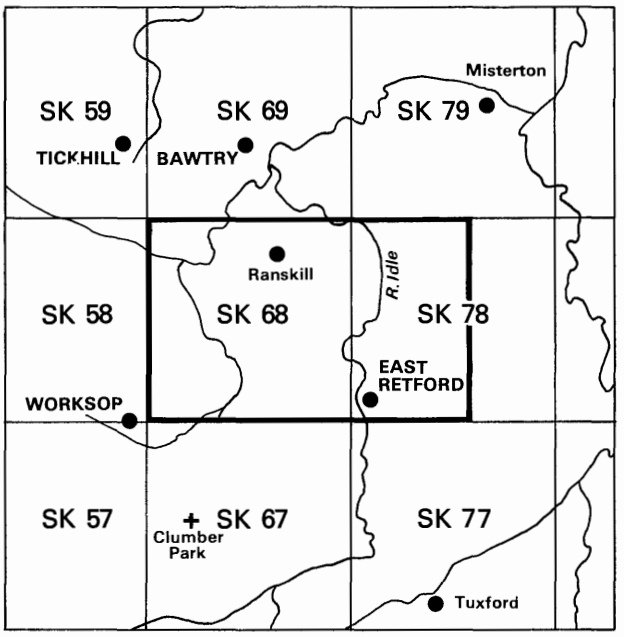

The sand and gravel resources of the country around Ranskill and East Retford, Nottinghamshire

Description of 1:25 000 resource sheet SK 68 and part of SK 78

D. Thomas

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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 co-operation of the Sand and Gravel Association of Great Britain.

This report describes the sand and gravel resources of the country around Ranskill and north and east of East Retford, Nottinghamshire, shown on the accompanying 1:25 000 resource map. The survey was conducted by Mr D. Thomas under the supervision of Mr D. Price. The work is base on six-inch scale geological surveys carried out by Institute Field Staff during 1946-63 and published on New Series One-inch Geological Sheet 101 (East Retford).

Mr J. D. Burnell (Land Agent) was responsible for negotiating access to land for drilling. The ready cooperation of landowners and tenants in this work is gratefully acknowledged.

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SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information, and 61 boreholes drilled for the Industrial Minerals Assessment Unit form the basis of the assessment of the sand and gravel resources.

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 1:25 000 map is divided into four resource blocks, containing between 9.6 and 14.3 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 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 alphanumeric descriptor (e.g. SK 68 NW 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 three elements alone (e.g. 68 NW 25).

All National Grid references in this publication lie within the 100-km square SK unless otherwise stated. Grid references may given to eight figures, accurate to within 10 m, or, for less precise locations, such as for quarries, to six figures, accurate to within 100 m.

Bibliographical reference

THOMAS, D. 1981. The sand and gravel resources of the country around Ranskill and East Retford, Nottinghamshire. Description of 1:25 000 resource sheet SK 68 and part of SK 78. Miner. Assess. Rep. Inst. Geol. Sci., No. 87.

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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 the No. 240-mesh B.S. sieve, about 1/16 mm) 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.

For the purposes of this survey, the unconsolidated, friable parts of the Bunter Sandstone occurring beneath superficial sand and gravel deposits have been taken to be mineral; the remainder of the Bunter Sandstone has not been assessed.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale 1/16 mm, ¼ 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 1/16 mm and 4 mm respectively (see Appendix C).

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

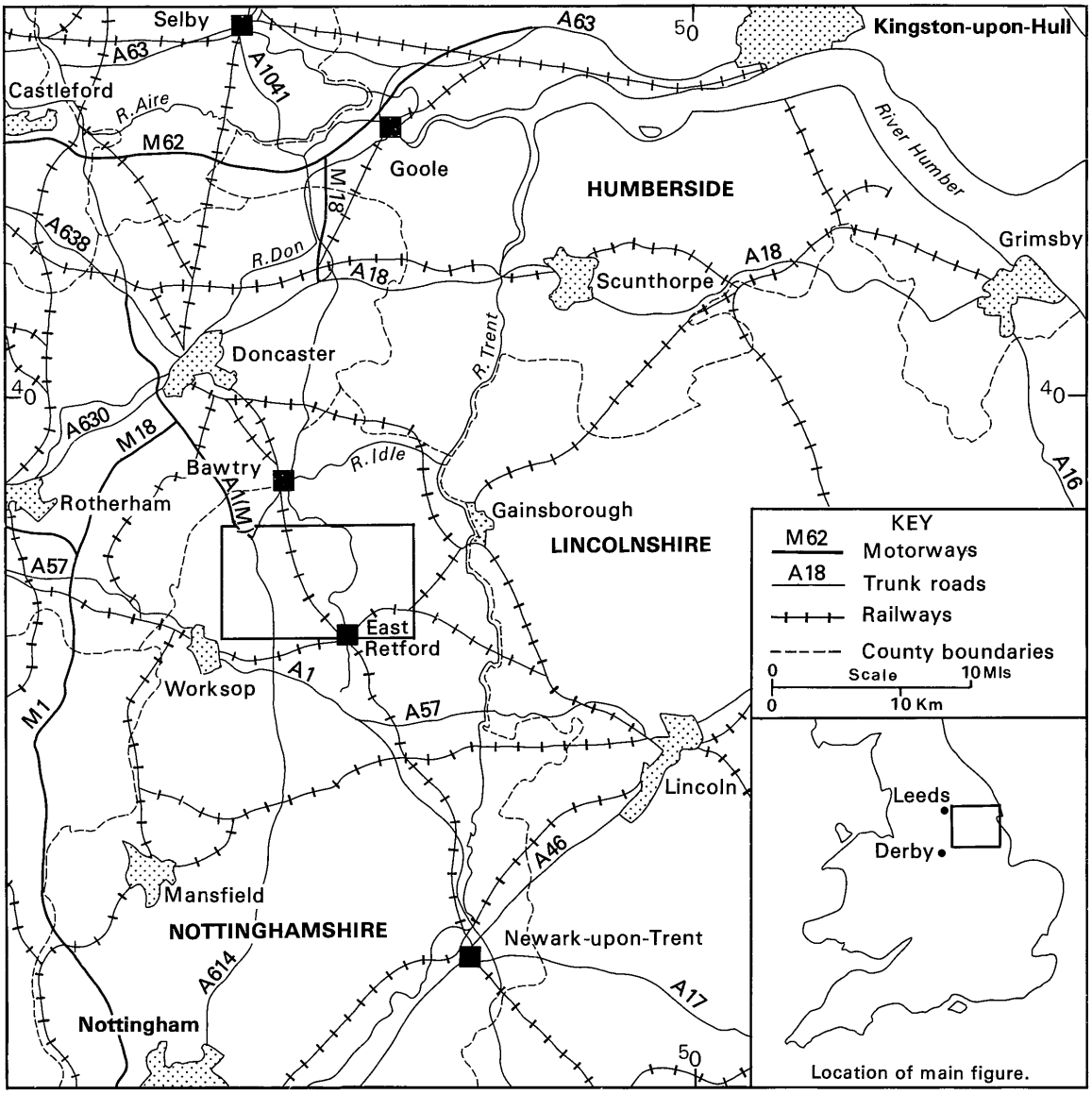


Figure 1 Sketch map showing the location of sheet SK 68 and part of SK 78.

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

The district comprises 160 km^2 of largely agricultural land in Nottinghamshire (Figure 1). East Retford, its only town, straddles the River Idle which flows northwards between raised banks in a wide valley. Low hills rise to the east to a maximum elevation of almost 90 m. Undulating sandy land extends westwards, gradually rising to an ill-defined escarpment which reaches an elevation of about 60 m in the south-west; it is drained by the River Ryton, a tributary of the Idle.

Sand and gravel has been worked extensively, especially on low ground in the Idle valley between Ranskill and Lound, and several pits are currently active (Appendix F).

GEOLOGY

The bedrocks and superficial deposits are listed in Table 1, as far as possible in order of increasing age; the relationships between them are illustrated in the generalised horizontal section (Figure 2). A brief description of the sequence is given below; for a more detailed account, see the East Retford memoir (Smith and others, 1973).

Solid

Upper Marl This formation, which crops out in the north-west corner of the district and, beneath Drift, south-west of Hodsock, consists of red, with subordinate greyish green, mudstones and silty mudstones containing bands and lenses of sand. It passes laterally into, and is also overlain by, Lower Mottled Sandstone. The latter generally comprises pink to red, fine-grained, locally micaceous, friable to compact sandstone. Pebbles are absent or sparse but bands and lenses of red or, less usually, green mudstone are common.

Bunter Pebble Beds These beds form rockhead across two-thirds of the district and are up to about 250 m thick. They consist of false-bedded, level-bedded or massive sandstone, predominantly medium- to coarse-grained. They are generally pink to red but substantial thicknesses of brown, yellow and grey varieties also

Table 1 Geological sequence.

DRIFT	
Recent and Pleistocene	Blown Sand
	Peat
	River Terrace Deposits
	Head
	Glacial Sand and Gravel
	Sandy Boulder Clay
	Boulder Clay
SOLID	
Permo-Triassic	Mercia Mudstone Group
	Keuper Marl (incl. Clarborough Beds)
	Waterstones
	Green Beds
	Sherwood Sandstone Group
	Bunter Pebble Beds
	Lower Mottled Sandstone
	Upper Marl

occur and mottling is fairly common. Despite the name, pebbles are sparse or absent except in the south of the district. The majority of pebbles present are of quartzite but quartz, siltstone, feldspathic sandstone and igneous rocks also occur. The pebbles range in size up to 15 cm across but the larger ones are rare; on average they decrease in size towards the north. Rolled and irregular fragments of red or green mudstone are common throughout the sandstone and lenses and bands of red and green mudstone and siltstone, up to a metre thick, are present in places.

Green Beds From about 9 to 15 m thick, the Green Beds overlie the Bunter Pebble Beds. They are thought to be present, largely beneath Drift, across the entire district but are traceable only south of the Clayworth area. They consist essentially of green to grey mudstones and siltstones but the basal beds are mainly or entirely red. Thin bands of fine or medium-grained sandstone, ranging widely in colour, are also included.

Waterstones These beds, which are present only south of the Lound area, are 20 to 30 m thick and consist of interbanded and interlaminated micaceous mudstones, siltstones and mainly fine-grained sandstones. They are generally red or brown but bands of grey or green mudstone and grey, green or yellow sandstone may be present.

Keuper Marl Both Green Beds and Waterstones pass laterally into, and are overlain by, Keuper Marl, which forms rockhead throughout the eastern part of the district. The Keuper Marl comprises mudstones and siltstones, predominantly red but with green and greyish green bands and patches. It also contains dolomitic siltstones and fine-grained sandstones (skerries), anhydrite and gypsum. The Clarborough Beds are a distinctive division of the Keuper Marl consisting of about 12 m of mudstone and silty mudstone with much gypsum and a higher than normal proportion of skerries.

Drift

Boulder Clay This occurs as small patches of thin red or brown pebbly clay resting on Keuper Marl in the east of the district. The pebbles are largely of quartzite derived from the Bunter Pebble Beds, but Permian and Carboniferous erratics are also present. The patches are regarded as remnants of a formerly more widespread deposit.

Sandy Boulder Clay The deposit, whose occurrence is confined to the Bunter Pebble Beds outcrop, is interpreted as a locally-derived ground moraine. Up to 3 m thick, it is composed essentially of red and brown sand with quartzite pebbles, although, locally, admixture of clay has produced clayey sand or pockets of clay; Carboniferous and Permian erratics may also be present. The deposit is found at the surface mainly on higher ground between the Ryton and Idle valleys but it may also occur beneath younger deposits.

Glacial Sand and Gravel Found in patches on the higher ground and in terrace-like spreads in the Idle valley, this deposit generally consists of false-bedded or horizontally-bedded sand and gravel in varying proportions. However, scattered ditch sections and auger holes on the outcrops in the south-east corner of the district show only 0.6 to 1.2 m of sandy clay and sand on Keuper Marl, and a borehole (78 SW 25) just to the north-east of East Retford found only clay on Waterstones. The 'high-level' deposits of sand are thickest, 8 m having been revealed in a pit [652 890] near Scrooby Top House; the terrace-like spreads are generally less than 3 m thick.

Head Solifluxion deposits, the lithology of which reflects that of the local rocks, occur in thin patches on the lower parts of some slopes and in minor valleys and depressions.

River Terrace Deposits Shown on the map as First Terrace, these occupy a large part of the Idle valley. They chiefly overlie Bunter Pebble Beds, where they consist mainly of sand and gravel up to 6.3 m thick. The pebbles are predominantly of quartzite, the bulk of which may have been derived from pre-existing gravels. They generally range up to 50 mm in diameter but larger pebbles and sporadic cobbles occur. Where terrace deposits overlie Keuper Marl they consist mainly of silt or clay. Terraces occur on at least three levels, but sections show that these features are cut in sand and gravel which originally filled the Idle valley to the highest level. The deposits, or at least their upper parts, are considered to be the time equivalents of the 25-Foot Drift of the Vale of York; they may be underlain locally by deposits comparable to the Older River Gravel of adjacent areas.

Alluvium Wide expanses of alluvium occur in the Idle and Ryton valleys and in narrow belts along minor streams. In the Idle valley it consists mainly of clay and sandy clay with, locally, beds of sand, gravel and peat. The wide area of alluvium at Whitewater Common, in the north-west of the district, is apparently the site of a former lake.

Peat Peat occurs at surface in the Idle valley in a strip broadening to rather more than a kilometre wide near Wiseton; it has been proved here to a depth of 6 m. It is also found in the Ryton valley and in a few other low lying areas.

Blown Sand This deposit has been mapped only in two small elongate patches near Broom House [696 837] where up to 3 m is present along the southern and western sides of hedges. However, elsewhere much of the surface of the Bunter Pebble Beds and sandy drift deposits is subject to blowing.

COMPOSITION OF THE SAND AND GRAVEL DEPOSITS

For the most part, potentially workable sand and gravel deposits in this district have a common provenance - the Permo-Triassic sandstones and conglomerates. As a result they are similar in composition, and, with the general exception of the river terrace deposits, so resemble each other that geological classification based on the disturbed bulk samples from IMAU boreholes becomes uncertain. However, sand and gravel resource,

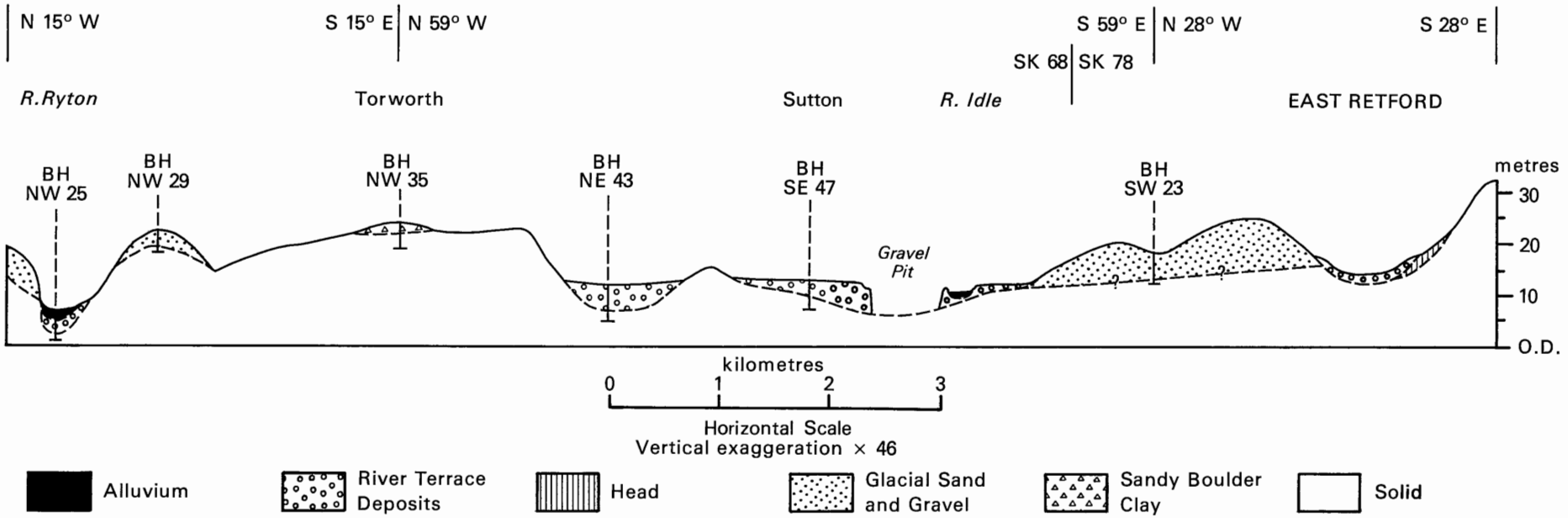


Figure 2 Generalized horizontal section showing the deposition of the Drift deposits.

in varying quantity and quality have been identified in Bunter Pebble Beds, sandy boulder clay, Glacial Sand and Gravel, river terrace deposits and alluvium.

Bunter Pebble Beds Weathering of Bunter Pebble Beds commonly produces a friable unconsolidated deposit, here referred to as 'Bunter Sand'. This sand passes downwards into generally soft sandstone and its base is taken at the level at which a Standard Penetration Test gives a penetration of less than 10 cm for 50 blows of the hammer. 'Bunter Sand' is considered to be mineral where it underlies Pleistocene sand and gravel and is likely to be worked with them. Where it occurs at the surface or beneath waste it is excluded from this assessment.

Within this district the 'Bunter Sand' is predominantly medium-grained; locally fine sand is dominant but coarse sand nowhere accounts for more than 2 per cent of the deposit. The sand consists mainly of iron-stained quartz with a substantial proportion of feldspar. In samples from IMAU boreholes, pebble content does not exceed 6 per cent and averages only 2 per cent. Fines average 9 per cent but at borehole 68 SE 56 samples containing up to 19 per cent were taken.

Sandy Boulder Clay This deposit was proved by IMAU boreholes and found to be rather variable in composition. It is generally 'clayey' to 'very clayey' with mean fines contents for individual boreholes ranging from 6 per cent to 27 per cent. Gravel content also ranges widely, from nil to 23 per cent. Pebbles are generally typical of those found in the Bunter Pebble Beds but Carboniferous sandstone and Magnesian Limestone erratics may also be present. The sand fraction is similar to that of the 'Bunter Sand'.

Glacial Sand and Gravel Proved by six IMAU boreholes, Glacial Sand and Gravel generally comprises 'clayey' sand with the fines content between 10 per cent and 16 per cent although at borehole 68 NW 29 no sample contained more than 7 per cent. Gravel was only found in other than trace amounts in two boreholes, 68 NW 26 and 29, where it averages 4 per cent; it consists mainly of quartzite derived from the Bunter Pebble Beds, together with minor proportions of sandstone, Keuper Marl and igneous and metamorphic rocks. The sand fraction consists predominantly of medium-grained quartz.

River Terrace Deposits North and east of East Retford the deposits forming the First Terrace of the River Idle consist mainly of clay and silt and cannot be considered to be 'mineral'. Elsewhere, however, the Idle terrace deposits constitute an important gravel resource and have been worked extensively. They have been proved by numerous boreholes, the majority of which found mean gravel contents in excess of 30 per cent (see Tables 5 and 6). Fines generally account for less than 10 per cent of the deposit but locally may be as high as 21 per cent. The mean grading of the resource, based on data from IMAU boreholes, is 7 per cent fines, 58 per cent sand and 35 per cent gravel.

The gravel fraction is generally fine- to coarse-grained but may include some cobbles up to about 100 mm in diameter. It is composed predominantly of quartzite but also includes quartz, some sandstone and chert and, less commonly, igneous and metamorphic rocks. The sand, largely quartz, is mainly medium-grained but in the more gravelly deposits as much as 30 per cent of the fraction may be of coarse grade.

Terrace deposits are also present in the Ryton valley, but to a much more limited extent, and for convenience, sandy and gravelly deposits beneath the alluvium of Whitewater Common and the valley to the south are here considered with them. They have a mean grading of 10 per cent fines, 59 per cent sand and 31 per cent gravel and are similar in composition to the Idle deposits.

Alluvium Although the Alluvium usually comprises silts and clays, a small number of boreholes have proved it to include 'clayey' sand, and at one locality (borehole 78 NW 15) it was pebbly.

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 topography is shown by contours in grey, the geological data in black and the mineral resource information in shades of red.

Geological data The geological boundary lines, symbols, etc., shown are taken from the geological map of this area, which was surveyed recently at the scale of 1:10 560 scale during 1946-63 by the field staff of the Institute's Yorkshire and East Midlands Unit. 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.

The geological boundaries are regarded as the best interpretation of the information available at the time of the survey. However, it is inevitable that local irregularities or discrepancies will be revealed as new evidence from boreholes and excavation becomes available.

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. The mineral is identified as 'exposed' where the overburden, commonly consisting only of soil and subsoil, averages less than 1.0 m in thickness.

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-bearing, even though it may include small areas where sand and gravel is not present or is not potentially workable. Where there is transition from one category to another which cannot be related to the geological boundaries and which cannot be delineated accurately, inferred boundaries, indicated by a distinctive zigzag symbol, have been inserted. Such boundaries 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 2. Fuller grading particulars are shown in Figure 3 and Tables 3 to 6.

Table 2 Statistical assessment of the sand and gravel resources of the district.

Block	Area		Mean thickness		Volume of sand and gravel			Mean grading percentage		
	Block	Mineral	Over-burden	Mineral		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	$m^3 \times 10^6$	± %	± $m^3 \times 10^6$			
A	42.3	10.6	1.2	2.8	30	44	13	8	72	20
B	22.0	9.6	0.3	7.7	74	43	32	10	87	3
C (Terrace)	33.4	14.3	0.4	3.1	44	37	16	7	60	33
C (Total)	33.4	14.3	0.4	4.5	64	25	16	7	71	22
D	57.9	14.3	1.1	2.5	36	32	12	9	72	19

Table 3 Block A: data from IMAU boreholes and section.

Borehole or section	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fines 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 mm
SK 68								
NW 24	2.4	1.0	16	75	9	0	0	0
NW 25	2.7+	2.8	2	10	53	11	13	11
NW 27	2.4	0.8	19	25	28	7	10	11
NW 28	4.3	0.5	8	10	30	10	18	24
NW 30	0.9	2.2	9	21	14	22	17	17
NW 31	1.9	2.7	1	5	14	14	26	40
NW 32	2.3	1.7	13	54	22	3	3	5
NW 34	1.8	1.4	7	38	53	0	0	2
SW 20	1.2	0.3	22	22	19	6	13	18
SW E1	7.3	0.2	3	33	57	2	2	3

Table 4 Block B: data from IMAU boreholes.

Borehole or section	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fines 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 mm
SK 68								
NW 26	7.0	0	10	37	51	1	0	1
NW 29	3.2	0	6	26	62	2	2	2
NW 35	4.0	0.3	13	27	62	1	1	3
NE 39	4.5	0.4	11	39	49	1	0	trace
SE 49	10.0	0	12	42	43	trace	1	2
SE 52	2.7	0.5	6	14	51	6	7	16
SE 55	6.2	0.5	9	36	53	1	1	trace
SE 56	12.0	0.4	17	37	44	1	1	trace
SE 57	11.7	0.3	4	30	58	2	1	5
SE 59	15.5	0.5	10	46	43	0	1	trace

Accuracy of results For each of the 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 15 per cent and 41 per cent. 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 (505 million m^3) can be estimated to limits of ± 13 per cent at the 95 per cent

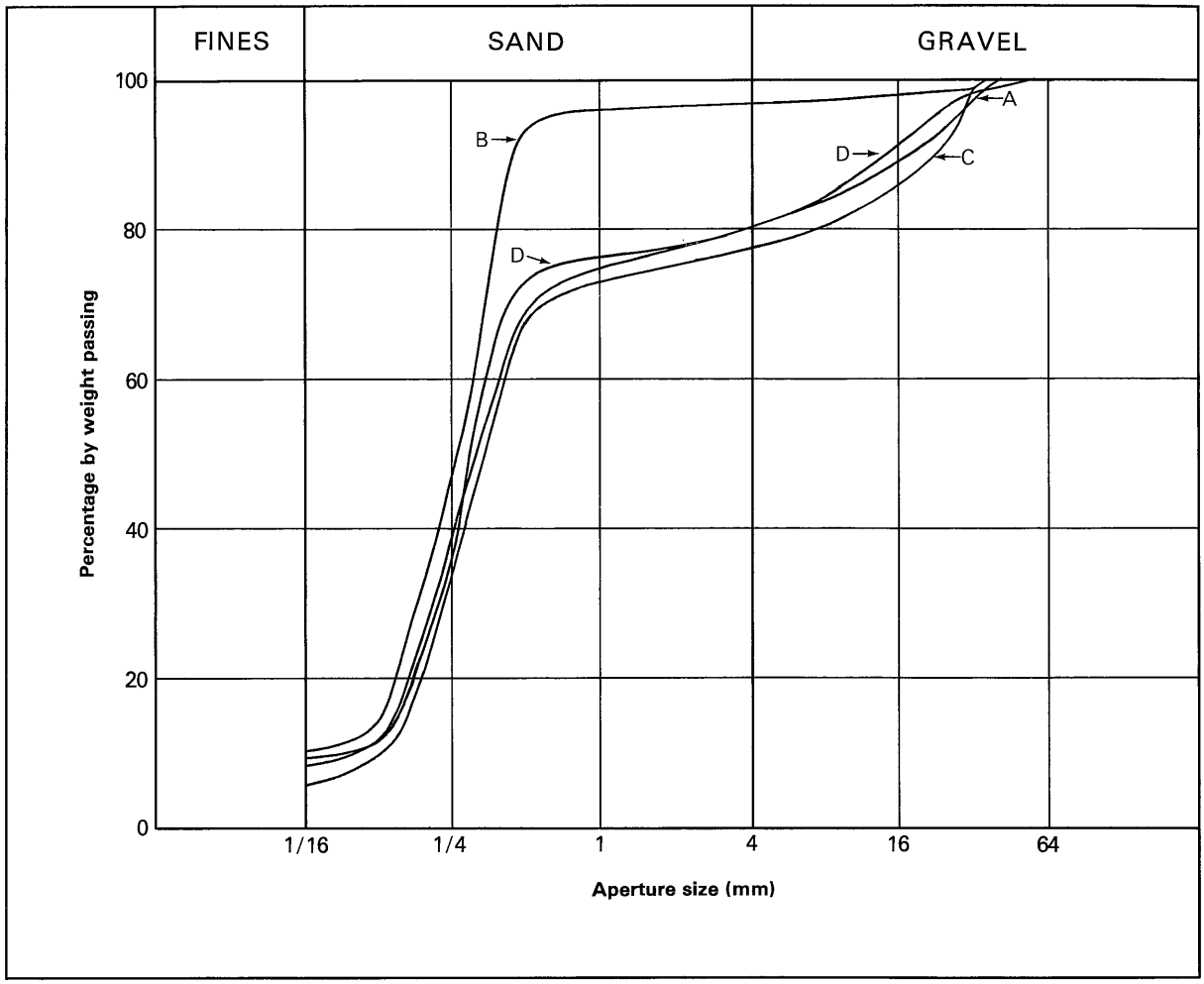
Table 5 Block C: data from IMAU boreholes.

Borehole or section	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fines 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 mm
DRIFT DEPOSITS								
SK 68								
NE 36	6.3	0.4	9	22	37	5	9	18
NE 37	1.0	0.3	12	35	44	1	3	5
NE 40	5.5+	0.3	7	16	26	7	19	25
NE 41	0.6	0.1	21	40	37	2	0	0
NE 42	3.6*	0.5	4	18	40	6	13	19
NE 43	3.0	0.5	3	10	21	12	22	32
NE 44	3.6?	1.0	6	32	59	1	1	1
SE 46	3.0	0.5	12	15	22	11	16	24
SE 47	2.0	0.8	19	41	36	1	2	1
SE 48	3.0	0.5	1	8	27	10	26	28
SE 50	0.9	0.3	1	9	21	10	33	26
SE 53	5.0+	0.4	2	12	31	10	21	24
SE 54	0.9	0.3	11	17	43	5	8	16
SE 58	0.6	0.2	not sampled					
DRIFT AND BUNTER DEPOSITS								
SK 68								
NE 36	6.3	0.4	9	22	37	5	9	18
NE 37	4.5	0.4	7	43	48	0	1	1
NE 40	5.5+	0.3	7	16	26	7	19	25
NE 41	4.8	0.1	9	55	35	1	0	0
NE 42	5.1*	0.5	5	26	39	5	10	13
NE 43	5.4	0.5	4	21	37	7	13	18
NE 44	3.6	1.0	6	32	59	1	1	1
SE 46	5.4	0.5	9	23	39	7	9	13
SE 47	4.8	0.8	13	42	43	1	1	trace
SE 48	6.3	0.5	4	25	38	6	13	14
SE 50	0.9	0.3	1	9	21	10	33	26
SE 53	5.0+	0.4	2	12	31	10	21	24
SE 54	0.9	0.3	11	17	43	5	8	16
SE 58	0.6	0.2	not sampled					

* Excluding a 0.4-m waste parting

Table 6 Block D: data from IMAU boreholes proving mineral.

Borehole or section	Recorded thickness (m)		Mean grading percentage					
	Mineral	Over-burden	Fines $-\frac{1}{16}$ mm	Fines 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 mm
SK 68								
NE 38	5.3+	0.2	8	37	43	3	6	3
SE 51	1.1	0	13	26	43	3	6	9
SK 78								
NW 10	2.1	5.7	1	3	28	15	26	27
NW 11	2.9	0.6	14	30	55	1	0	0
NW 12	3.7	2.8	8	41	32	5	9	5
NW 13	2.8+	2.8	6	24	32	5	16	17
NW 14	1.6	0.7	11	21	66	2	0	0
NW 15	2.8	0	9	19	21	11	22	18
NW 16	2.0	0.9	21	22	52	3	0	2
NW 18	1.6	1.0	6	19	33	6	19	17
NW 20	1.9	0.1	6	14	21	8	29	22
SW 20	1.7	0.6	10	15	32	7	21	15
SW 23	4.9	0	10	43	46	1	0	trace



Resource block	Percentage by weight passing					
	$-\frac{1}{16}$ mm	$+\frac{1}{16}-\frac{1}{4}$ mm	$+\frac{1}{4}$ -1 mm	+1 -4 mm	+4 -16 mm	+16 mm
A	9	30	36	6	8	11
B	10	37	49	1	1	2
C	7	28	38	5	9	13
D	9	28	39	5	10	9

Figure 3 Mean particle-size distribution for the mineral in the resource blocks.

probability level by a calculation based on the data from the 81 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 THE RESOURCE BLOCKS

The mineral in the district has been divided amongst four resource blocks, A to D. The relationships between these blocks and the geology are shown in Figure 4.

Block A (Table 3)

The mineral of this block consists of fluvial deposits together with some Glacial Sand and Gravel and 'Bunter Sand'. Small patches of Head in the Ryton valley, though probably sandy, are not included in the assessment, and the sandy boulder clay is believed to be too thin to be potentially workable.

Potentially workable fluvial deposits occur in long narrow strips in the valleys of the River Ryton and its tributaries and also beneath Whitewater Common. Borehole 68 NW 24 proved 2.4 m of pebble-free 'clayey' sand which is tentatively classified as alluvium; the remaining boreholes encountered more or less pebbly terrace deposits. The latter range in proved thickness from 0.4 m to 4.3 m with a mean of 2.2 m. In two of the boreholes, 68 NW 32 and 34, the gravel content of the terrace deposits was 8 per cent or less, but elsewhere it lies between 21 per cent and 66 per cent; the mean grading approximates to 10 per cent fines, 58 per cent sand and 32 per cent gravel. 'Bunter Sand' was found beneath these deposits only in borehole 68 NW 34.

Glacial Sand and Gravel occurs in a number of small patches, commonly too small to be included in this assessment. It has not been proved by IMAU boreholes but has been examined in excavations. A section

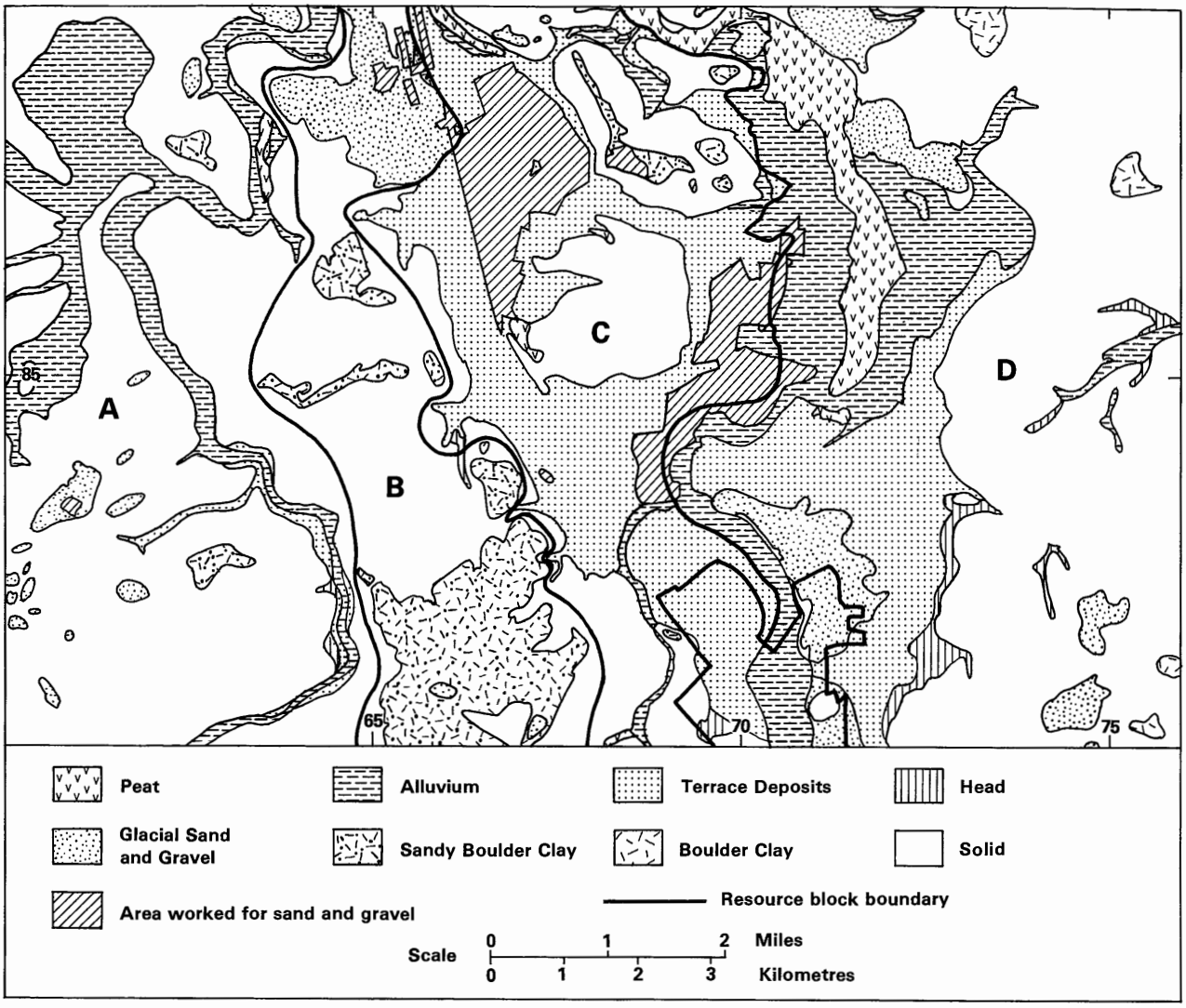


Figure 4 Relationship between resource blocks and geology.

(68 SW E1) in a standing pit east of Broom Covert revealed, in 1979, 1.1 m of sandy gravel resting on 6.2 m of sand with sporadic pebbles in the highest part. Bunter Pebble Beds, virtually pebble-free, are visible at the base of the section and most of the sand is probably derived from them by weathering.

The estimated volume of mineral in the block is 30 million m $\pm$ 44 per cent and its mean grading is 8 per cent fines, 72 per cents sand and 20 per cent gravel.

Where its presence is indicated on the resource map, overburden consists of alluvial clay and silt up to 2.7 m thick. Elsewhere it generally consists of thin sandy soil only.

Block B (Table 4)

The mineral of this block comprises Glacial Sand and Gravel, sandy boulder clay and 'Bunter Sand'. The last is not everywhere readily distinguished from the drift deposits.

Glacial Sand and Gravel is found mainly in the northern part of the block and overlies 'Bunter Sand'. Three IMAU boreholes proved total mineral thicknesses of 7.0 m, 3.2 m and 4.5 m with 'Bunter Sand' predominating. No sample yielded more than 6 per cent of gravel but sections in the pit [652 890] at Scrooby Top have shown appreciable amounts of this fraction (Smith and others, 1973, p. 223).

Sandy boulder clay covers about 5 km^2 near Babworth and is found in a number of small patches to the north. It is almost every where underlain by 'Bunter Sand' which again accounts for the greater part of the mineral found here. Proved mineral thicknesses range from 2.7 m to 15.5 m. Gravel content is generally low but at borehole 68 SE 52, where there is no 'Bunter Sand', it reaches 23 per cent and in boreholes 68 NW 35 and SE 49 the higher parts of the mineral yiedled 9 per cent and 15 per cent of gravel respectively.

The mineral in the block has a mean proved thickness of 7.7 m and an estimated volume of 74 million m^3 $\pm$ 43 per cent. Its mean grading is 10 per cent fines, 87 per cent sand and 3 per cent gravel.

Block C (Table 5)

River Idle terrace deposits, almost entirely 'exposed', together with underlying 'Bunter Sand' constitute almost the whole of the mineral in this block. A number of patches of Glacial Sand and Gravel on the northern margin are too small to merit assessment and sandy boulder clay near Mattersey is thought to be too thin to be potentially workable.

IMAU boreholes found thicknesses of terrace deposits ranging from 0.6 m to 5.5 m, although borehole 68 SE 53 had to be abandoned after having proved 5.0 m; the Sutton borehole (68 SE 1) records them to a depth of 7.3 m. The estimated mean proved thickness is 3.1 m. Gravel was not encountered in borehole 68 NE 41 and boreholes 68 NE 37 and 44 and SE 47 yielded only small amounts of this fraction. Elsewhere, however, gravel accounts for between 24 per cent and 59 per cent of the deposit. Mean fines contents of individual boreholes range from 1 per cent to 21 per cent, the higher values resulting from the presence of 'clayey' to 'very clayey'

sediments in the upper part of the mineral at some sites. A 0.4-m waste parting, not included in the mineral thickness, was found in borehole 68 NE 42. The terrace deposits have been worked extensively throughout the block; the estimated volume remaining is 44 million m^3 ± 37 per cent and the mean grading 7 per cent fines, 60 per cent sand and 33 per cent gravel.

'Bunter Sand' up to 4.2 m thick was found beneath terrace deposits in several boreholes; it consists of fine to medium-grained sand with a few pebbles in places. When this is included in the assessment the mean mineral thickness rises to 4.5 m and the estimate of volume to 64 million m^3 ± 25 per cent. However, the mean grading becomes 7 per cent fines, 7 per cent sand and 2 per cent gravel (Table 2).

Block D (Table 6)

This block encompasses the remaining terrace deposits of the district together with some Glacial Sand and Gravel and minor amounts of alluvial sand and 'Bunter Sand'. The terrace deposits are largely concealed beneath alluvial overburden and in their eastern part become predominantly argillaceous or have been replaced by younger alluvial clays and silts. The approximate eastern limit of fluvial mineral is indicated on the resource map by an inferred boundary.

Terrace deposits range up to 2.1 m in proved thickness but they were not bottomed by borehole 68 NE 38. Gravel content generally ranged from 26 per cent to 69 per cent, although at borehole 68 SE 51 it was only 15 per cent; fines commonly do not exceed 6 per cent. About 15 million m^3 of terrace mineral with a mean grading of 5 per cent fines, 52 per cent sand and 43 per cent gravel are present in the block. At boreholes 68 NE 38 and 78 NW 15 the gravelly terrace deposits are overlain by sand and 'clayey' pebbly sand respectively which have, somewhat arbitrarily, been classified as 'Alluvium', as has the 'very clayey' sand resting on bedrock in borehole 78 NW 16.

Glacial Sand and Gravel at Clayworth and to the north may be up to about 6.4 m thick (the maximum proved thickness being found in an unregistered shot-hole) and two IMAU boreholes show it to consist of 'clayey' sand. At East Retford two IMAU boreholes were sited on the outcrop of Glacial Sand and Gravel; one, 78 SW 23, found 4.9 m of 'clayey' sand but the other, SW 25, proved only clay above bedrock. Since the limits of the barren area are not known the whole of that part of the outcrop assessed is shown as mineral-bearing, but the 'nil' value has been included in the volume calculations. The outcrops of Glacial Sand and Gravel east of Little Gringley are deemed not potentially workable.

Total proved mineral thicknesses, including 'Bunter Sand' which was found only in borehole 78 NW 12 and 13, range from 1.1 m to 6.4 m, with a mean of 2.5 m. The estimated volume of mineral is 36 million m^3 ± 32 per cent and the mean grading 9 per cent fines, 72 per cent sand and 19 per cent gravel.

Alluvial overburden may be up to 5.7 m thick but is generally thinner than 2.8 m. Where mineral is shown as 'exposed' on the resource map, overburden consists of thin sandy soil only.

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.

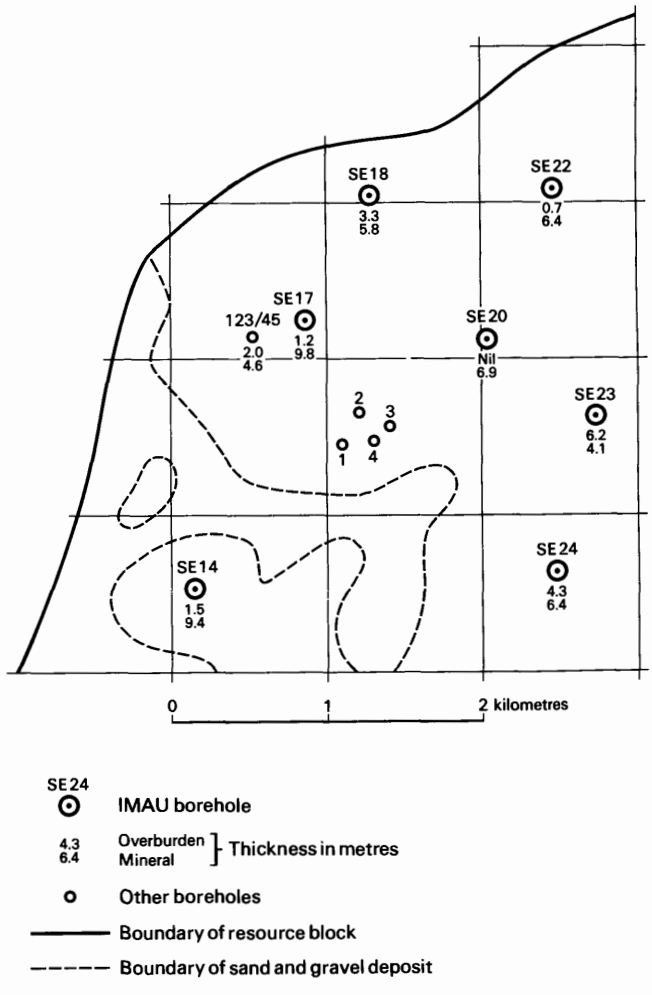
The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30 m (100 ft) at a diameter of about 200 mm (8 in), beneath different types of overburden. It should 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	
123/45	½	2.0		4.6		Hydrogeology Unit record
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, 1957), 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. Origninal 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

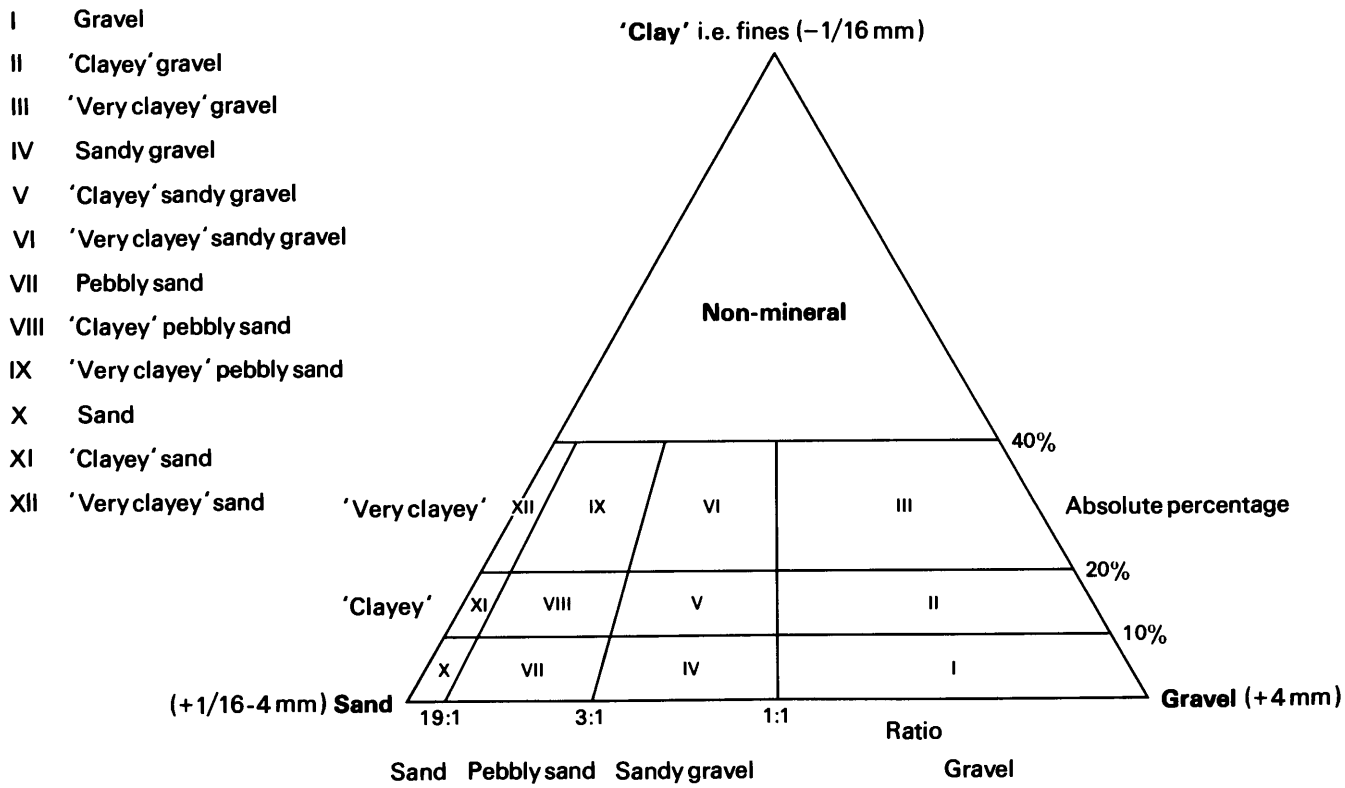


Diagram showing the descriptive categories used in the classification of sand and gravel

APPENDIX D
EXPLANATION OF THE BOREHOLE RECORDS

Annotated fictitious example

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

Surface level (+49.7 m) +163 ft[2]
Water struck at +45.9 m[3]
October 1977[4]

Overburden[5] 2.8 m
Mineral 5.4 m
Waste 1.1 m
Mineral 1.4 m
Bedrock 0.7 m+[6]

LOG

Geological classification	Lithology[7]	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, silty, dark brown	2.6	2.8
River Terrace Deposits	**a** Gravel Gravel: fine to coarse, with cobbles towards base, angular to rounded, flint and limestone with ironstone and some quartz and chalk 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[8]

	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	2.8-3.8	20	14	62	2	2		
				3.8-4.8	2	2	12	18	42	24	
				4.8-5.8	1	3	24	13	35	24	
				5.8-6.8	0	4	21	20	26	29	
				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			
				10.3-10.7	9	85	5	1			
				Mean	5	77	17	1			
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 above.

1 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.

2 Surface level
The surface level at the borehole site is given in metres above Ordnance Datum.

3 Groundwater conditions
If groundwater was present, the level at which it was encountered or the level at which it stood on the completion of drilling is normally given (in metres relative to Ordnance Datum)

4 Type of drill and date of drilling
Unless otherwise stated the borehole was drilled by a shell and auger rig using 152-mm diameter casing. The month and year of completion of drilling are stated.

5 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.

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

7 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 fractions. Where more than one mineral horizon 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.

8 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 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 mm) are stated.

The mean gradings of groups of samples making up an identified mineral horizon are also given in detail and in summary. Where more than one horizon is recognised the mean grading for the whole of the mineal 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.

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 corase gravel may be lower.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE RECORDS

SK 68 NW 24 **6107 8916** **Whitewater** **Block A**

Surface level +10.8 m
Water level not recorded
November 1976

Overburden 1.0 m
Mineral 2.4 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, brown	1.0	1.0
	'Clayey' sand, brown to pink: fine, subangular to rounded quartz	2.4	3.4
Lower Mottled Sandstone	Sandstone, pink, fine	0.2+	3.6

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages			
Fines	Sand	Gravel		Fines	Sand		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1 -4 mm
16	84	0	1.0-2.0	16	76	8	0
			2.0-2.9	16	74	10	0
			2.9-3.4	16	75	9	0
			Mean	16	75	9	0

SK 68 NW 25 **6393 8953** **Serlby Park** **Block A**

Surface level +6.6 m
Water level +6.3 m
November 1976

Overburden 2.8 m
Mineral 2.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on grey to black clayey silt	2.8	2.8
First Terrace	Sandy gravel on pebbly sand Gravel: fine to medium, subangular to rounded quartzite with angular to rounded quartz and chert and some well rounded tabular sandstone Sand: medium, subangular to rounded quartz with a trace of finely disseminated coal debris	2.7+	5.5
	Borehole abandoned due to 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 mm
2	74	24	2.8-3.8	2	9	38	11	22	18
			3.8-4.8	2	10	62	10	8	8
			4.8-5.5	3	12	68	11	8	3
			Mean	2	10	53	11	13	11

SK 68 NW 26 **6488 8970** **Green Lane** **Block B**

Surface level +28.3 m
Water not encountered
November 1976

Mineral 7.0 m
Bedrock 1.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	**a** 'Clayey' sand with some pebbles Gravel: fine to coarse, well rounded, quartz and quartzite Sand: fine to medium, subangular to rounded, quartz with quartzite	2.0	2.0
Bunter Pebble Beds	**b** 'Clayey' sand, brown to buff; fine to medium, subangular to subrounded, quartz with some quartzite; few quartzite pebbles	5.0	7.0
	Sandstone, fine, brown	0.1+	7.1

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 mm
a	10	86	4	0-1.0	12	39	43	1	1	4
				1.0-2.0	8	37	52	0	2	1
				Mean	10	38	48	0	2	2
b	10	90	0	2.0-3.0	9	33	57	1	0	0
				3.0-4.0	9	35	55	1	0	0
				4.0-5.0	11	47	47	1	0	0
				5.0-6.0	10	40	49	1	0	0
				6.0-7.0	11	37	51	1	0	0
				Mean	10	37	52	1	0	0
a + b	10	89	1	Mean	10	37	51	1	0	1

SK 68 NW 27 **6107 8824** **Toad Holes** **Block A**

Surface level +11.8 m
Water level not recorded
November 1976

Overburden 0.8 m
Mineral 2.4 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, light brown, with quartzite pebbles	0.8	0.8
First Terrace	'Clayey' sandy gravel Gravel: fine and coarse, subrounded quartzite Sand: fine to medium, well rounded, quartz with traces of darker mineral in lower part	2.4	3.2
Lower Mottled Sandstone	Sandstone, brown, fine, hard	0.1+	3.3

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 mm
19	60	21	0.8-2.4	21	29	26	6	8	10
			2.4-3.2	16	17	31	8	14	14
			Mean	19	25	28	7	10	11

SK 68 NW 28 **6345 8848** **Brechs Wood** **Block A**

Surface level +8.3 m
Water level +6.3 m
November 1976

Overburden 0.5 m
Mineral 4.3 m
Bedrock 0.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on sandy clay	0.5	0.5
First Terrace	**a** 'Very clayey' sandy gravel Gravel: mainly fine, rounded quartzite with some tabular sandstone Sand: medium, subrounded, quartz with quartzite	1.3	1.8
	b Gravel Gravel: fine to coarse, rounded, quartzite with some sandstone Sand: medium, rounded, quartz with quartzite	3.0	4.8
Bunter Pebble Beds	Sandstone, pink, including fragments of red and green mudstone	0.4+	5.2

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 mm
a	23	64	13	0.5-1.8	23	20	39	5	10	3
b	2	44	54	1.8-2.8	1	4	17	11	23	44
				2.8-3.8	1	5	24	13	26	31
				3.8-4.8	3	9	36	11	16	25
				Mean	2	6	26	12	22	32
a + b	8	50	42	Mean	8	10	30	10	18	24

SK 68 NW 29 **6414 8867** **Bishop Field** **Block B**

Surface level +22.8 m
Water not encountered
November 1976

Mineral 3.2 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	Sand, light brown, partly pebbly Gravel: fine to coarse, well rounded, quartzite with some igneous rock Sand: medium, angular to rounded, quartz with some quartzite and a trace of black chert	3.2	3.2
Bunter Pebble Beds	Sandstone, brown, fine, hard	0.1+	3.3

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 mm
6	90	4	0-1.0	7	29	56	2	2	4
			1.0-2.0	6	20	67	2	3	2
			2.0-3.2	6	27	63	2	1	1
			Mean	6	26	62	2	2	2

SK 68 NW 30 **6097 8750** **Oldcoates Dyke** **Block A**

Surface level +13.1 m
Water level +11.7 m
November 1976

Overburden 2.2 m
Mineral 0.9 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil, pale brown	0.3	0.3
	Clay, brown, sandy; some quartzite pebbles in lower part	1.9	2.2
First Terrace	Sandy gravel Gravel: fine to coarse, subangular, sandstone and oolitic sandy limestone Sand: fine to coarse, angular to subrounded, quartz and quartzite	0.9	3.1
Lower Mottled Sandstone	Sandstone, red, fine	0.1+	3.2

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 mm
9	57	34	2.2-3.1	9	21	14	22	17	17

SK 68 NW 31 **6233 8761** **Normay** **Block A**

Surface level +10.9 m
Water level +9.6 m
November 1976

Overburden 2.7 m
Mineral 1.9 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, brown	1.0	1.0
	Silt, clayey, grey, soft, with peat	1.7	2.7
First Terrace	Gravel Gravel: mainly coarse, well rounded quartzite with some tabular grey sandstone and siltstone Sand: medium to coarse, rounded quartz and quartzite	1.9	4.6
Bunter Pebble Beds	Sandstone, brown	0.1+	4.7

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 mm
1	33	66	2.7-3.7	1	4	9	12	28	46
			3.7-4.6	2	6	19	16	24	33
			Mean	1	5	14	14	26	40

SK 68 NW 32 **6069 8510** **Hodsock** **Block A**

Surface level +16.1 m
Water level +14.1 m
November 1976

Overburden 1.7 m
Mineral 2.3 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on brown sandy clay with few pebbles of sandy limestone	1.7	1.7
?First Terrace	'Clayey' pebbly sand Gravel: fine to coarse, rounded, limestone with some quartzite Sand: fine, angular to rounded quartz	2.3	4.0
Lower Mottled Sandstone	Sandstone, pink to brown, hard	0.5+	4.5

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 mm
13	79	8	1.7-2.7	14	56	22	3	2	3
			2.7-4.0	12	52	23	2	4	7
			Mean	13	54	22	3	3	5

SK 68 NW 34 **6197 8592** **Ash Holt** **Block A**

Surface level +12.6 m
Water level +11.5 m
November 1976

Overburden 1.4 m
Mineral 1.8 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on soft grey silt	1.4	1.4
	Sand, brown to pink: medium, angular to rounded quartz; a few quartzite and sandstone pebbles at top	0.8	2.2
Bunter Pebble Beds	Sand, pink: fine, angular to rounded quartz	1.0	3.2
	Sandstone, hard, fine, pink	0.2+	3.4

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 mm
7	91	2	1.4-3.2	7	38	53	0	0	2

SK 68 NW 35 **6476 8648** **Jubilee Farm** **Block B**

Surface level +21.0 m
Water not encountered
November 1976

Overburden 0.3 m
Mineral 4.0 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.3	0.3
Sandy Boulder Clay	**a** 'Very clayey' pebbly sand Gravel: mainly coarse, well rounded quartzite Sand: fine to medium, angular to rounded, quartz with quartzite	1.0	1.3
Bunter Pebble Beds	**b** Sand, pink to brown, with some pebbles Gravel: fine to coarse, well rounded, quartz with quartzite	3.0	4.3
	Sandstone, fine, pink	0.1+	4.4

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 mm
a	27	64	9	0.3-1.3	27	27	35	2	2	7
b	8	89	3	1.3-2.3	9	27	64	0	0	0
				2.3-3.3	9	29	56	0	2	4
				3.3-4.3	6	24	65	1	1	3
				Mean	8	27	62	trace	1	2
a + b	13	83	4	Mean	13	27	55	1	1	3

SK 68 NE 36 **6588 8920** **Scrooby** **Block C**

Surface level +7.9 m
Water level +4.9 m
November 1976

Overburden 0.4 m
Mineral 6.3 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.4	0.4
First Terrace	**a** 'Clayey' sandy gravel Gravel: fine to coarse, well rounded quartzite Sand: fine to medium, subangular quartz	2.3	2.7
	b Gravel Gravel: mainly coarse, well rounded quartzite with some chert and tabular sandstone Sand: mainly medium, subangular quartz	1.0	3.7
	c Pebbly sand Gravel: mainly coarse, rounded quartzite with some chert and tabular sandstone Sand: mainly medium, subangular to subrounded quartz	3.0	6.7
Bunter Pebble Beds	Sandstone, yellow-brown; scattered quartzite pebbles	0.5+	7.2

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 mm
a	18	58	24	0.4-1.4	21	29	26	6	8	10
				1.4-2.7	16	17	31	8	14	14
				Mean	18	22	29	7	12	12
b	2	33	65	2.7-3.7	2	8	18	7	17	48
a+b	13	51	36	Mean	13	18	26	7	13	23
c	4	78	18	3.7-4.7	4	24	44	3	4	21
				4.7-5.7	4	25	49	2	3	17
				5.7-6.7	4	33	54	2	5	2
				Mean	4	27	49	2	4	14
a+b+c	9	64	27	Mean	9	22	37	5	9	18

SK 68 NE 37 **6825 8940** **Mattersey Thorpe** **Block C**

Surface level +6.0 m
Water level +4.3 m
November 1976

Overburden 0.3 m
Mineral 4.5 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy, with quartzite pebbles	0.3	0.3
Alluvium	**a** 'Clayey' pebbly sand, brown Gravel: fine to coarse, well rounded quartzite Sand: fine to medium, well rounded quartz	1.0	1.3
Bunter Pebble Beds	**b** Sand: fine to medium, angular to subrounded quartz with some quartzite and green mudstone fragments	3.5	4.8
	Sandstone, grey, fine, hard	0.2+	5.0

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 mm
a	12	80	8	0.3-1.3	12	35	44	1	3	5
b	5	95	0	1.3-2.3	6	45	49	0	0	0
				2.3-3.3	6	44	50	0	0	0
				3.3-4.8	5	45	50	0	0	0
				Mean	5	45	50	0	0	0
a + b	7	91	2	Mean	7	43	48	0	1	1

SK 68 NE 38 **6961 8947** **Mattersey** **Block D**

Surface level +5.3 m
Water level +2.6 m
November 1976

Overburden 0.2 m
Mineral 1.5 m
Waste 0.8 m
Mineral 3.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.3	0.3
Alluvium	**a** Sand, pink to brown; fine, subangular to rounded quartz	1.5	1.8
	Clay, brown, soft, with quartzite pebbles	0.8	2.6
	b 'Clayey' sand, pebbly in lower part Gravel: fine, rounded, quartzite and quartz with some chert Sand: mainly medium, subangular to rounded, quartz with some quartzite	2.2	4.8
First Terrace	**c** Sandy gravel: gravel and sand as above	1.6+	6.4
	Hole abandoned due to 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 mm
a	6	94	0	0.3-1.8	6	59	34	1	0	0
b	15	83	2	2.6-4.8	15	31	50	2	2	0
c	2	72	26	4.8-6.4	2	23	42	7	16	10
a+b+c	8	83	9	Mean	8	37	43	3	6	3

SK 68 NE 39 **6530 8805** **High House** **Block B**

Surface level +29.0 m
Water not encountered
November 1976

Overburden 0.4 m
Mineral 4.5 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy and pebbly	0.4	0.4
Glacial Sand and Gravel on Bunter Pebble Beds	'Clayey' sand with a few pebbles Gravel: fine to medium rounded quartzite Sand: red, fine to medium, subangular to subrounded quartz	4.5	4.9
Bunter Pebble Beds	Sandstone, fine, hard, pink	0.1+	5.0

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 mm
11	89	Trace	0.4-1.4	16	37	47	0	0	0
			1.4-2.4	9	40	49	1	0	1
			2.4-3.4	9	35	54	1	0	1
			3.4-4.9	10	41	48	1	0	0
			Mean	11	39	49	1	0	trace

SK 68 NE 40 **6575 8733** **Cemetery** **Block C**

Surface level +12.4 m
Water level not recorded
November 1976

Overburden 0.3 m
Mineral 5.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy	0.3	0.3
First Terrace	**a** 'Very clayey' sandy gravel Gravel: fine to coarse with subangular to well rounded quartzite and quartz with some chert Sand: fine to coarse, angular to subrounded, quartz with quartzite	1.0	1.3
	b Gravel, sandy in lower part Gravel: as above Sand: mainly medium, as above	4.5+	5.8
	Hole abandoned due to 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 mm
a	24	54	22	0.3-1.3	24	25	19	10	13	9
b	4	47	49	1.3-2.3	2	6	19	8	33	32
				2.3-3.3	3	6	23	9	19	40
				3.3-4.3	5	19	37	7	17	15
				4.3-5.8	5	21	29	3	14	28
				Mean	4	14	27	6	20	29
a + b	7	49	44	Mean	7	16	26	7	19	25

SK 68 NE 41 **6795 8706** **Danes Hill** **Block C**

Surface level +13.8 m
Water level +12 m
November 1976

Overburden 0.1 m
Mineral 4.8 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
First Terrace	**a** 'Clayey' sand: grey to brown, fine to medium quartz; few quartzite pebbles	0.6	0.7
Bunter Pebble Beds	**b** Sand, grey: mainly fine quartz	4.2	4.9
	Sandstone, grey, fine, hard	0.1+	5.0

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages			
	Fines	Sand	Gravel		Fines	Sand		
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$
a	21	79	0	0.1-0.7	21	40	37	2
b	7	93	0	0.7-2.7	7	56	37	0
				2.7-4.9	8	59	32	1
				Mean	7	58	34	1
a + b	9	91	0	Mean	9	55	35	1

SK 68 NE 42 **6977 8675** **Neat Holme Road** **Block C**

Surface level +9.2 m
Water level +8.4 m
November 1976

Overburden 0.5 m
Mineral 1.3 m
Waste 0.4 m
Mineral 3.8 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
First Terrace	**a** Sand with some pebbles Gravel: fine to coarse quartzite Sand: mainly medium quartz	1.3	1.8
	Clay, brown	0.4	2.2
	b Sandy Gravel Gravel: mainly coarse, subrounded to ronded, quartzite with some quartz Sand: mainly medium, subrounded quartz	2.3	4.5
Bunter Pebble Beds	**c** Sand, pebbly in top 0.3 m Gravel: coarse, subrounded to rounded quartzite Sand: fine to medium quartz	1.5	6.0
	Sandstone, fine, brown	0.3+	6.3

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 mm
a	6	91	3	0.5-1.8	6	31	59	1	1	2
b	3	50	47	2.2-3.5	4	12	23	11	22	28
				3.5-4.5	1	10	36	8	16	29
				Mean	3	11	29	10	19	28
a + b	4	64	32	Mean	4	18	40	6	13	19
c	9	84	7	4.5-6.0	9	43	39	2	2	5
a+b+c	5	70	25	Mean	5	26	39	5	10	15

SK 68 NE 43 **6647 8562** **College Farm** **Block C**

Surface level +10.6 m
Water not encountered
November 1976

Overburden 0.5 m
Mineral 5.4 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
First Terrace	Soil, black, on dark sandy stony clay	0.5	0.5
	a Gravel Gravel: fine to coarse with scattered cobbles, rounded quartzite and tabular sandstone with chert Sand: fine to coarse, angular to rounded, quartz and quartzite	3.0	3.5
? Bunter Pebble Beds	**b** Sand, pale reddish brown, pebbly in upper part Gravel: fine to coarse, rounded quartzite and quartz Sand: mainly medium, subangular, quartz and quartzite	2.4	5.9
Bunter Pebble Beds	Sandstone, fine, pale reddish brown, hard	0.1+	6.0

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 mm
a	3	43	54	0.5-1.5	3	11	24	11	19	32
				1.5-2.5	5	9	17	13	22	34
				2.5-3.5	2	10	23	10	26	29
				Mean	3	10	21	12	22	32
b	6	92	2	3.5-4.5	6	35	52	2	3	2
				4.5-5.9	6	34	59	1	0	0
				Mean	6	35	56	1	1	1
a + b	4	65	31	Mean	4	21	37	7	13	18

SK 68 NE 44 **6692 8582** **Danes Hall South** **Block C**

Surface level +9.2 m
Water level +7.7 m
November 1976

Overburden 1.0 m
Mineral 3.6 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
First Terrace ?on	Soil on dense sandy clay with quartzite pebbles	1.0	1.0
Bunter Pebble Beds	Sand, pale brown; mainly medium, subangular to rounded quartz; some quartzite pebbles	3.6	4.6
Bunter Pebble Beds	Sandstone, pale brown, fine, hard	0.1+	4.7

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 mm
6	92	2	1.0-2.0	6	27	62	1	1	3
			2.0-3.0	6	29	61	1	1	2
			3.0-4.0	6	34	58	1	1	0
			4.0-4.6	6	39	53	1	1	0
			Mean	6	32	59	1	1	1

SK 68 SW 20 **6426 8290** **Bilby** **Block A**

Surface level +17.5 m
Water not encountered
November 1976

Overburden 0.3 m
Mineal 1.2 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.3	0.3
First Terrace	'Very clayey' sandy gravel Gravel: fine to coarse, well rounded, quartz and quartzite Sand: fine to medium, subangular, quartz with some quartzite	1.2	1.5
Bunter Pebble Beds	Sandstone, fine, hard, pink	0.5+	2.0

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 mm
22	47	31	0.3-1.5	22	22	19	6	13	18

SK 68 SW E1 **6090 8332** **Broom Covert** **Block A**

Surface level +c 48 m
May 1979

Overburden 0.2 m
Mineral 7.3 m
Bedrock –

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	**a** Sand with bands of gravel, brown to reddish brown Gravel: mainly coarse, generally well rounded, quartzite with some soft reddish brown sandstone and quartz Sand: medium, angular to rounded, mainly quartz	1.1	1.3
Bunter Pebble Beds	**b** Sand, brown to red, with sporadic pebbles in upper part: mainly medium but fine towards base, angular to rounded, mainly quartz	6.2	7.5
	Sandstone, red-brown	–	–

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 mm
a	4	63	33	0.2-1.3	4	14	42	7	12	21
b	2	97	1	1.3-2.3	1	18	79	1	1	0
				2.3-3.3	2	28	68	1	1	0
				3.3-4.3	2	19	76	2	1	0
				4.3-5.3	1	24	75	trace	0	0
				5.3-6.3	3	64	33	trace	trace	0
				6.3-7.5	5	60	35	trace	0	0
				Mean	2	36	60	1	1	0
a + b	2	92	6	Mean	2	33	57	2	3	3

SK 68 SE 46 **6678 8465** **Ash Holt** **Block C**

Surface level +11.8 m
Water not encountered
November 1976

Overburden 0.5 m
Mineral 5.4 M
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
First Terrace	Soil on sandy clay	0.5	0.5
	a 'Very clayey' pebbly sand Gravel: fine, well rounded, quartzite with some quartz Sand: fine to coarse, angular to rounded quartz Fines: pale brown clayey silt	1.0	1.5
	b Gravel Gravel: mainly coarse, subrounded to well rounded, quartzite with some quartz Sand: fine to coarse, angular to rounded, quartz with some quartzite	2.0	3.5
Bunter Pebble Beds	**c** Sand: mainly medium, subangular to rounded quartz	2.4	5.9
	Sandstone, fine, red, hard	0.1+	6.0

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 mm
a	32	54	14	0.5-1.5	32	21	23	10	11	3
b	2	44	54	1.5-2.5	2	6	16	15	25	36
				2.5-3.5	2	17	27	8	13	33
				Mean	2	12	21	12	19	35
a + b	12	48	40	Mean	12	15	22	11	16	24
c	6	93	1	3.5-4.5	5	28	64	2	0	1
				4.5-5.9	6	33	59	1	1	0
				Mean	6	31	61	1	1	0
a+b+c	9	69	22	Mean	9	23	39	7	9	13

SK 68 SE 47 **6799 8445** **Sutton** **Block C**

Surface level +12.7 m
Water level +10.7 m
November 1976

Overburden 0.8 m
Mineral 4.8 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, reddish brown, sandy	0.8	0.8
First Terrace	**a** 'Clayey' sand, reddish brown: fine to medium, angular to subrounded quartz; some pebbles	2.0	2.8
Bunter Pebble Beds	**b** Sand, reddish brown: fine to medium, angular to subrounded quartz	2.8	5.6
	Sandstone, fine, hard, reddish brown	0.1+	5.7

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 mm
a	19	78	3	0.8-1.8	20	41	34	1	2	2
				1.8-2.8	18	40	38	1	3	0
				Mean	19	41	36	1	2	1
b	8	92	0	2.8-5.6	8	43	48	1	0	0
a + b	13	86	1	Mean	13	42	43	1	1	trace

SK 68 SE 48 **6897 8472** **Bellmoor Farm** **Block C**

Surface level +10.1 m
Water level +6.2 m
November 1976

Overburden 0.5 m
Mineral 6.3 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.5	0.5
First Terrace	**a** Gravel Gravel: fine to coarse, rounded, quartzite with some chert, tabular sandstone, gneiss and schist Sand: mainly medium, angular to rounded, quartz with some dark grains	3.0	3.5
Bunter Pebble Beds	**b** Sand, pebbly near top: fine to medium, angular to subrounded quartz	3.3	6.8
	Sandstone, fine, red, hard	0.2+	7.0

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 mm
a	1	45	54	0.5-1.5	2	8	21	8	25	36
				1.5-2.5	1	5	19	13	31	31
				2.5-3.5	1	10	42	10	22	15
				Mean	1	8	27	10	26	28
b	6	90	4	3.5-4.5	3	30	53	5	6	3
				4.5-6.8	7	46	45	1	0	1
				Mean	6	41	47	2	2	2
a + b	4	69	27	Mean	4	25	38	6	13	14

SK 68 SE 49 **6674 8348** **Fox Covert, Barnby Moor** **Block B**

Surface level +31.6 m
Water not encountered
November 1976

Mineral 10.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Sandy Boulder Clay	**a** 'Clayey' pebbly sand, brown Gravel: coarse, well rounded, quartzite with some brown tabular sandstone Sand: fine to medium, angular to rounded, quartz with some quartzite	2.0	2.0
Bunter Pebble Beds	**b** 'Clayey' sand, brown to red: fine to medium, angular to rounded quartz with some quartzite; a few pebbles of quartzite near top	8.0	10.0
	Sandstone, red, fine	0.2+	10.2

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 mm
a	18	67	15	0-2.0	18	34	31	2	5	10
b	11	89	0	2.0-4.0	13	43	42	0	1	1
				4.0-6.0	10	39	51	0	0	0
				6.0-8.0	9	43	48	0	0	0
				8.0-10.0	11	49	42	0	0	0
a + b	12	85	3	Mean	12	42	43	trace	1	1

SK 68 SE 50 **6763 8359** **Great North Road** **Block C**

Surface level +13.3 m
Water not encountered
November 1976

Overburden 0.3 m
Mineral 0.9 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, black	0.3	0.3
First Terrace	Gravel, sandy in upper part Gravel: fine to coarse, rounded, quartz and quartzite with some brown sandstone Sand; fine to coarse, subangular to rounded, quartz with quartzite	0.9	1.2
Bunter Pebble Beds	Sandstone, fine, pink, hard	0.1+	1.3

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 mm
1	40	59	0.3-1.2	1	9	21	10	33	26

SK 68 SE 51 **6991 8377** **Tiln** **Block D**

Surface level +11.2 m
Water not encountered
December 1976

Mineral 1.1 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
First Terrace	'Clayey' pebbly sand	1.1	1.1
	Gravel: fine to coarse, rounded quartz and quartzite Sand: mainly medium, subangular to rounded quartz		
Bunter Pebble Beds	Sandstone, brown, hard	0.5+	1.6

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 mm
13	72	15	0.0-1.1	13	26	43	3	6	9

SK 68 SE 52 **6671 8242** **Forest House** **Block B**

Surface level +36.1 m
Water not encountered
November 1976

Overburden 0.5 m
Mineral 2.7 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown sandy	0.5	0.5
Sandy Boulder Clay	Sandy gravel Gravel: fine to coarse, well rounded quartzite and quartz Sand: medium, angular to rounded quartz	2.7	3.2
Bunter Pebble Beds	Sandstone, reddish-brown, fine, hard	0.1+	3.3

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 mm
6	71	23	0.5-1.5	6	10	40	5	10	29
			1.5-3.2	6	17	57	6	6	8
			Mean	6	14	51	6	7	16

SK 68 SE 53 **6823 8286** **Botany Bay** **Block C**

Surface level +15.0 m
Water level +10.0 m
November 1976

Overburden 0.4 m
Mineral 5.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, black, sandy, with pebbles	0.4	0.4
First Terrace	Sandy gravel Gravel: fine to coarse, rounded, quartzite with some tabular sandstone and some dark igneous rock Sand: mainly medium, angular to subrounded, quartz with some dark grains	5.0+	5.0
	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 mm
2	53	45	0.4-1.4	1	11	37	12	28	11
			1.4-2.4	1	10	33	12	21	23
			2.4-3.4	2	12	40	10	16	20
			3.4-4.4	3	8	20	11	25	33
			4.4-5.4	4	17	25	5	16	33
			Mean	2	12	31	10	21	24

SK 68 SE 54 **6913 8296** **Glebe Farm** **Block C**

Surface level +12.0 m
Water not encountered
November 1976

Overburden 0.3 m
Mineral 0.9 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown to black, pebbly	0.3	0.3
First Terrace	'Clayey' sandy gravel Gravel: mainly coarse, well rounded, quartzite and quartz with tabular sandstone and traces of chert Sand: mainly medium, angular to subrounded quartz	0.9	1.2
Bunter Pebble Beds	Sandstone, fine, brown, hard	0.8+	2.0

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 mm
11	65	24	0.0-1.2	11	17	43	5	8	16

SK 68 SE 55 **6548 8171** **Ranby** **Block B**

Surface level +36.7 m
Water not encountered
November 1976

Overburden 0.5 m
Mineral 6.2 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy, with quartzite pebbles	0.5	0.5
Sandy Boulder Clay on Bunter Pebble Beds	Sand, pale reddish brown, with a few pebbles Gravel: fine, well rounded, quartzite with quartz and some chert Sand: medium, angular to subrounded, quartz with some quartzite	6.2	6.7
	Sandstone, pale reddish brown, fine	0.1+	6.8

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 mm
9	90	1	0.5-2.5	10	35	52	1	1	1
			2.5-4.5	9	39	50	1	1	0
			4.5-6.7	9	33	56	1	1	0
			Mean	9	36	53	1	1	trace

SK 68 SE 56 **6635 8140** **Green Mile South** **Block B**

Surface level +40.9 m
Water level +36.9 m
November 1976

Overburden 0.4 m
Mineral 12.0 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy with quartzite pebbles	0.4	0.4
Sandy Boulder Clay	**a** 'Clayey' sand, pale brown, with some pebbles Gravel: mainly coarse, well rounded, quartzite and quartz with some grey sandstone Sand: fine to medium, angular to subangular, quartz with some quartzite	2.0	2.4
Bunter Pebble Beds	**b** 'Clayey' sand, pale brown: fine to medium, angular to subangular, quartz with some quartzite; few quartzite pebbles	10.0	12.4
	Sandstone, red, fine, hard, with traces of red marl	0.1+	12.5

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 mm
a	15	81	4	0.4-2.4	15	38	42	1	1	3
b	18	82	trace	2.4-4.4	14	38	46	1	1	0
				4.4-6.4	16	35	48	1	0	0
				6.4-8.4	19	39	41	1	0	0
				8.4-10.4	19	37	42	1	1	0
				10.4-12.4	19	36	44	1	0	0
				Mean	18	37	44	1	trace	0
a + b	17	82	1	Mean	17	37	44	1	1	trace

SK 68 SE 57 **6740 8095** **New Plantation** **Block B**

Surface level +39.5 m
Water not encountered
November 1976

Overburden 0.3 m
Mineral 11.7 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.3	0.3
Sandy Boulder Clay	**a** 'Clayey' sand, pale brown, with some pebbles Gravel: mainly fine, well rounded, quartzite and quartz with some tabular sandstone and chert Sand: mainly medium, subangular, quartz with some quartzite	2.0	2.3
? Bunter Pebble Beds	**b** Pebbly sand, pale brown Gravel: mainly coarse, as above Sand: as above	9.7	12.0
Bunter Pebble Beds	Sandstone, pale brown	0.1+	12.1

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 mm
a	15	81	4	0.3-2.3	15	25	53	3	3	1
b	2	92	6	2.3-4.3	2	27	63	2	0	6
				4.3-6.3	2	33	57	1	1	6
				6.3-8.3	2	40	55	1	1	1
				8.3-10.3	1	31	58	1	1	7
				10.3-12.0	3	26	60	3	3	5
				Mean	2	32	59	1	1	5
a + b	4	90	6	Mean	4	30	58	2	1	5

SK 68 SE 58 **6873 8213** **Lady Bridge** **Block C**

Surface level +17.8 m
Water not encountered
November 1976

Overburden 0.2 m
Mineral 0.6 m
Bedrock 0.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown sandy	0.2	0.2
First Terrace	Sand with pebbles of quartzite, quartz, sandstone and chert (not sampled)	0.6	0.8
Bunter Pebble Beds	Sandstone, hard, yellow to brown	0.8+	1.6

SK 68 SE 59 **6560 8035** **Beechwood Farm** **Block B**

Surface level +41.9 m
Water not encountered
November 1976

Overburden 0.5 m
Mineral 15.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, sandy, pebbly	0.5	0.5
Sandy Boulder Clay on Bunter Pebble Beds	'Clayey' sand, pale reddish brown with some pebbles near base; thin dark argillaceous partings below 8.0 m Gravel: fine, well rounded, quartzite, quartz and chert Sand: fine to medium, angular to subrounded, red stained quartz with some quartzite and darker minerals	15.5+	16.0

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 mm
10	89	1	0.5-2.5	11	48	41	0	0	0
			2.5-4.5	11	45	44	0	0	0
			4.5-6.5	7	49	44	0	0	0
			6.5-8.5	10	48	42	0	0	0
			8.5-10.5	12	53	34	0	0	1
			10.5-12.5	10	54	36	0	0	0
			12.5-14.5	8	30	56	2	4	0
			14.5-16.0	8	38	51	0	3	0
			Mean	10	46	43	0	1	trace

SK 78 NW 10 **7030 8979** **Mattersey Priory** **Block D**

Surface level +6.9 m
Water level +6.1 m
November 1976

Overburden 5.7 m
Mineral 2.1 m
Bedrock 0.3 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Black soil on silty peat; 0.3 m of clay with quartzite pebbles at 0.9 m and laminated silt partings between 3.0 and 5.0 m	5.7	5.7
First Terrace	Gravel Gravel: fine to coarse, subrounded to well rounded, quartzite with quartz and some chert and tabular sandstone Sand: mainly medium, angular to subrounded, quartz with some quartzite and chert	2.1	7.8
Bunter Pebble Beds	Sandstone, hard	0.3+	8.1

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 mm
1	46	53	5.7-7.8	1	3	28	15	26	27

SK 78 NW 11 **7180 8964** **Wiseton** **Block D**

Surface level +15.6 m
Water level +11.7 m
December 1976

Overburden 0.6 m
Mineral 2.9 m
Bedrock 2.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, reddish-brown, sandy	0.6	0.6
Glacial Sand and Gravel	'Clayey' sand, reddish-brown to greyish-brown: mainly medium, angular to subrounded quartz	2.9	3.5
Keuper Marl	Clay, soft, reddish-brown	1.1	4.6
	Mudstone, red to brown	1.4+	6.0

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages			
Fines	Sand	Gravel		Fines	Sand		
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}$ -1	+1 -4 mm
14	86	0	0.6-2.0	15	32	52	1
			2.0-3.5	13	28	58	1
			Mean	14	30	55	1

SK 78 NW 12 **7041 8838** **Blaco Farm** **Block D**

Surface level +6.5 M
Water not encountered
November 1976

Overburden 2.8 m
Mineral 3.7 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.7	0.7
Alluvium	Clay, soft, brown and green mottled	2.1	2.8
First Terrace	**a** Sandy gravel Gravel: mainly fine, rounded, quartzite and quartz with some tabular sandstone and chert Sand: fine to medium, angular to subrounded, quartz with some quartzite	1.5	4.3
Bunter Pebble Beds	**b** 'Clayey' sand: fine to medium, angular to subrounded, quartz with some quartzite and a trace of green mudstone	2.2	6.5
	Sandstone, fine, pink, hard	0.1+	6.6

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 mm
a	4	63	33	2.8-4.3	4	18	33	12	21	12
b	11	89	0	4.3-6.5	11	57	31	1	0	0
a + b	8	78	14	Mean	8	41	32	5	9	5

SK 78 NW 13 **7111 8827** **Idle Bank, Blaco Hill** **Block D**

Surface level +6.2 m
Water level +5.6 m
November 1976

Overburden 2.8 m
Mineral 2.8 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Soil, black, on peat	2.8	2.8
First Terrace	**a** Gravel Gravel; fine to coarse, well rounded,quartzite and quartz with some chert Sand: mainly medium, subrounded quartz	1.3	4.1
Bunter Pebble Beds	**b** Sand, brown to pink, with a little gravel Gravel: coarse, rounded quartz and quartzite Sand: fine to medium, subangular to subrounded, quartz	1.5	5.6
	Borehole abandoned due to rising sand		

GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages					
	Fines	Sand	Gravel		Fines	Sand			Gravel	
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16$ mm
a	3	28	69	2.8-4.1	3	5	15	8	35	34
b	8	90	2	4.1-5.6	8	41	46	3	0	2
a + b	6	61	33	Mean	6	24	32	5	16	17

SK 78 NW 14 **7193 8833** **Leyfield Farm** **Block D**

Surface level +12.3 m
Water level +11.8 m
December 1976

Overburden 0.7 m
Mineral 1.6 m
Bedrock 2.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil,brown to black, peaty, sandy	0.7	0.7
Glacial Sand and Gravel	'Clayey' sand, brown in upper part,grey below: medium, angular to subrounded, quartz with some quartzite	1.6	2.3
Keuper Marl	Clay, soft, grey to blue	1.0	3.3
	Mudstone, green-blue and brown, variegated	1.7+	5.0

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 mm
11	89	0	0.7-2.3	11	21	66	2	0	0

SK 78 NW 15 **7067 8710** **Neat Holme Road** **Block D**

Surface level +7,0 m
Water level +6.0 m
November 1976

Mineral 2.8 m
Bedrock 0.7 m

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	**a** 'Clayey' pebbly sand Gravel: fine to coarse, rounded quartzite and quartz Sand: fine to medium, subangular to rounded, quartz with some quartzite Fines: thin clay partings	1.0	1.0
First Terrace	**b** Gravel Gravel: fine to coarse, subangular to rounded, quartz with quartzite, tabular sandstone and some chert Sand: fine to medium, subangular to rounded, quartz with with some quartzite	1.8	2.8
Bunter Pebble Beds	Sandstone, fine brown	0.7+	3.5

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 mm
a	19	72	9	0-1.0	19	30	36	6	5	4
b	3	39	58	1.0-2.8	3	13	13	13	32	26
a + b	9	51	40	Mean	9	19	21	11	22	18

SK 78 NW 16 **7215 8747** **Black Syke Drain** **Block D**

Surface level +7.6 m
Water not encountered
December 1976

Overburden 0.9 m
Mineral 2.0 m
Bedrock 2.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown to black, sandy	0.3	0.3
Alluvium	Clay, brown	0.6	0.9
	'Very clayey' sand Sand: medium, subangular to rounded, quartz with traces of brown and green mudstone Fines; brown silty clay partings	2.0	2.9
Keuper Marl	Clay, mottled grey-green and brown	2.1+	5.0

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 mm
21	77	2	0.9-2.9	21	22	52	3	0	2

SK 78 NW 17 **7331 8702** **Common Cottage** **Block D**

Surface level +10.1 m
Water not encountered

Waste 3.4 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium on Keuper Marl	Soil on brown clay; thin partings of silty peat in the upper part; green mottling in lower part	3.4	3.4
	Mudstone and siltstone	0.1+	3.5

SK 78 NW 18 **7127 8651** **Cross Lane** **Block D**

Surface level +7.1 m
Water level +6.5 m
November 1976

Overburden 1.0 m
Mineral 1.6 m
Bedrock 0.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on hard stony clay	1.0	1.0
First Terrace	Sandy gravel with thin clay partings Gravel: fine to coarse, subrounded quartzite and quartz with some rounded tabular sandstone and a trace of chert Sand: mainly medium, subangular to rounded, quartz with some quartzite	1.6	2.6
Bunter Pebble Beds	Sandstone, hard, fine, red	0.5+	3.1

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages					
Fines	Sand	Gravel		Fines	Sand			Gravel	
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	$+1-4$	$+4-16$	$+16$ mm
6	58	36	1.0–2.6	6	19	33	6	19	17

SK 78 NW 19 **7266 8674** **Common Cottage Field** **Block D**

Surface level +8.0 m
Water not encountered
December 1976

Waste 1.4 m
Bedrock 1.6 m

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown	0.8	0.8
Alluvium	Clay, brown, slightly sandy, with rounded quartz and quartzite pebbles	0.6	1.4
Keuper Marl	Clay, soft, reddish brown	1.1	2.5
	Mudstone, unbedded, variegated red and purple	0.5+	3.0

SK 78 NW 20 **7103 8573** **Chain Bridge Road** **Block D**

Surface level +8.0 m
Water level +6.5 m
December 1976

Overburden 0.1 M
Mineral 1.9 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy and stony	0.1	0.1
First Terrace	Gravel Gravel: fine to coarse, subrounded, quartzite and quartz with some tabular sandstone and chert Sand: fine to coarse, rounded, quartz with quartzite	1.9	2.0
Bunter Pebble Beds	Sandstone, fine, red, hard	1.5+	3.5

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 mm
6	43	51	0.1-2.0	6	14	21	8	29	22

SK 78 NW 21 **7175 8560** **Chain Bridge Road** **Block D**

Surface level +7.2 m
Water level +5.7 m
December 1976

Waste 4.9 m
Bedrock 0.9 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Peat	Soil on peaty silt	0.7	0.7
First Terrace	Clayey sandy gravel	0.3	1.0
	Clay, grey and purple, slightly sandy, with quartz and quartzite pebbles	3.9	4.9
? Keuper Green Beds	Sandstone, fine, brown	0.9+	5.8

SK 78 SW 20 **7060 8413** **Tiln** **Block D**

Surface level +9.7 m
Water not encountered
December 1976

Overburden 0.6 m
Mineral 1.7 m
Bedrock 0.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown	0.6	0.6
First Terrace	Sandy gravel with clay partings Gravel: fine to coarse, rounded, quartzite quartz and tabular sandstone Sand: mainly medium, subangular quartz	1.7	2.3
Bunter Pebble Beds	Sandstone, fine, brown, with quartzite pebbles	0.7+	3.0

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 mm
10	54	36	0.6-2.3	10	15	32	7	21	15

SK 78 SW 21 **7235 8415** **Church Lane, Hayton** **Block D**

Surface level +9.5 m
Water level +7.7 m
December 1976

Waste 3.0 m
Bedrock 0.2 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
First Terrace on Keuper Marl	Clay, brown to reddish brown	3.0	3.0
	Siltstone, grey, bedded	0.2+	3.2

SK 78 SW 22 **7149 8364** **Sneeth Lane, Clarborough** **Block D**

Surface level +10.1 m
Water not encountered
December 1976

Waste 2.3 m
Bedrock 2.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown	0.3	0.3
First Terrace	Clay, brown, with some cobbles of rounded quartzite	2.0	2.3
Keuper Waterstones	Mudstone, weathered, purple to brown, with green flecks increasing with depth	2.7+	5.0

SK 78 SW 23 **7067 8294** **Bolham Hall** **Block D**

Surface level +18.1 m
Water not encountered
December 1976

Mineral 4.9 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	'Clayey' sand, pale yellow to brown and pink: fine to medium, angular to subrounded, quartz with some quartzite above 1.0 m and traces of mica below	4.9	4.9
?Keuper Green Beds	Sandstone, fine, pink to brown, hard	0.1+	5.0

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 mm
a	10	90	trace	0.0-1.0	10	39	49	2	0	0
				1.0-3.0	11	39	48	1	0	1
				3.0-4.9	9	48	43	0	0	0
				Mean	10	43	46	1	0	trace

SK 78 SW 24 **7039 8237** **River Flats** **Block D**

Surface level +11.7 m
Water not encountered
December 1976

Waste 1.0 m
Bedrock 1.5 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Soil on black peat	1.0	1.0
Bunter Pebble Beds	Sand, brown passing down into sandstone	1.5+	2.5

SK 78 SW 25 **7140 8231** **Longholme** **Block D**

Surface level +16.6 m
Water not encountered
December 1976

Waste 2.0 m
Bedrock 3.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey	0.3	0.3
	Clay, grey to green, with olive mottling and root remains	1.7	2.0
Keuper Waterstones	Mudstone, brown, micaceous	3.0+	5.0

SK 78 SW 26 **7223 8260** **Bone Mill Lane** **Block D**

Surface level +11.7 m
Water level +10.2 m
December 1976

Waste3.0 m
Bedrock 0.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, clayey	0.3	0.3
First Terrace	Clay, silty to sandy, brown and green; 0.6 m of silty peat at 1.5 m and reed remains near base	2.7	3.0
Keuper Waterstones	Sandstone	0.1+	3.1

SK 78 SE 27 **7187 8147** **Greenlands** **Block D**

Surface level +15.2 m
Water level +14.3 m
December 1976

Waste 1.9 m
Bedrock 1.6 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown	0.3	0.3
?First Terrace	Clay, red to brown	1.6	1.9
Keuper Waterstones	Mudstone, red to brown	1.6+	3.5

SK 78 SW 28 **7193 8014** **Walmoor Farm** **Block D**

Surface level +19.5 m
Water not encountered
December 1976

Waste 2.3 m
Bedrock 1.7 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, loamy	0.3	0.3
First Terrace	Silt, clayey, pale orange brown; few well rounded quartzite pebbles in lower part	2.0	2.3
Keuper Marl	Mudstone, red to brown, with micaceous partings, weathered	1.7+	4.0

APPENDIX F

LIST OF WORKINGS

Name of quarry	Grid reference	Deposits worked
Bellmore Farm	688 838	River Terrace Deposits
Broom Covert	609 832	Glacial Sand and Gravel and Bunter Pebble Beds
Carlton Forest	602 823	Glacial Sand and Gravel and Bunter Pebble Beds
East Retford	700 860	River Terrace Deposits
Mattersey	684 879	Sandy Boulder Clay and Bunter Pebble Beds
North Road	656 888	Glacial Sand and Gravel
Ranskill	668 885	River Terrace Deposits
Rotherham	659 884	Glacial Sand and Gravel
Scrooby	656 900	River Terrace Deposits
Scrooby Sidings	657 897	River Terrace Deposits
Scrooby Top	652 890	Glacial Sand and Gravel and Bunter Pebble Beds
Torworth	668 864	River Terrace Deposits

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INDUSTRIAL MINERALS ASSESSMENT UNIT

THE SAND & GRAVEL RESOURCES OF SHEET SK 68 & PART OF SHEET SK 78 (RANSKILL & EAST RETFORD, NOTTINGHAMSHIRE).

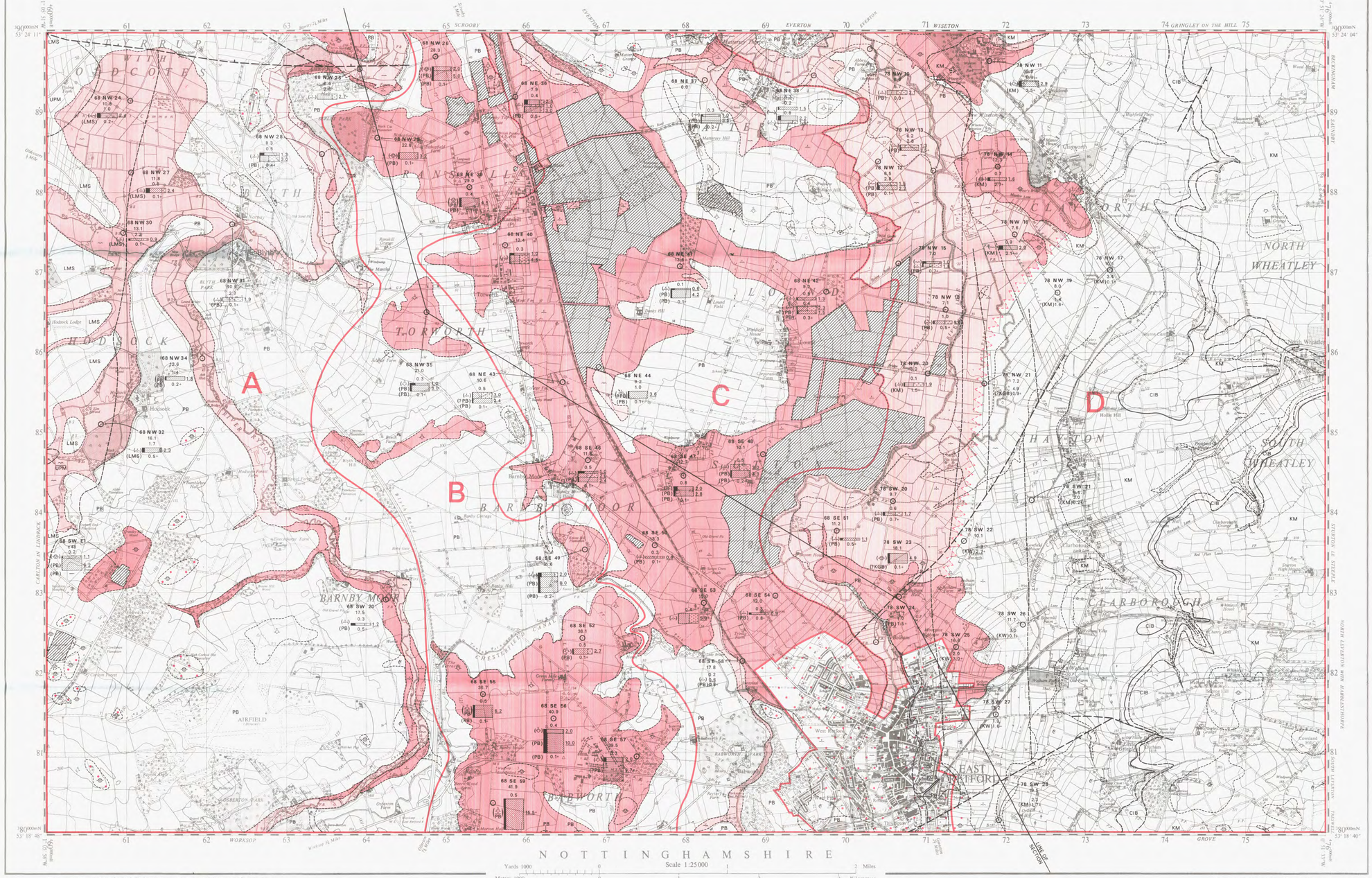
THE SAND & GRAVEL RESOURCES OF SHEET SK 68 & PART OF SHEET SK 78 (RANSKILL & EAST RETFORD, NOTTINGHAMSHIRE).

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

ORDNANCE SURVEY
SHEET SK68 & PART OF SK78
PROVISIONAL EDITION

87

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



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

DRIFT

	Blown Sand - fine sand BS-7	RECENT AND PLEISTOCENE
	Peat P-1	
	Alluvium - silt and clay with some peat and sand A-58	
	River Terrace Deposits: 1st Terrace - mainly sandy gravel and gravel but silt and clay in eastern parts RT-22	
	Head - clay or sand H-36	
	Glacial Sand and Gravel - generally 'clayey' sand with little gravel GS-60	
	Sandy Boulder Clay - mainly 'clayey' pebbly sand SB-2	
	Boulder clay - pebbly clay BC-33	

SOLID

KM,CIB	Keuper Marl including Clarborough Beds - mudstones with thin sandstones and gypsum bands	PERMO-TRIASSIC
KW	Keuper Waterstones - interbedded micaceous mudstones, siltstones and sandstones	
KGB	Keuper Green Beds - mudstones and siltstones, with some sandstones	
PB	Bunter Pebble Beds - mainly fine to medium sandstone with some pebbles in the southern part	
LMS	Lower Mottled Sandstone - fine, locally micaceous sandstone	
UPM	Upper Marl - partly silty mudstones with lenses of sand	

Area worked for sand and gravel WO-20

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 → 68 NE 42
Surface level in metres above O.D. (Newlyn) → 9.2
Borehole site → ○ 0.5 ← Overburden
Geological classification: Waste (–) 1.3 / 0.4; Mineral (Sand and Gravel) (–) 2.3 / (PB) 1.5; Bedrock (PB) 0.3+
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. 68 NE 42. The first number and letters refer to the quarter sheet and the second number to the I.G.S. serial number for that quarter. The unique designation for borehole 68 NE 42 is SK 68 NE 42.

Grading Diagrams

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

The height of the diagram is proportional to the mineral thickness. The widths of the divisions shows 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.

EXPOSURE RECORDS

Information from inspection of exposures is shown in the same way as for boreholes but it is located by an asterisk thus ✳
Records are registered in their own series and serial numbers have the prefix E.

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

Where appropriate on other sheets a category "Discontinuous spreads of mineral beneath overburden" is recognised.

RESOURCE BLOCKS

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

A horizontal section along the line drawn on the map constitutes Fig. 2 of the Report.

Detailed records may be consulted on application to the Head, Industrial Minerals Assessment Unit, Institute of Geological Sciences, Keyworth, Nottingham NG12 5GG

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

Geological survey on the six-inch scale by R.A. Eden, E.G. Smith, R.F. Goossens, V.A. Eyles, G.H. Rhys and W. Edwards in 1946-61. V.A. Eyles, W. Edwards, A.W. Woodland and D.R.A. Ponsford, District Geologists.

Sand and Gravel Survey by D. Thomas in 1976 R.G. Thurrell, Head, Industrial Minerals Assessment Unit.

1 : 25,000 Sand and Gravel Resources Sheet published 1981. G.M. Brown, D.Sc.,F.R.S., Director, Institute of Geological Sciences.

Drawn and printed for the Institute of Geological Sciences, by Cook Hammond & Kell Ltd., Mitcham and Westminster

The GRID lines on this sheet are at 1 Kilometre interval. Heights are in feet above Mean Sea Level at Newlyn. Contour values are in feet. 1 square inch on this map represents 99 859 acres on the ground.

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.

Compiled from 6" sheets last fully revised 1914-18. Other partial systematic revision 1938-51 has been incorporated. Airfield revised 1959. Major roads revised 1965-72

Made and published by the Ordnance Survey, Southampton.

Diagram showing the relation of the National Grid 1 : 25,000 sheets with the One-Inch Geological Sheets 87, 88, 100, 101, 112 and 113