

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

Description of 1:25 000  
resource sheet SE 46

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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 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

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

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## PREFACE

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

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

This report describes the resources of sand and gravel of the country around Tholthorpe, North Yorkshire, shown on the accompanying 1:25 000 resource map SE 46. The survey was conducted by Mr R. Stanczyszyn under the supervision of Mr D. L. Dundas, assisted in the drilling and sampling programme by Mr D. Thomas, Mr A. M. Harrison, and Mr D. Price.

The work is based on six-inch scale geological surveys carried out by Institute Field Staff in 1975 to 1976. The account of the geology of the area has been contributed by Mr H. Johnson of the Yorkshire and East Midlands Unit. Mr J. D. Burnell (Land Agent) has been responsible for negotiating access to land for drilling. The ready cooperation of land owners and tenants in this work is gratefully acknowledged.

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## MAP

The sand and gravel resources of the country around Tholthorpe, North Yorkshire	<i>in pocket</i>
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# The sand and gravel resources of the country around Tholthorpe, North Yorkshire

Description of 1:25 000 resource sheet SE 46

R. STANCZYSZYN

## SUMMARY

The geological maps of the Institute of Geological Sciences, pre-existing borehole information and 90 boreholes drilled for the Industrial Minerals Assessment Unit, form the basis of the assessment of sand and gravel resources of the country around Tholthorpe, North Yorkshire.

All deposits which 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 five resource blocks; for each block the mineral-bearing area, the mean grading and the estimated volume of mineral are stated. For three of the blocks, where the available data are sufficient, the mean thicknesses of mineral and overburden, together with statistical assessments of the volume of mineral, are given also; for the two remaining blocks inferred assessments of the volume are made. Detailed borehole data are presented in Appendix E. The geology, the position of the boreholes, and the boundaries of the resource blocks are shown on the accompanying map.

### Note

All National Grid references fall within the 100-km square SE and all Borehole Registration Numbers fall within the 1:25 000 sheet SE 46.

### Bibliographical reference

STANCZYSZYN, R. 1981. The sand and gravel resources of the country around Tholthorpe, North Yorkshire: description of 1:25 000 resource sheet SE 46. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 88.

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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, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot 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; Harris and others, 1974).

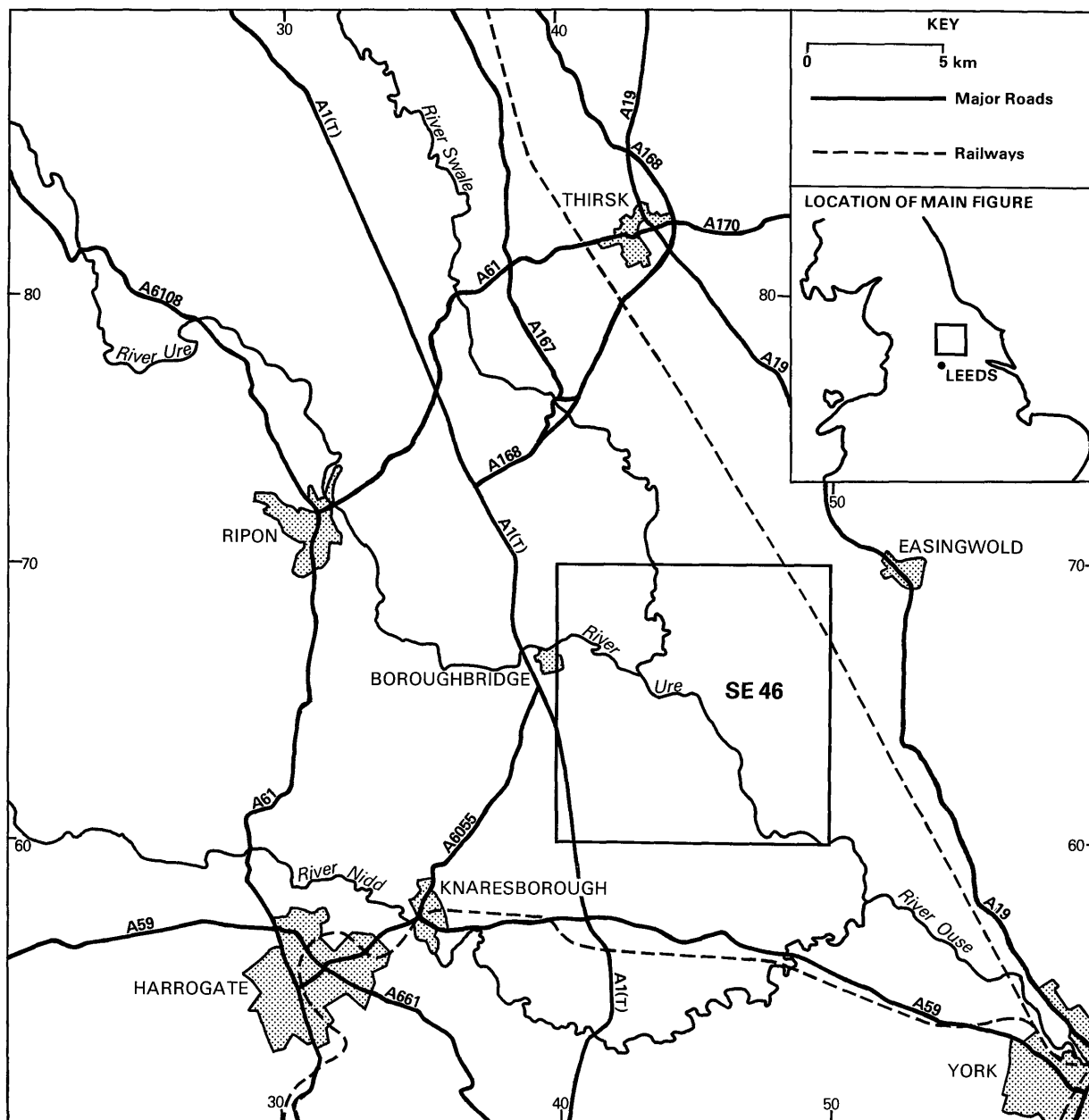
The survey provides information at the 'indicated' level 'for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are 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  $\frac{1}{16}$  mm) should not exceed 40 per cent.
- d The deposit must 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.

The Sherwood Sandstone Group, which was proved in many of the boreholes, has not been assessed in this survey, although in places it is friable or unconsolidated and may satisfy the criteria for mineral.



**Figure 1** Map showing location of Sheet SE 46

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

The volume and other characteristics are assessed within resource blocks, each of which, ideally, contains approximately 10 km<sup>2</sup> of sand and gravel. No account is taken of any factors, for example, roads, villages and 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 the mineral in parts of a block, except in the immediate vicinity of the actual sample points.*

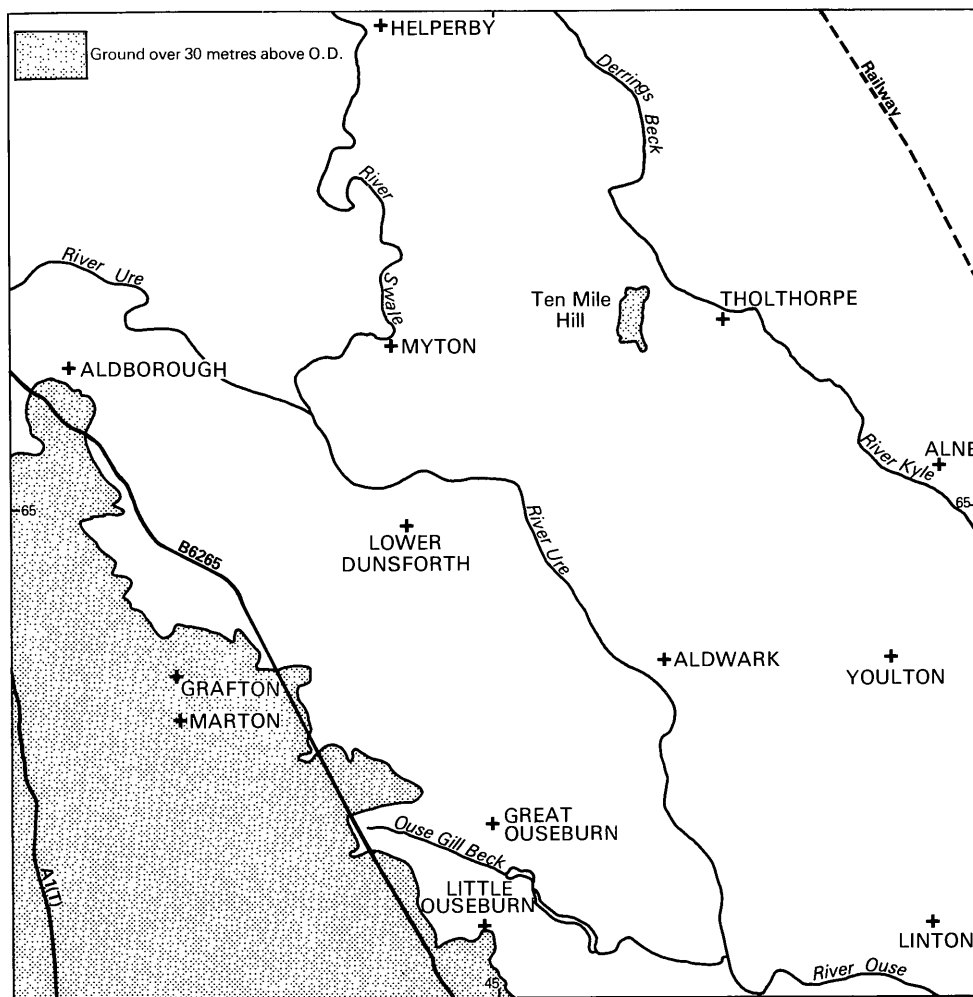
## DESCRIPTION OF THE DISTRICT

### GENERAL

The district described in this report lies north-west of York, almost entirely between the A1 trunk road and the main London-Edinburgh railway (Figure 1). It is dominantly agricultural with both arable land and pasture. The population is scattered in a number of villages—the small towns of Boroughbridge and Easingwold lie respectively just west and east of the district. Several small gravel pits on the eastern side of the district, together with a more extensive pit between Marton and Grafton [420 632], have been worked intermittently in recent years.

### TOPOGRAPHY

The B6265 Boroughbridge-York road runs near the foot of a marked north-east-facing slope (Figure 2). The higher ground to the south-west of this is hummocky and has a general elevation of about 60 m above Ordnance Datum; its highest point (75 m above Ordnance Datum)



**Figure 2** The topographical features of the district

is Grafton Hills [421 632]. The remainder of the district lies mostly between 15 and 30 m above Ordnance Datum and has low relief; its only notable feature is a low ridge, which extends south-eastwards from Helperby and culminates in a conspicuous knoll called Ten Mile Hill [463 670], which rises to about 38 m above Ordnance Datum.

The other important elements of the topography are the rivers Ure and Swale, whose confluence lies about 2 km east of Aldborough [406 663]. The Ure flows in a generally south-easterly direction for about 8 km below the confluence before turning eastwards just downstream of its junction with Ouse Gill Beck [473 604], from which point it is called the Ouse. The floodplain of the Ure and Swale north and east of Lower Dunsforth is 1 km or more wide, but west of Aldwark it narrows to only about 200 m before widening to 600 m further downstream, south of Hunters Lodge [476 608].

### **GEOLOGY**

A general description of the geology of the Harrogate region is given in Fox-Strangways' *Memoir* (1908), and Rayner and Hemingway's *Geology and Mineral resources of Yorkshire* (1974), which contains extensive bibliographies and is a comprehensive compilation of existing knowledge.

The Solid rocks and Drift deposits found at and near the surface in the district are listed in Table 1 and their relationships are illustrated in cross-sections (Figure 3).

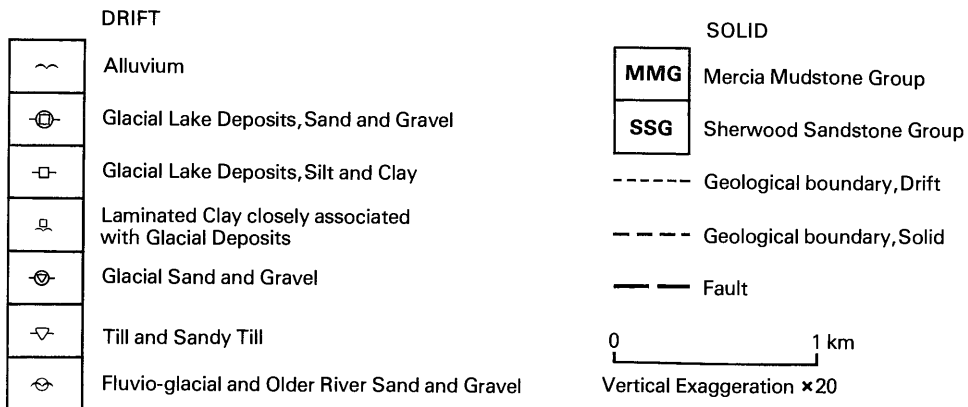
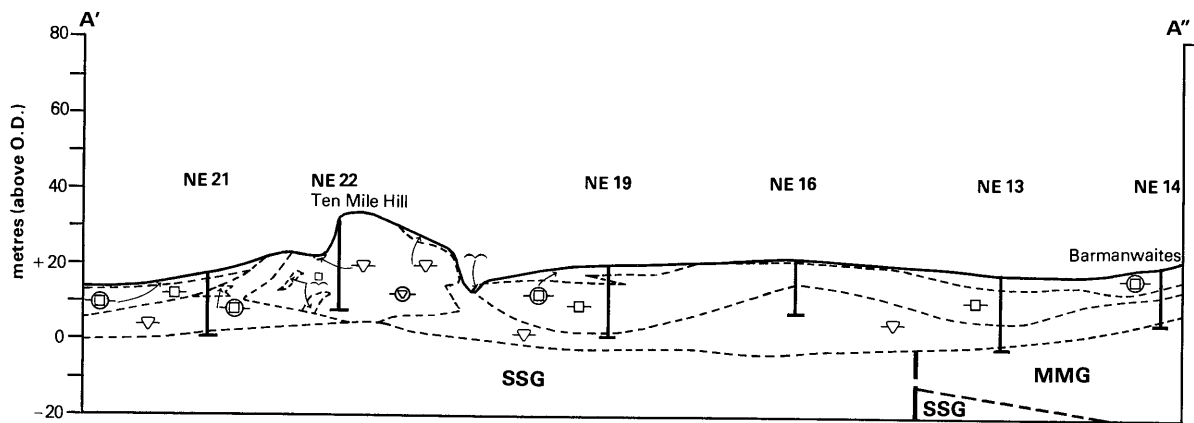
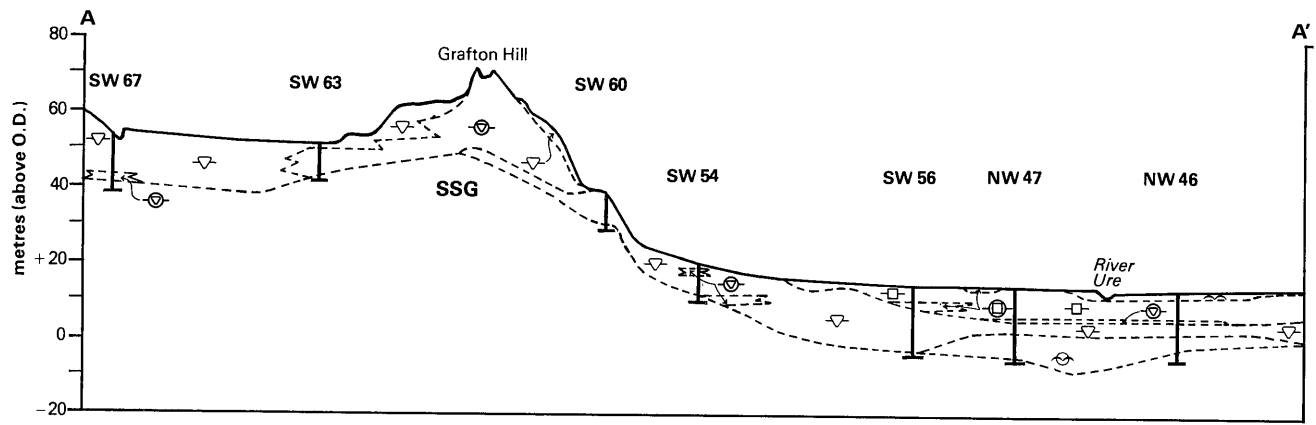
### **SOLID**

#### *Sherwood Sandstone Group*

This group consists of up to 300 m of reddish brown and grey, fine- to medium-grained sandstone, which is usually cross-bedded and micaceous with sporadic grey-green mudstone and mudstone beds occur, more commonly at the base of the group, and normally form the tops of upward-fining cycles, 1 to 2 m thick. Much of the sandstone is friable, even at depth, and at outcrop it may be unconsolidated. The outcrop is largely concealed by Drift, but exposures occur around Aldborough, Great Ouseburn and Little Ouseburn.

#### *Mercia Mudstone Group*

There are no exposures of these rocks in the area, all of the outcrop being covered by Drift. Boreholes, however, prove up to 18 m of red-brown and grey-green mudstone with gypsum. The mudstone is commonly brecciated, probably due to collapse after solution of gypsum.



**Figure 3** Cross-sections showing the relationships between the Drift deposits



**Table 1** Geological succession

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DRIFT
<b>Quaternary</b>
Peat
Alluvium
River Terrace Deposits, undifferentiated
Glacial Lake Deposits (Silt and Clay, and Sand and Gravel)
Laminated clay closely associated with Glacial Deposits
Glacial Sand and Gravel
Till and Sandy Till
Fluvio-glacial and Older River Sand and Gravel
SOLID
<b>Triassic</b>
Mercia Mudstone Group
Sherwood Sandstone Group

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DRIFT

*Fluvio-glacial and Older River Sand and Gravel*

These deposits occupy the bottom of a channel system cut into bedrock (Figure 4) and are probably of alluvial and proglacial origin. They consist of sand and gravel with very little interstitial silt and clay and are generally overlain by till. The contained pebbles and cobbles are composed mainly of Carboniferous sandstone and limestone, but also of Permian limestone and Triassic Sherwood Sandstone. The floor of this channel system falls from about Ordnance Datum in the north-west to more than 9.6 m below Ordnance Datum in the south-east. The upper surface of the deposits is irregular, suggesting that they have been affected by glacial scour.

*Till and Sandy Till*

In most of the area Till and Sandy Till of Devensian age overlie bedrock. The tills are generally exposed on the relatively high ground and may be up to 20 m thick. Their matrix varies from fine-grained, clayey sand to sandy clay and is reddish brown to dark brown in colour. Where till overlies Sherwood Sandstone its lower part is usually more sandy. The dominant erratics are Carboniferous sandstones and chert, but erratics of Sherwood Sandstone and Carboniferous Limestone are common at depth. There are also Permian limestone erratics, commonest in the western part of the area, and sporadic igneous rocks. Lenses and discontinuous beds of laminated clay, and sand and gravel are present within the tills.

*Glacial Sand and Gravel*

These deposits vary considerably in their content, thickness, and topographic expression, and in their relationship to the tills. They range from reddish brown, fine- to medium-grained sand with clay laminae to coarse gravel. The sand exhibits a wide variety of sedimentary structures, many of which are indicative of rapid sedimentation. The gravels are usually cross-bedded. The contained pebbles are of similar lithologies to those of the tills. Much of the sand and gravel seems to have been deposited on top of and within a stagnating ice-sheet and commonly has a cover of flow till.

*Laminated clay closely associated with Glacial Deposits*  
Small patches of laminated clay with silt and sand beds occur within the glacial sequence; boreholes prove these deposits to be up to 12 m thick. Sections commonly show the bedding to be contorted, possibly due to melt-out of ice support.

*Glacial Lake Deposits*

Clay, silts and sands of lacustrine origin are extensive in the north and east of the area. They generally occupy low ground and form flat expanses.

*Silt and Clay* Firm to stiff, grey to brown clay, commonly with numerous laminae of silt and fine-grained sand, forms the bulk of the lacustrine deposits and is more than 17 m thick at Tholthorpe Moor. Pebbles and cobbles, though very rare, are present and are presumably ice-rafted.

*Sand and Gravel* Fine- to medium-grained sand and clayey sand are interbedded with the lacustrine clays. Small pebbles, mainly of Carboniferous sandstone, occur sporadically at the base of minor channels.

*River Terrace Deposits, undifferentiated*

In the north-west of the area a deposit of fine- to medium-grained, clayey sand forms a terrace marginal to, and 1.5 m above, the alluvium of the River Swale.

*Alluvium*

Clay and silt form the alluvium of the rivers and are generally less than 5 m thick. Numerous ill-drained hollows contain alluvial clay and silt, commonly associated with peat. The majority are situated in localities mantled by glacial deposits and some are typical kettle holes.

*Peat*

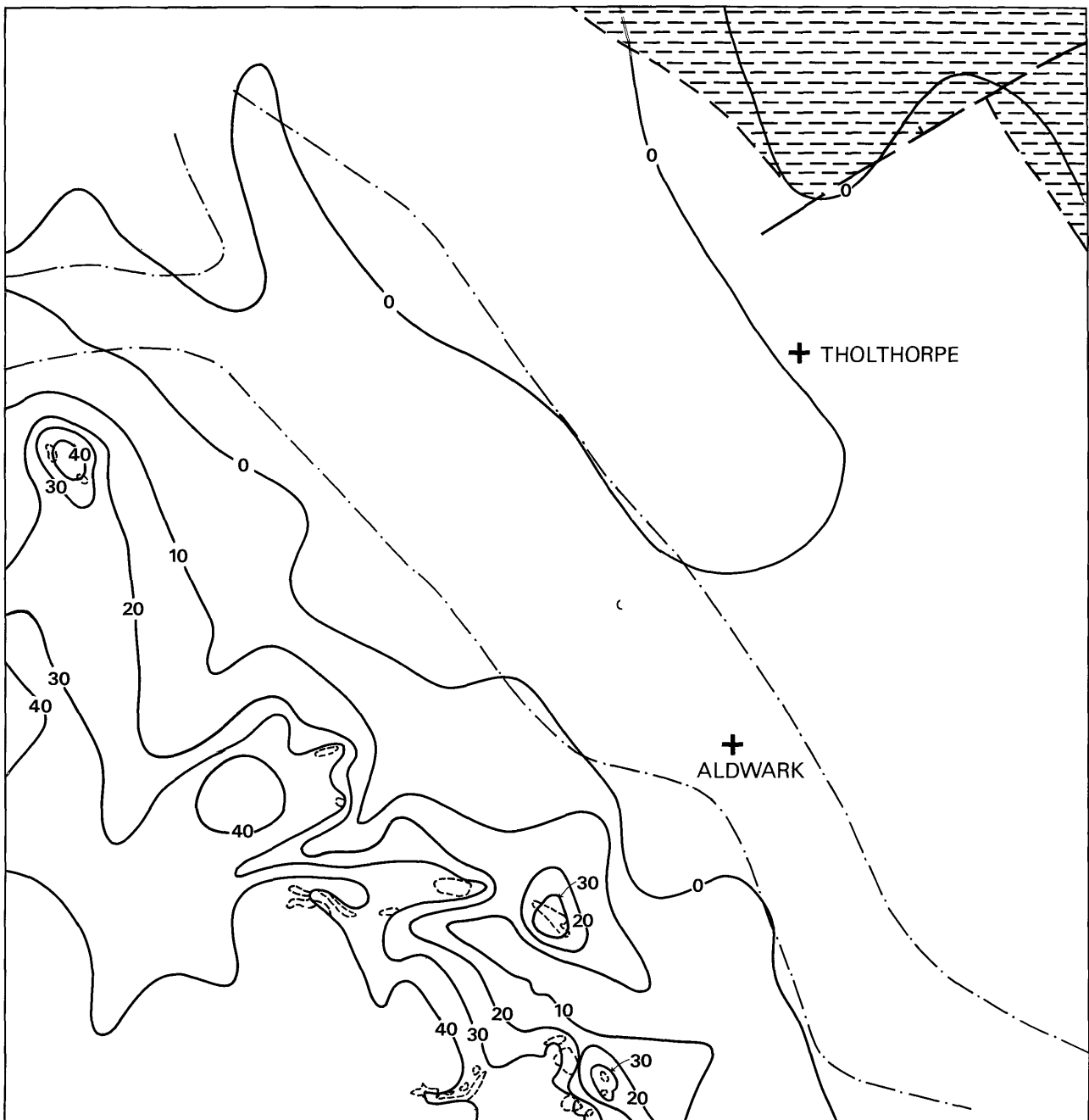
Peat occupies low-lying, ill-drained land and is generally less than 2 m thick.

**COMPOSITION OF THE SAND AND GRAVEL DEPOSITS**

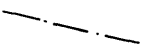
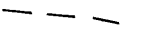



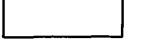
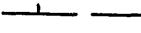
Five deposits containing potentially workable sand and gravel occur within the district: Fluvio-glacial and Older River Sand and Gravel, Glacial Sand and Gravel, Sandy Till, Glacial Lake Deposits Sand and Gravel, and Alluvium. The first-mentioned of these deposits is always concealed beneath younger Drift, but the others can be found at the surface.

*Fluvio-glacial and Older River Sand and Gravel* This deposit, which everywhere has been graded as mineral, is markedly thicker to the south-east than it is in the north-west of the district. The overall mean thickness as proved in IMAU boreholes is 4.6 m.

The mean grading for this deposit is fines 6 per cent, sand 58 per cent, and gravel 36 per cent; mean gradings for individual boreholes show a consistently low fines content, which exceeds 10 per cent in one borehole (NW 33) only. However, all the samples were recovered from below the water table and were thus liable to loss of the fines fraction. The percentages of sand and of gravel are more variable than that of fines.



KEY

- |   |   |   |                          |
|---|---|---|--------------------------|
|  | Approximate limit of Fluvio-glacial and Older River Sand and Gravel |  | Geological boundary      |
|  | Contour on bedrock surface (metres above O.D.)                      |  | Mercia Mudstone Group    |
|  | Bedrock outcrop   |  | Sherwood Sandstone Group |
|  | Fault: tick marks indicate downthrow side                           |   |                          |

0 1 km

Figure 4 Contours on the bedrock surface

**Table 2** Lithological analyses of the gravel fraction from random samples of Fluvio-glacial and Older River Sand and Gravel

Borehole number	Depth below surface (m)	Percentage by weight (and by number)						
		Sandstone	Limestone	Dolomite	Soft sedimentary	Chert	Igneous	Ironstone
NW 25	11.5–15.4	79 (62)	17 (32)	1 (1)	trace (1)	1 (2)	2 (2)	—
NW 39	9.0–12.3	79 (45)	12 (36)	4 (6)	trace (1)	1 (1)	4 (7)	trace (4)
NW 41	13.3–15.3	57 (40)	36 (38)	5 (11)	1 (8)	1 (2)	—	trace (1)
NW 45	10.4–13.2	74 (59)	15 (23)	1 (2)	5 (8)	2 (2)	1 (trace)	2 (6)
NW 46	10.4–13.4	60 (54)	13 (20)	22 (14)	trace (1)	1 (3)	4 (8)	—
SE 29	12.5–14.5	70 (56)	18 (21)	6 (8)	5 (11)	1 (2)	trace (1)	trace (1)
SE 44	10.8–17.1	76 (56)	5 (10)	2 (2)	8 (13)	6 (8)	1 (1)	2 (10)
	Mean	73 (54)	14 (24)	5 (5)	3 (7)	2 (3)	2 (3)	1 (4)

**Table 3** Lithological analyses of the gravel fraction from random samples of Glacial Sand and Gravel

Borehole number	Depth below surface (m)	Percentage by weight (and by number)						
		Sandstone	Limestone	Dolomite	Soft sedimentary	Chert	Igneous	Ironstone
NW 29	10.8–15.4	45 (46)	32 (35)	13 (7)	4 (6)	2 (2)	2 (1)	2 (3)
NW 31	6.6–8.7	90 (90)	6 (6)	—	1 (2)	3 (2)	—	—
NW 42	8.5–10.0	36 (29)	44 (49)	14 (15)	6 (7)	—	—	—
NW 45	6.5–7.8	69 (66)	13 (5)	2 (1)	13 (24)	2 (2)	1 (2)	—
NE 18	13.8–15.4	89 (84)	1 (3)	—	3 (8)	6 (4)	1 (trace)	trace (1)
NE 22	2.0–4.0	70 (56)	19 (22)	1 (4)	4 (10)	4 (3)	2 (2)	trace (3)
NE 22	5.3–11.3	73 (59)	15 (15)	3 (5)	3 (12)	3 (2)	2 (2)	1 (5)
NE 24	2.7–3.7	55 (50)	23 (22)	7 (8)	12 (16)	1 (2)	2 (2)	—
SW 72	4.5–9.5	56 (40)	28 (35)	9 (12)	4 (7)	2 (3)	1 (3)	—
	Mean	64 (56)	21 (23)	6 (6)	4 (9)	3 (2)	1 (2)	1 (2)

Carboniferous sandstone pebbles, usually equant and subrounded to well-rounded, predominate in the gravel (Table 2). They are grey or light brown and are well cemented; they are especially numerous in the coarse gravel fraction, so that their mean percentage by weight is much higher (73 per cent) than by number (54 per cent). The other main constituent, black and dark grey and light grey Carboniferous limestone, has a correspondingly higher percentage in the fine gravel than in the coarse gravel fraction. Other rock types, chert (probably Carboniferous), dolomite (probably exclusively Permian), soft sedimentary rocks (mostly Triassic), ironstone, and igneous rocks, are present in amounts generally between trace (less than 0.5 per cent) and 10 per cent, and are commonest in the fine gravel fraction.

*Glacial Sand and Gravel* Individual samples of this deposit show a wide variation in their particle-size distribution but the mean grading for the mineral proved in IMAU boreholes was found to be fines 17 per cent, sand 71 per cent and gravel 12 per cent; the thicknesses are also very variable but have a mean of 5.0 m.

South-west of the Ure, the mineral can rarely be correlated between borehole sites and probably forms isolated lenticular bodies within a much greater volume of till. In this area the proved thicknesses of mineral range from 1.0 to 13.5 m, and the mean grading is fines 18 per cent, sand 61 per cent and gravel 21 per cent.

However, north-east of the Ure the Glacial Sand and Gravel forms a continuous body, masked in places by a cover of till or lacustrine deposits, which extends over an area of about 17 km<sup>2</sup> between Helperby and Youlton. Proved thicknesses of mineral in this body vary from 1.0 to 19.7 m. It usually has a markedly lower content of gravel than is found in the deposits south-west of the Ure: its mean grading is fines 17 per cent, sand 77 per cent and gravel 6 per cent.

The gravel of the Glacial Sand and Gravel deposits contains a somewhat higher proportion of Carboniferous limestone pebbles, especially in the coarse gravel fraction, than does that of the Fluvio-glacial and Older River Sand and Gravel, although Carboniferous sandstone is still by far the commonest rock type (Table 3), outweighing limestone in the ratio of about 3:1. Other rock types together amount to only 15 per cent by weight in the overall mean composition. In the west of the district, pebbles of Permian dolomite comprise in places more than 10 per cent by weight of the gravel and tend to be more common towards the base of the deposits, but elsewhere they rarely exceed 5 per cent. None of the other constituent rock types normally exceeds 5 per cent. The Triassic soft sedimentary rocks rarely exceed 4 per cent by weight, except in the vicinity of Ten Mile Hill, where they form about 12 per cent of the gravel; being easily comminuted, these rocks are much less common in the coarse gravel fraction.

**Sandy Till** Three areas mapped as Sandy Till near the abandoned gravel pits at Grafton Hills have yielded samples that have been graded as mineral; although their fines content is high (between 21 and 30 per cent), it falls within the range of that of the Glacial Sand and Gravel of this area. Accordingly, these samples from the Sandy Till have been grouped with those of the Glacial Sand and Gravel described above. Another area of Sandy Till, near Helperby Grange [444 694], has a similar grading to the nearby deposits of Glacial Sand and Gravel at Ten Mile Hill.

Lithological analyses of two samples of Sandy Till from borehole SW 56, west of Lower Dunsforth [438 647], show that the mean composition of the gravel fraction (sandstone 63 per cent and limestone 27 per cent by weight, with other constituents not exceeding 5 per cent individually) is close to the overall mean composition of the Glacial Sand and Gravel.

**Glacial Lake Deposits Sand and Gravel** The mean grading of this deposit, which is widespread at the surface in the north-east of the district, is fines 14 per cent and sand 86 per cent. The sand content in individual boreholes shows a relatively limited range from 71 per cent to 94 per cent. The thicknesses proved in IMAU boreholes range from 1.0 to 7.5 m, with a mean of 2.9 m.

**Alluvium** Alluvium of mineral grading was encountered in only two (NW 36 and NW 38) out of the ten IMAU boreholes sited on this deposit. Borehole NW 36 proved 1.8 m of fine sand beneath 3.0 m of clay, and borehole NW 38 proved 9.5 m of 'very clayey' sand, which is presumably alluvium.

#### THE MAP

The sand and gravel resource map is folded into the pocket at the back cover 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, the geological data in black and the mineral resource information in shades of red.

**Geological data** The geological boundary lines are based on six-inch geological surveys carried out by members of the Institute's Yorkshire and East Midlands Unit in 1975-76. These boundaries are regarded as being the best interpretation of the information available at the time of writing. However, as the bedrocks are almost entirely concealed, the position of faults and solid geological boundaries is conjectural. Borehole data, which include the stratigraphic relations, thicknesses and gradings of deposits of sand and gravel classed as mineral, are also shown.

It is inevitable, with Drift deposits such as those present in this area, which change rapidly both laterally and vertically, that borehole data should sometimes reveal local anomalies in the boundaries drawn on the basis of surface mapping.

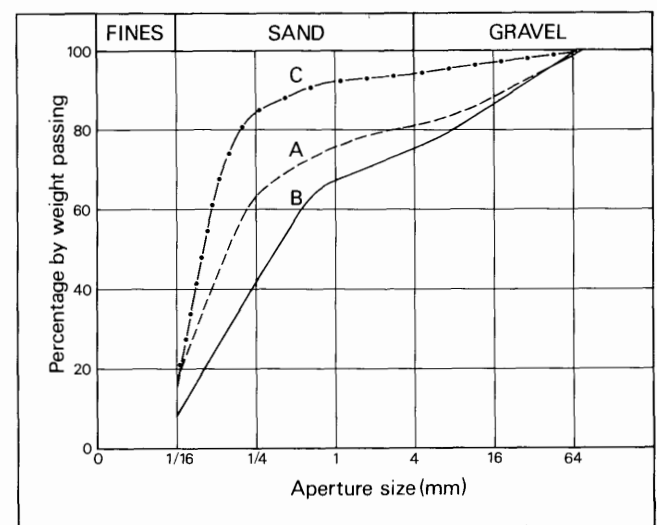
**Mineral resource information** The mineral-bearing ground is divided into resource blocks (see Appendix A). Within a resource block the mineral is subdivided into areas where it is exposed, that is, where overburden averages less than 1 m in thickness; areas where it is continuous or almost continuous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

overburden. Areas where bedrock is exposed, or where sand and gravel are probably absent or not potentially workable are uncoloured on the map.

Where appropriate, the depicted distribution of the various categories of deposits is based on the mapped geological boundaries. However, where there is transition from one category to another that cannot be delineated precisely on the map, a zigzag symbol is used to indicate an inferred boundary. This symbol shows the approximate location of the boundary but is not intended to indicate the width of the transition zone between the categories. For the purpose of measuring area the centre line of the symbol is used.

#### RESULTS

The results of the assessment of the five resource blocks into which the district has been divided are summarised in Table 4. The mineral in three, blocks A, B and C, has been assessed statistically; a comparison of the mean particle-size distribution curves is shown in Figure 5.



**Figure 5** Mean particle-size distribution curves for the mineral in blocks A, B and C

Blocks D and E contain only limited areas of mineral and the data available are insufficient to allow a statistical assessment of their resources to be made. The confidence limits at the 95 per cent probability level (see Appendix B) for the estimated volume of mineral in the statistically assessed blocks A, B and C are  $\pm 39$ ,  $\pm 27$ ,  $\pm 31$  per cent respectively. The size of the limits is essentially a reflection of the variability of the mineral thickness proved in the assessment boreholes. For the purposes of volume assessment the entire area of each of the statistically assessed blocks, except where bedrock crops out, has been regarded as potentially mineral-bearing. The error introduced by this procedure on block A, where the mineral is designated as 'discontinuous beneath overburden', should have been compensated for by the fact that nil thicknesses have been entered for those boreholes in which mineral was proved to be absent or lying beneath excessive overburden.

It must be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be extracted in practice, since no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of land for mineral working.

**Table 4** The sand and gravel resources of the country around Tholthorpe, North Yorkshire: summary of statistical results

Block (and number of data points)	Area		Mean thickness		Volume of mineral			Mean grading percentage		
	Block	Mineral	Mineral	Overburden	Limits at the 95% confidence level			Fines	Sand	Gravel
	km <sup>2</sup>	km <sup>2</sup>	m	m	m <sup>3</sup> × 10 <sup>6</sup>	±%	±m <sup>3</sup> × 10 <sup>6</sup>	−½ mm	+½ mm −4 mm	+4 mm
A (31)	35.2	34.9†	3.9	2.6	136	39	53	18	63	19
B (21)	17.5	17.5†	5.4	‡	95	27	26	9	66	25
C (22)	27.2	27.2†	9.1	1.0	248	31	77	16	78	6
D (6)	6.5	1.1	—	—	4*	speculative		11	50	39
E (10)	13.6	2.0	—	—	6*	speculative		20	79	1
A–E (90)	100.0	82.7	—	—	489	—	—	—	—	—

\* Inferred assessment

† Denotes the potentially mineral-bearing area in each block; the actual mineral-bearing areas in blocks A, B and C are likely to be about 26.1, 15.0 and 24.7 km<sup>2</sup> respectively, on the assumption that the ratio of the mineral-bearing area to the total area of a block is equal to the ratio between the number of mineral-bearing boreholes to the total number of boreholes

‡ The mean thickness of overburden for this block is not given; for discussion, see the 'Notes on the resource blocks, Block B', p. 10.

**Table 5** Block A: data from IMAU boreholes

Borehole number	Recorded thickness			Mean grading percentage						
	Mineral	Overburden	Waste*	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
	m	m	m	−½ mm	+½–¼ mm	+¼–1 mm	+1–4 mm	+4–16 mm	+16–64 mm	+64 mm
NW 38	12.7	0.3	—	23	53	22	2	0	0	0
NW 42	excessive overburden									
NW 43	5.8	3.4	—	9	28	17	12	17	15	2
NW 44	absent									
SW 52	absent									
SW 53	7.2	0.0	1.5	28	46	14	5	3	3	1
SW 54	1.3	2.0	—	20	52	8	6	7	7	0
SW 55	excessive overburden									
SW 56	2.1	3.8	—	6	54	37	2	1	0	0
SW 58	1.6	0.0	—	29	65	5	1	0	0	0
SW 59	7.8	2.6	5.6	6	18	14	9	21	27	5
SW 60	2.2	4.0	—	23	23	10	7	18	19	0
SW 61	4.3	0.5	4.2	14	59	17	2	2	6	0
SW 62	17.8	4.8	0.2	24	56	14	2	1	2	1
SW 63	6.0	0.0	—	21	35	12	5	7	17	3
SW 64	2.0	0.5	—	30	51	9	3	1	4	2
SW 65	3.0	0.3	—	24	51	7	2	3	6	7
SW 66	5.7	4.2	3.9†	17	58	7	3	5	8	2
SW 67	3.3	7.2	—	2	11	13	16	22	31	5
SW 68	absent									
SW 69	2.0	0.5	—	22	65	7	2	2	2	0
SW 70	3.8	4.0	—	4	33	14	10	18	20	1
SW 71	5.4	6.2	—	8	12	8	7	17	34	14
SW 72	4.8	4.5	0.2	5	9	16	7	20	36	7
SW 73	5.2	1.3	—	20	57	8	7	2	5	1
SE 32	excessive overburden									
SE 33	excessive overburden									
SE 37	10.6	0.0	—	21	71	8	0	0	0	0
SE 38	4.5	7.5	—	29	53	10	3	3	2	0
SE 41	1.1	0.9	—	28	64	7	1	0	0	0
SE 42	absent									
Mean	3.9	2.6	—	18	45	13	5	7	10	2

\* Refers to a single waste parting between two mineral layers, unless otherwise stated

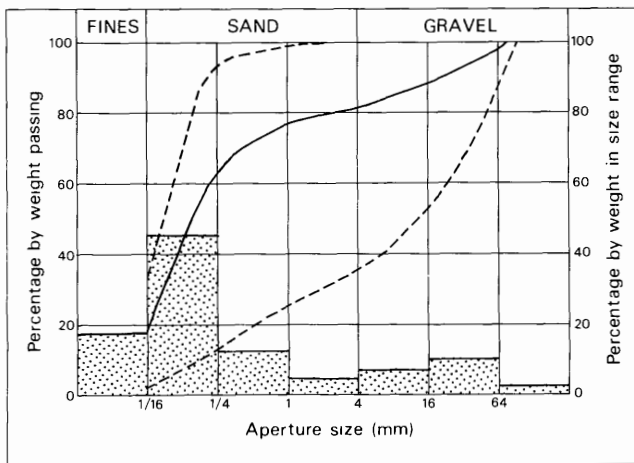
† The sum of two waste partings

**NOTES ON THE RESOURCE BLOCKS**

The boundaries of the resource blocks have been delineated so as to include, as far as possible within each individual block, deposits with a particular mode of occurrence that is distinct from that of the deposits in other blocks.

**Block A (Table 5; Figure 6)**

The mineral in this block comprises predominantly the Glacial Sand and Gravel and the mineral-grade Sandy Till of the higher ground south-west of the River Ure. Out of a total of 31 IMAU boreholes, 23 proved mineral; of these, 21 proved the above-mentioned deposits; at the other two sites, NW 38 and SW 56, deposits of mineral-grade alluvial and lacustrine sand were proved. The Glacial Sand and Gravel usually forms discontinuous lenticular bodies of mineral, which are often concealed beneath till overburden; this overburden has a mean proved thickness of 2.6 m, but in many places its thickness differs widely from this mean, and as much as 7.5 m of overburden was proved in borehole SE 38. However, the base of the underlying mineral was usually reached at a depth of less than 12 m, except in boreholes SW 59, SW 62 and SW 66.



**Figure 6** Particle-size distribution of the mineral in Block A. The weighted mean grading of the mineral is represented by the continuous line and also by the histogram. The broken lines delimit the envelope within which the mean grading curves for individual boreholes fall.

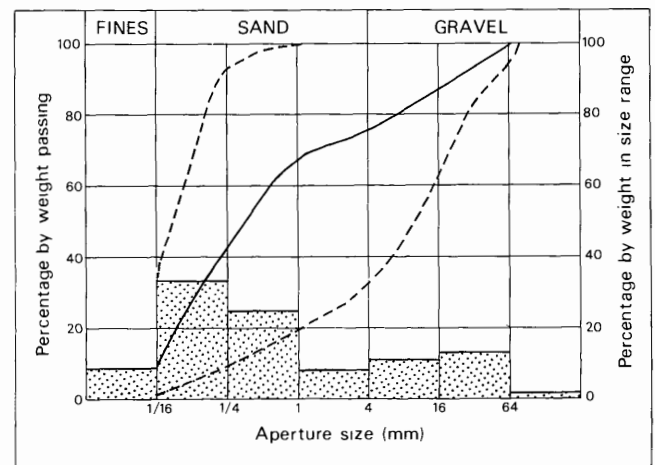
Although 11 of the 23 mineral-bearing boreholes proved potentially workable material within 1.0 m of the surface, they are irregularly interspersed with boreholes that are either barren or prove mineral beneath overburden, so that it is not feasible on the borehole evidence available to delineate areas of exposed mineral (i.e. areas where the mineral is on average within 1.0 m of the surface) other than those that have been revealed by the surface geological mapping.

The overall mean thickness of mineral proved in the IMAU boreholes is 3.9 m, and the estimated total volume of mineral present in the block is 136 million m<sup>3</sup> ± 39 per cent. The mean grading of the mineral is fines 18 per cent, sand 63 per cent and gravel (including cobbles) 19 per cent; there are, however, wide deviations from this mean grading in individual samples of these unpredictable glacial deposits.

**Block B (Table 6; Figure 7)**

The boundaries of this block were drawn so as to coincide approximately with the inferred limits of the Fluvio-glacial and Older River Sand and Gravel. The 21 IMAU boreholes all proved this deposit, but in four of these (NW 30, NW 45, NW 46 and SE 45) the deposit was designated as non-mineral because of the presence of excessive overburden (see Introduction, p. 1). In 12 of the boreholes other deposits grading as mineral (Alluvium, Glacial Lake Deposits or Glacial Sand and Gravel) overlie the Fluvio-glacial and Older River Sand and Gravel. The overlying mineral is usually separated from the deeply buried Fluvio-glacial and Older River Sand and Gravel by a considerable thickness of waste. The grading data in Table 6 have therefore been tabulated by deposit, because the essential differences between the near-surface mineral, consisting almost entirely of 'clayey' or 'very clayey' sand, and the deeply buried mineral, consisting mostly of gravel or sandy gravel, would have been obscured if overall mean grading alone had been given for each borehole. It is probable, indeed, that none of the mineral in this block is commercially attractive under present economic conditions, since the near-surface mineral contains virtually no gravel, whereas the gravel-bearing deposits are buried beneath at least 7.5 m, and in many places significantly greater thicknesses, of overlying material. This material, which, where the near-surface mineral deposits are present, should strictly be categorised as waste and mineral, has been treated as overburden in Table 6 so as not to obscure the fact that the gravel-bearing Fluvio-glacial and Older River Sand and Gravel is always deeply buried.

The overall mean grading of the mineral in the block is calculated to be fines 9 per cent, sand 66 per cent and



**Figure 7** Particle-size distribution of the mineral in Block B. For explanation, see Figure 6.

gravel 25 per cent and its mean total thickness to be 5.4 m (although in three boreholes the base of the mineral was not reached). The total volume of mineral present in the block is estimated to be 95 million m<sup>3</sup> ± 27 per cent.

**Table 6** Block B: data from IMAU boreholes

Borehole number	Recorded thickness			Mean grading percentage						
	Mineral	Overburden	Waste parting	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
	m	m	m	-1/16 mm	+1/16-1/4 mm	+1/4-1 mm	+1-4 mm	+4-16 mm	+16-64mm	+64 mm
<b>ALLUVIUM</b>										
NW 36	1.8	3.0	—	8	47	31	13	1	0	0
SE 45	1.0	2.0	—	33	60	6	1	0	0	0
<b>GLACIAL LAKE DEPOSITS</b>										
NW 33	4.6	4.0	—	11	74	14	1	0	0	0
NW 35	5.4	1.6	—	16	46	29	9	0	0	0
NW 41	2.6	5.7	—	7	72	19	1	0	1	0
NW 46	1.1*	7.8	—	10	71	18	1	0	0	0
NW 47	1.4	8.9	—	10	80	9	1	0	0	0
NE 25	4.1	—	0.4	19	67	13	1	0	0	0
SW 57	1.5	2.0	—	16	65	17	1	1	0	0
SE 29	1.0	1.0	—	29	67	4	0	0	0	0
<b>GLACIAL SAND AND GRAVEL</b>										
NW 36	2.3	6.5†	—	9	26	54	11	0	0	0
NW 45	1.3*	6.5	—	5	14	31	14	21	15	0
SE 25	3.5	0.4	—	31	66	3	0	0	0	0
SE 34	1.0	—	—	36	53	9	0	0	2	0
<b>FLUVIO-GLACIAL AND OLDER RIVER SAND AND GRAVEL</b>										
NW 25	3.9	11.5	—	1	8	10	14	20	41	6
NW 30	3.0*	9.3	—	2	5	14	10	19	47	3
NW 33	1.8	12.2†	—	20	59	10	3	3	5	0
NW 35	5.9	9.1†	—	10	17	55	8	5	5	0
NW 36	1.7	10.8†	—	3	14	22	5	20	32	4
NW 39	3.3	9.0	—	2	8	17	12	25	36	0
NW 40	6.2	7.5	—	5	7	25	12	23	27	1
NW 41	2.0	13.3	—	9	23	55	4	3	6	0
NW 45	2.8*	10.4†	—	4	16	25	10	17	24	4
NW 46	3.0*	10.4†	—	4	10	12	7	22	43	2
NW 47	4.8	11.7†	—	4	19	32	6	17	22	0
NE 25	4.8+	9.3†	—	6	16	49	18	5	6	0
SW 57	6.0	9.5†	—	7	39	29	9	10	6	0
SE 23	6.0	10.4	—	5	30	20	6	13	24	2
SE 25	7.9+	17.5†	—	7	18	23	13	18	17	4
SE 29	4.0	12.5†	—	5	42	17	11	10	14	1
SE 34	6.5	17.0†	—	7	16	20	11	17	24	5
SE 39	5.1+	15.0	—	7	27	33	10	10	13	0
SE 43	7.2	8.5	—	8	41	21	8	8	12	2
SE 44	6.3	10.8	—	3	15	26	10	22	24	0
SE 45	0.8+*	17.2†	—	No data available						

+ Indicates that the base of the deposit was not reached

\* Denotes a thickness of sand and gravel classified as non-mineral due to excessive overburden

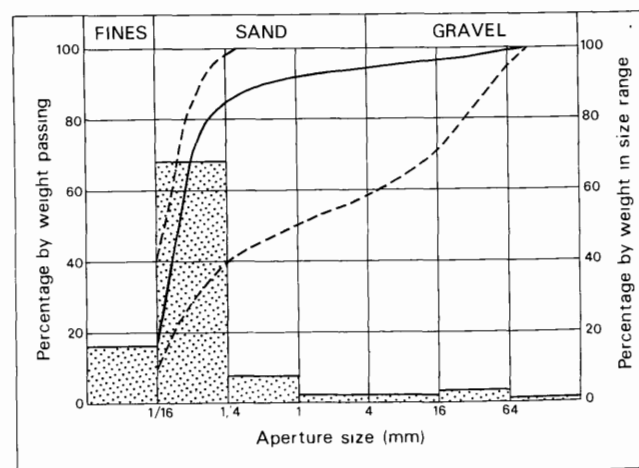
† Includes the thickness of one or more overlying deposits of mineral

**Block C** (Table 7; Figure 8)

Mineral was proved in 20 out of the 22 IMAU boreholes on this block; it belongs mostly to the deposit of Glacial Sand and Gravel, which forms the continuous body that extends from Helperby to Youlton. The remainder of the mineral belongs to the Glacial Lake Deposits, which overlap the glacial feature in places. Where present, the top of the mineral is within 3.5 m of the surface (except in borehole NE 28, where there is 9.3 m of overburden) and the mean overburden thickness is only 1.0 m.

The overall mean grading of the mineral present in the block is fines 16 per cent, sand 78 per cent and gravel 6 per cent. However, the mineral in the Glacial Lake Deposits consists entirely of 'clayey' or 'very clayey' sand, whereas that of the Glacial Sand and Gravel is often pebbly in parts, so that the mean percentage of gravel in some boreholes (such as SE 24) where the Glacial Lake Deposits are absent is significantly higher than that indicated by the overall mean grading of the mineral in the block. The mean thickness of mineral proved, 9.1 m, reflects the considerable thicknesses of Glacial Sand and

Gravel present in some boreholes (more than 22.0 m in NE 24).



**Figure 8** Particle-size distribution of the mineral in Block C. For explanation see Figure 6.

**Table 7** Block C: data from IMAU boreholes

Borehole number	Recorded thickness			Mean grading percentage						
	Mineral	Overburden	Waste*	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
	m	m	m	-1/16 mm	+1/16-1/4 mm	+1/4-1 mm	+1-4 mm	+4-16 mm	+16-64 mm	+64 mm
NW 28	13.3	0.0	—	8	81	8	1	1	1	0
NW 32	7.7	2.3	—	11	78	5	1	1	4	0
NW 37	1.5	0.0	—	18	61	20	1	0	0	0
NE 18	7.8	0.5	7.1†	10	60	14	2	4	9	1
NE 21	1.3	0.0	—	24	55	19	2	0	0	0
NE 22	21.7+	2.0	1.3	11	75	9	1	1	3	0
NE 23	8.8	0.0	3.4	31	32	14	4	7	10	2
NE 24	22.0+	0.0	3.0†	13	77	5	1	1	2	1
NE 26	8.7	0.5	—	11	78	6	2	2	1	0
NE 27	20.1+	3.5	1.4	11	60	15	5	4	5	0
NE 28	10.7+	9.3	—	10	78	12	0	0	0	0
NE 29	15.0	0.3	6.4	32	58	10	0	0	0	0
NE 30	6.1	0.2	3.9†	36	59	5	0	0	0	0
SE 24	10.0	0.0	—	9	31	11	8	13	23	5
SE 26	excessive overburden									
SE 27	10.5	0.0	—	25	71	4	0	0	0	0
SE 28	6.0	0.2	—	26	66	6	1	1	0	0
SE 30	5.0	0.2	—	20	77	3	0	0	0	0
SE 31	13.0	0.3	—	24	74	2	0	0	0	0
SE 35	4.0	1.5	—	15	82	3	0	0	0	0
SE 36	7.5	0.0	—	6	88	6	0	0	0	0
SE 40	absent									
Mean	9.1	1.0	—	16	68	8	2	2	3	1

\* Refers to a single waste parting between two mineral layers, unless otherwise stated

† The sum of two waste partings

+ Indicates that the base of the mineral was not reached

The estimated total volume of mineral present in the block is 248 million m<sup>3</sup> ±31 per cent. However, it is probable that only a small fraction of this total volume, comprising the gravel-rich material, such as that proved in boreholes NE 23 and SE 24, would be commercially attractive at present.

#### Block D (Table 8)

Only two out of the six IMAU boreholes in this block

proved mineral, and the deposits that they proved are almost certainly isolated from one another; sand and gravel found in a third borehole lay beneath excessive overburden. With the limited data available the assessment of resources of mineral in the block can be made at the inferred level only. The total volume of mineral present in the block is thus estimated to be about 4 million m<sup>3</sup>, the bulk of which is buried beneath more than 10 m of overburden.

**Table 8** Block D: data from IMAU boreholes

Borehole number	Recorded thickness		Mean grading percentage						
	Mineral	Overburden	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
	m	m	-1/16 mm	+1/16-1/4 mm	+1/4-1 mm	+1-4 mm	+4-16 mm	+16-64 mm	+64 mm
NW 24	absent								
NW 26	2.5	2.5	7	24	50	6	7	6	0
NW 27	absent								
NW 29	4.6	10.8	13	7	17	10	37	16	0
NW 31	excessive overburden								
NW 34	absent								



**Table 9** Block E: data from IMAU boreholes

Borehole number	Recorded thickness			Mean grading percentage						
	Mineral	Overburden	Waste*	Fines	Fine sand	Medium sand	Coarse sand	Fine gravel	Coarse gravel	Cobbles
	m	m	m	− 1/16 mm	+ 1/16–1/4 mm	+ 1/4–1 mm	+ 1–4 mm	+ 4–16 mm	+ 16–64 mm	+ 64 mm
NE 10	absent									
NE 11	absent									
NE 12	absent									
NE 13	3.0	1.0	—	17	72	10	1	0	0	0
NE 14	5.0	0.2	—	22	54	22	1	1	0	0
NE 15	absent									
NE 16	absent									
NE 17	absent									
NE 19	2.2	0.6	1.0	21	58	20	1	0	0	0
NE 20	absent									

\* Refers to a single waste parting

### Block E (Table 9)

This block covers the generally barren area north and east of Tholthorpe; although it contains extensive areas mapped as Glacial Lake Deposits Sand, the material is in many places too silty to be classed as mineral. Indeed, only three of the 10 IMAU boreholes in the block proved potentially workable deposits. A total volume of about 6 million m<sup>3</sup> of mineral is inferred to be present in the block, consisting entirely of 'clayey' or 'very clayey' sand.

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## 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, 10 km<sup>2</sup>, 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. Exceptionally, other schemes for subdividing the resource sheet area (for example, the use of 'resource sub-blocks') may be used where these are considered to be more appropriate.

A reconnaissance of the ground is carried out to record and sample any exposures, and inquiries are made to ascertain what borehole information is available. In addition, shallow trenches may be cut to investigate the grading of deposits, particularly in very coarse material, and to test the geology prior to commencing the drilling programme. 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 (sometimes referred to as 'percussion' 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 deposit, or, ideally, 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 British Standard 1377 (1975). Random checks on the accuracy of the grading are made in the Institute's laboratories.

Other methods of drilling and sampling are occasionally employed, for example the Minuteman power auger rig, and downhole tests such as U4 and SPT may be carried out. The Minuteman, which is small and portable, is normally used when access to land with shell rigs would be difficult to arrange and when information is requested quickly.

The auger tool comprises a continuous-'flight' 76-mm (3-inch) spiral auger; the use of this equipment, as with all 'open-hole' drilling methods, inevitably leads to the mixing and contamination of the sampled material. Thus, data relating to depth and composition cannot always be accurately determined.

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 office of the Institute: the address is shown on page ii of this report, next to the preface.

## APPENDIX B

### STATISTICAL PROCEDURE

#### *Statistical assessment*

1 A statistical assessment is made of an area of mineral greater than 2 km<sup>2</sup>, if there is a minimum of 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, pp. 192–193 in Thurrell, 1981). Conventional symmetrical confidence limits are calculated for the 95 per cent probability level, that is, there is a 5 per cent or one in twenty chance of a result falling outside the stated limits.

3 The volume estimate ( $V$ ) for the mineral in a given block is the product of the 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

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

4 The above relationship may be transposed such that

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

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 mean 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  $l_{m_1}, l_{m_2}, \dots, l_{m_n}$ , then the best estimate of mean thickness,  $\bar{l}_m$ , is given by

$$\bar{l}_m = (l_{m_1} + l_{m_2} + \dots + l_{m_n})/n.$$

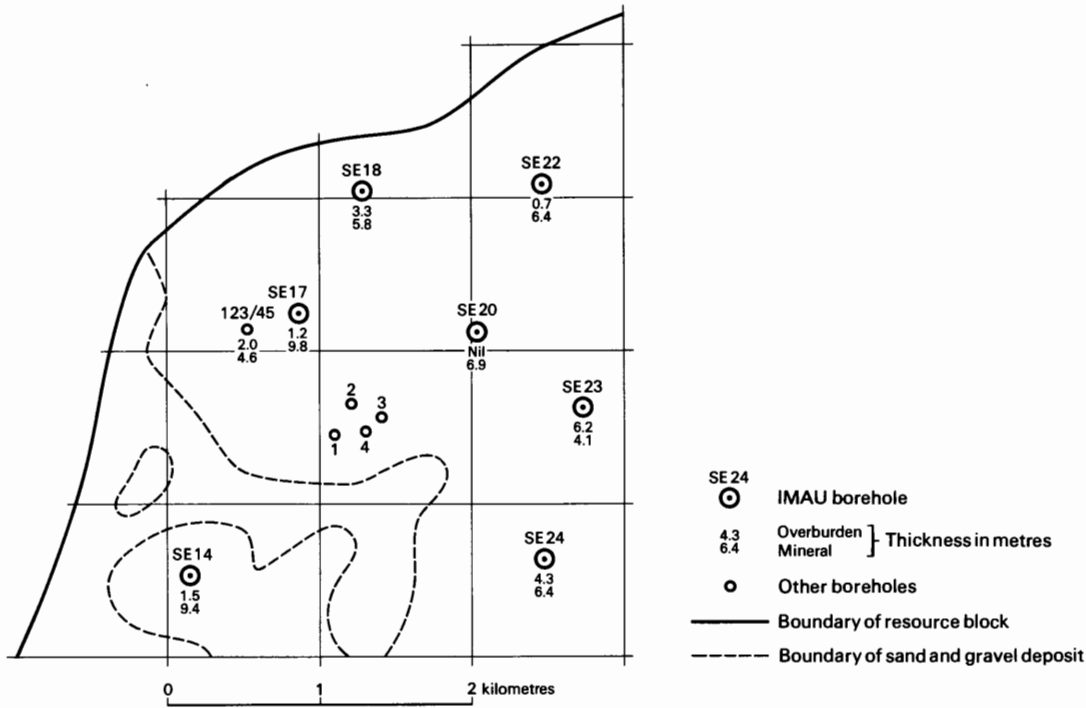
For groups of closely spaced boreholes a discretionary weighting factor may be applied to avoid bias (see note on weighting below). The standard deviation for mean thickness  $S_{\bar{l}_m}$ , expressed as a proportion of the mean thickness, is given by

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

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 deposit). Where the area

Example of resource block assessment: map of fictitious block, calculation and results.



**Block calculation** 1:25 000 block: Fictitious

Area  
 Block: 11.08 km<sup>2</sup>  
 Mineral: 8.32 km<sup>2</sup>

Mean thickness  
 Overburden: 2.5 m  
 Mineral: 6.5 m

Volume  
 Overburden: 21 million m<sup>3</sup>  
 Mineral: 54 million m<sup>3</sup>

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 m<sup>3</sup>

Thickness estimate (measurements in metres)  
*l<sub>o</sub>* = overburden thickness *l<sub>m</sub>* = mineral thickness

Sample point	Weighting <i>w</i>	Overburden		Mineral		Remarks
		<i>l<sub>o</sub></i>	<i>wl<sub>o</sub></i>	<i>l<sub>m</sub></i>	<i>wl<sub>m</sub></i>	
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	1/2	1.2	1.6	9.8	7.2	Hydrogeology Unit record
123/45	1/2	2.0		4.6		
1	1/4	2.7	2.6	7.3	5.8	Close group of four boreholes (commercial)
2	1/4	4.5		3.2		
3	1/4	0.4		6.8		
4	1/4	2.8		5.9		
Totals	Σ <i>w</i> = 8	Σ <i>wl<sub>o</sub></i> = 20.2		Σ <i>wl<sub>m</sub></i> = 52.0		
Means		<i>wl<sub>o</sub></i> = 2.5		<i>wl<sub>m</sub></i> = 6.5		

*Calculation of confidence limits*

<i>wl<sub>m</sub></i>	$ (\overline{wl_m} - wl_m) $	$(\overline{wl_m} - wl_m)^2$
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<sub>v</sub>* is calculated as

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

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

$$= 20.3$$

$$\approx 20 \text{ per cent}$$

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 usually small relative to those in thickness. The relationship  $S_A/S_m \leq \frac{1}{3}$  is assumed in all cases. It follows from equation [2] that

$$S_m \leq S_r \leq 1.05 S_m \quad [3]$$

7 The limits on the estimate of mean thickness of mineral,  $L_m$ , may be expressed in absolute units  $\pm (t/\sqrt{n}) \times S_m$  or as a percentage  $\pm (t/\sqrt{n}) \times S_m \times (100/\bar{l}_m)$  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, *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:  $L_m \leq L_r \leq 1.05 L_m$ .

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

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

per cent, and when  $n$  is greater than 20, as

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

per cent (weighting factors may be included: see paragraph 15).

11 The application of this procedure to a fictitious area is illustrated in the diagram which accompanies this Appendix.

#### *Inferred assessment*

12 If the sampled area of mineral in a resource block is between 0.25 km<sup>2</sup> and 2 km<sup>2</sup> an assessment is inferred, based on 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<sup>2</sup>.

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 need 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 within the zone as the weighting factor.

## 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 (less than  $\frac{1}{16}$  mm) and coarser than pebbles (more than 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 not considered to be 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 (illustrated at the end of this appendix). The procedure is as follows:

- 1 Classify according to ratio of sand to gravel.
- 2 Describe 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 the note on lithological description in Appendix D).

Many differing proposals exist 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, which is used in this report, and which appears in the table at the end of this appendix.

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 Standard 1377: 1975). 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. Subsequently, the descriptive categories of the mineral for each borehole are modified according to the results obtained from the mean particle size analysis of the samples.

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 very approximate 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 constituents are referred to as 'trace'.

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

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

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

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

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

Well-rounded: no 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
64 mm -	Cobble	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

- I Gravel
- II 'Clayey' gravel
- III 'Very clayey' gravel
- IV Sandy gravel
- V 'Clayey' sandy gravel
- VI 'Very clayey' sandy gravel
- VII Pebbly sand
- VIII 'Clayey' pebbly sand
- IX 'Very clayey' pebbly sand
- X Sand
- XI 'Clayey' sand
- XII 'Very clayey' sand

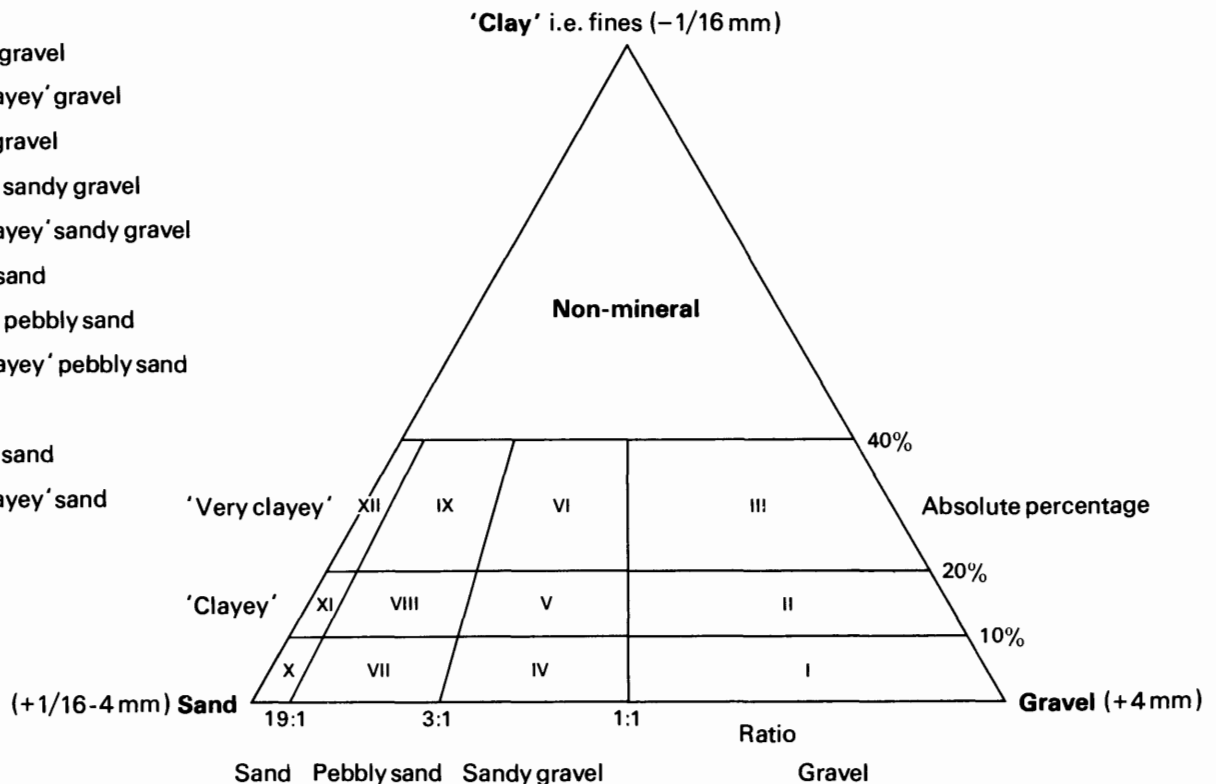


Diagram showing the descriptive categories used in the classification of sand and gravel

**APPENDIX D**

**EXPLANATION OF THE BOREHOLE RECORDS**

**Annotated example**

SE 46 NW 29<sup>1</sup> 4066 6832<sup>2</sup> Myton Gate House, Milby<sup>3</sup>

**Block D**

Surface level +16.5 m<sup>4</sup>  
 Water struck at +6.5 m<sup>5</sup>  
 152 mm<sup>6</sup> percussion  
 April 1978<sup>7</sup>

Overburden<sup>8</sup> 10.8 m  
 Mineral 4.6 m  
 Waste 1.6 m  
 Bedrock 0.2 m+<sup>9</sup>

**LOG**

Geological classification <sup>10</sup>	Lithology <sup>11</sup>	Thickness m	Depth m
Glacial Lake Deposits	Clay, yellowish brown mottled with reddish brown and grey, firm to stiff, with thin sand laminae until 1.8 m depth where sand layers thicken (up to 5 cm) and alternate with clay	3.0	3.0
Till	Pebbly clay, sandy, dark brown, soft and incohesive becoming stiff, pebbles mostly 4–32 mm of black limestone and yellow-brown sandstone	7.8	10.8
Glacial Sand and Gravel	'Clayey' gravel Gravel: fine with coarse, equant to tabular, rounded to well rounded, yellowish brown sandstone and buff dolomite with black limestone Sand: medium, equant, rounded quartz with sandstone and limestone fragments Fines: yellow-brown silt, plentiful between 12.0 to 12.6 m	4.6	15.4
Till	Pebbly clay, reddish brown, firm to stiff, pebbles mostly 4–10 mm	1.6	17.0
Sherwood Sandstone Group	Sandstone, red, weakly cemented, well bedded	0.2+	17.2

**GRADING<sup>12</sup>**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				–1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16–64	+64
13	34	53	10.8–12.0	6	20	30	14	24	6	0
			12.0–12.6	36	11	28	7	14	4	0
			12.6–15.4	10	2	9	9	47	23	0
			Mean	13	7	17	10	37	16	0

**COMPOSITION<sup>13</sup>**

Depth below surface (m)	Percentage by weight (and number) in 4–16 mm fraction						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
10.8–15.4	45 (46)	32 (35)	2 (2)	13 (7)	4 (6)	2 (1)	2 (3)

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

#### 1 Borehole Registration Number

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

1 The number of the 1:25 000 sheet on which the borehole lies, for example SE 46.

2 The quarter of the 1:25 000 sheet on which the borehole lies and the number of the borehole in a series for that quarter, for example NW 29.

Thus the full Registration Number is SE 46 NW 29. Usually this is abbreviated to NW 29 in the text.

#### 2 The National Grid reference

All National Grid references in this publication lie within the 100-km square SE unless otherwise stated. Grid references are given to eight figures, accurate to within 10 m for borehole locations. (In the text, six-figure grid references are used for more approximate locations, for example, for farms.)

#### 3 Location

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

#### 4 Surface level

The surface level at the borehole site is given in metres above Ordnance Datum. All measurements were made in metres.

#### 5 Groundwater conditions

If groundwater was present the level at which it was encountered is normally given (in metres above Ordnance Datum).

#### 6 Type of drill

A shell and auger rig using 203- and/or 152-mm casing was used.

#### 7 Date of drilling

The month and year of completion are stated.

#### 8 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 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.

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

#### 10 Geological classification

The geological classification corresponds to Table 1.

#### 11 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. The description of other rocks is based on visual examination, in the field. Where more than one mineral deposit is recognised, each is designated by a letter, e.g. **a**, **b**, etc.

#### 12 Grading data

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

For each bulk sample the percentages of fines ( $-1/16$  mm), fine sand ( $+1/16-1/4$  mm), medium sand ( $+1/4-1$  mm), coarse sand ( $+1-4$  mm), fine gravel ( $+4-16$  mm), coarse gravel ( $+16-64$  mm) and cobble gravel ( $+64$  mm) are stated. The mean grading of groups of samples making up an identified mineral horizon are also given in detail and, to the left, in summary. Where more than one horizon is recognised the mean grading for the whole of the mineral in the borehole is also given. Where necessary in calculating the mean grading, data for individual samples are weighted by the thickness represented.

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

#### 13 Composition

Details of the composition of the gravel fraction of selected samples or grouped samples may be given. Where appropriate the calculated weighted mean composition of grouped samples may be indicated.

**APPENDIX E**

**INDUSTRIAL MINERALS ASSESSMENT UNIT  
BOREHOLE RECORDS**

**SE 46 NW 24    4046 6986    Low Grounds, Kirby Hill**

**Block D**

Surface level +19.9 m  
Water struck at +6.4 m  
152 mm percussion  
April 1978

Waste 13.5m  
Bedrock 0.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, mid- to dark brown, stiff to hard, changing below 1.4 m to sandy clay, reddish brown, soft	2.7	2.7
Till	Pebbly clay, sandy, dark greyish brown, stiff; contains numerous pebbles and cobbles of brown sandstone and black limestone. Thin bands of reddish brown sand near the base	10.8	13.5
Sherwood Sandstone Group	Sand, silty, bright reddish brown, fine-grained	0.7+	14.2



Surface level +17.3 m  
 Water struck at +5.8 m  
 152 mm percussion  
 May 1978

Overburden 11.5 m  
 Mineral 3.9 m  
 Bedrock 0.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.9	0.9
Glacial Lake Deposits	Clay, grey, firm, with numerous partings of grey silt and reddish brown sand	5.9	6.8
Till	Pebbly clay, dark grey changing downwards to reddish brown, stiff, numerous pebbles 4–16 mm	4.7	11.5
Fluvio-glacial and Older River Sand and Gravel	Gravel, sandy below 14.5 m Gravel: coarse and fine with some cobbles, equant subangular to well-rounded brown sandstone with black and grey limestone Sand: coarse and medium and fine, equant, well-rounded quartz with subangular to well-rounded sandstone and limestone	3.9	15.4
Sherwood Sandstone Group	Sand, silty, bright red, fine-grained	0.5+	15.9

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				– <sup>1</sup> / <sub>16</sub>	+ <sup>1</sup> / <sub>16</sub> – <sup>1</sup> / <sub>4</sub>	+ <sup>1</sup> / <sub>4</sub> –1	+1–4	+4–16	+16–64	+64
1	32	67	11.5–12.5	1	6	9	20	15	32	17
			12.5–13.5	1	4	7	5	24	59	0
			13.5–14.5	1	3	6	7	20	56	7
			14.5–15.4	3	20	20	24	22	11	0
			Mean	1	8	10	14	20	41	6

**COMPOSITION**

Depth below surface (m)	<i>Percentage by weight (and number) in 8–64 mm fraction</i>				
	Sandstone	Limestone	Chert	Soft sedimentary	Igneous
11.5–12.5	81 (69)	17 (24)	–	2 (5)	trace (2)
12.5–13.5	80 (57)	15 (40)	trace (trace)	trace (2)	4 (1)
13.5–14.5	86 (63)	11 (29)	1 (4)	–	2 (4)
14.5–15.4	69 (59)	28 (38)	3 (3)	trace (trace)	–

Surface level +14.8 m  
 Water struck at +12.3 m  
 152 mm percussion  
 May 1978

Overburden 2.5 m  
 Mineral 2.5 m  
 Waste 9.7 m  
 Bedrock 1.1 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
River Terrace Deposits	Silt, sandy, dark brown, soft and incohesive, mostly equant brown quartz	2.5	2.5
Glacial Sand and Gravel	Pebbly sand, pebbles more numerous below 3.5 m Gravel: fine and coarse, subrounded, mostly light brown sandstone with black limestone in fine fraction Sand: medium and fine with coarse, subrounded, mostly sandstone and quartz with some black limestone common in coarse fraction <i>Base is marked by several sub-horizontal bands of silty clay</i>	2.5	5.0
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, with most pebbles 4–16 mm, equant, subangular brown sandstone and black limestone	9.7	14.7
Sherwood Sandstone Group	'Clayey' sand, red, fine-grained	1.1+	15.8

## GRADING

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				–1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16–64	+64
7	80	13	2.5–3.5	9	30	52	5	4	0	0
			3.5–5.0	6	20	48	7	9	10	0
			Mean	7	24	50	6	7	6	0

Surface level +13.8 m  
 Water struck at +5.8 m  
 152 mm percussion  
 May 1978

Waste 9.5 m  
 Bedrock 1.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark brown with light brown and grey mottling, soft, contains rootlets	2.2	2.2
Glacial Lake Deposits	Clay, grey, firm, contains thin laminations of red sand, becoming silty below 4.2 m	3.0	5.2
Till	Pebbly clay, sandy, dark reddish brown, firm, with pebbles of subangular brown sandstone and mudstone	4.3	9.5
Sherwood Sandstone Group	Sand, silty, red, fine-grained	1.0+	10.5

Surface level +23.2 m  
 Water struck about +12 m  
 152 mm percussion  
 June 1978

Mineral 13.3 m  
 Waste 6.1 m  
 Bedrock 0.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	Sand, pebbly in top 1 m Sand: fine, well sorted, equant and tabular, opaque and red quartz Small nodules of red clay are common between 1.0 to 3.0 m and 5.0 to 6.5 m	13.3	13.3
Till	Pebbly clay, sandy, red, firm, pebbles are mostly 4–16 mm of rounded, black limestone and light brown sandstone with buff dolomite and dark green sandstone	6.1	19.4
Sherwood Sandstone Group	'Clayey' sand, red, fine-grained, with scattered pebbles from deposit above	0.3+	19.7

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
8	90	2	0-1.0	6	51	19	5	10	9	0
			1.0-2.0	14	78	4	1	2	1	0
			2.0-3.0	11	83	4	1	1	0	0
			3.0-4.0	9	84	6	1	0	0	0
			4.0-5.0	2	71	27	0	0	0	0
			5.0-6.5	13	81	5	1	0	0	0
			6.5-8.5	8	82	10	0	0	0	0
			8.5-10.0	7	91	2	0	0	0	0
			10.0-11.5	8	86	5	1	0	0	0
			11.5-13.3	7	86	6	1	0	0	0
			Mean	8	81	8	1	1	1	0

Surface +16.5 m  
 Water struck at +6.5 m  
 152 mm percussion  
 April 1978

Overburden 10.8 m  
 Mineral 4.6 m  
 Waste 1.6 m  
 Bedrock 0.2 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, yellowish brown mottled with reddish brown and grey, firm to stiff, with thin sand laminae until 1.8 m depth where sand layers thicken (up to 5 cm) and alternate with clay	3.0	3.0
Till	Pebbly clay, sandy, dark brown, soft and incohesive becoming stiff, pebbles mostly 4–32 mm of black limestone and yellow-brown sandstone	7.8	10.8
Glacial Sand and Gravel	'Clayey' gravel Gravel: fine with coarse, equant to tabular, rounded to well rounded, yellowish brown sandstone and buff dolomite with black limestone Sand: medium, equant, rounded, quartz with sandstone and limestone fragments Fines: yellowish brown silt, plentiful between 12.0 to 12.6 m	4.6	15.4
Till	Pebbly clay, reddish brown, firm to stiff, pebbles mostly 4–10 mm	1.6	17.0
Sherwood Sandstone Group	Sandstone, red, weakly cemented, well bedded	0.2+	17.2

## GRADING

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
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
13	34	53	10.8–12.0	6	20	30	14	24	6	0
			12.0–12.6	36	11	28	7	14	4	0
			12.6–15.4	10	2	9	9	47	23	0
			Mean	13	7	17	10	37	16	0

## COMPOSITION

Depth below surface (m)	<i>Percentage by weight (and number) in 4–16 mm fraction</i>						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
10.8–15.4	45 (46)	32 (35)	2 (2)	13 (7)	4 (6)	2 (1)	2 (3)

Surface level +14.7 m  
 Water struck at +5.4 m  
 152 mm percussion  
 May 1978

Waste 12.3 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
River Terrace Deposits	Clay, becoming silty downwards, dark brown with irregular grey silt patches, soft	3.4	3.4
Till	Pebbly clay, sandy, dark reddish brown, firm, pebbles mostly 4-16 mm, subangular and subrounded, light brown sandstone and black limestone, pebbles infrequent below 8.0 m	5.9	9.3
Fluvio-glacial and Older River Sand and Gravel	Gravel, with cobbles between 10.3 and 11.3 m Gravel: coarse with fine, equant to tabular, subangular and subrounded brown sandstone, and equant, subrounded black limestone Sand: medium with coarse, mostly equant and subrounded, sandstone and limestone fragments	3.0	12.3
Sherwood Sandstone Group	Sandstone, red, fine-grained, well bedded	1.0+	13.3

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*2	29	69	9.3-10.3	1	6	22	19	23	29	0
			10.3-11.3	5	9	18	9	12	39	8
			11.3-12.3	1	1	2	2	21	73	0
			Mean	2	5	14	10	19	47	3

\* Non-mineral: excessive overburden

Surface level +13.3 m  
 Water struck at +10.5 m  
 152 mm percussion  
 May 1978

Waste 8.7 m  
 Bedrock 0.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, sandy, brown with grey mottling, soft, contains carbonaceous detritus	4.9	4.9
Till	Pebbly clay, sandy, red, firm, pebbles of limestone, sandstone and chert	1.7	6.6
Glacial Sand and Gravel	Pebbly sand Gravel: coarse with fine, angular to rounded, sandstone and limestone Sand: medium and fine, red and brown quartz with some limestone fragments	2.1	8.7
Sherwood Sandstone Group	Sand, red quartz, medium and fine, micaceous	0.5+	9.2

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*5	79	16	6.6-8.0	5	23	48	11	6	7	0
			8.0-8.7	4	34	32	7	7	16	0
			Mean	5	26	43	10	6	10	0

**COMPOSITION**

Depth below surface (m)	<i>Percentage by weight (and number) in 4-16 mm fraction</i>			
	Sandstone	Limestone	Chert	Soft sedimentary
6.6-8.0	87 (86)	9 (9)	3 (2)	1 (3)
8.0-8.7	98 (98)	trace (trace)	2 (2)	-

\* Non-mineral: excessive overburden

Surface level +20.1 m  
 Water struck at +14.6 m  
 152 mm percussion  
 May 1978

Overburden 2.3 m  
 Mineral 7.7 m  
 Waste 4.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Silt, sandy, becoming clayey with depth, containing pebbles, dark brown to reddish brown, soft	0.6	0.6
Laminated clay closely associated with Glacial Deposits	Clay, sandy, containing scattered pebbles, dark reddish brown, soft becoming stiff downwards, showing faint lamination at top, becoming well marked downwards	1.7	2.3
Glacial Sand and Gravel	'Clayey' pebbly sand, no pebbles in top 2-7 m Gravel: mostly coarse, rounded to well rounded, light brown sandstone with black limestone Sand: fine, subrounded, red and opaque quartz Fines: mostly dispersed within sand, except for thin seams (c. 2 cm) of silty clay in top 1.2 m	7.7	10.0
Till	Pebbly clay, sandy, yellowish brown, firm to stiff, with pebbles of black limestone and brown sandstone with some buff dolomite and scattered soft red sandstone	4.5+	14.5

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
11	84	5	2.3-3.5	12	84	4	0	0	0	0
			3.5-5.0	12	77	10	1	0	0	0
			5.0-6.5	7	68	6	2	4	11	2
			6.5-8.0	15	74	4	2	1	4	0
			8.0-10.0	12	80	2	2	1	3	0
			Mean	11	78	5	1	1	4	0

Surface level +12.7 m  
 Water struck at +8.7 m  
 152 mm percussion  
 August 1978

Overburden 4.0 m  
 Mineral 4.6 m  
 Waste 3.6 m  
 Mineral 1.8 m  
 Bedrock 2.4 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, brown with traces of reddish brown, firm to stiff, with seam from 2.7 to 3.0 m containing sand and scattered pebbles	4.0	4.0
Glacial Lake Deposits	<b>a</b> 'Clayey' sand Sand: fine with some medium, with greater proportion of medium below 6.0 m, equant, rounded brown and opaque quartz with some subangular to rounded black limestone Fines: small nodules of greyish brown silty clay in sub-horizontal layers	4.6	8.6
Till	Pebbly clay, silty, dark grey, firm to stiff, pebbles mostly 4–16 mm of equant, subrounded light brown sandstone, and tabular subangular black limestone	3.6	12.2
Fluvio-glacial and Older River Sand and Gravel	<b>b</b> 'Very clayey' pebbly sand Gravel: coarse with fine, rounded light brown sandstone and subrounded black limestone with some rounded red sandstone Sand: fine, equant, subrounded red and brown quartz with some black limestone Fines: nodules of coarse, light brown silt	1.8	14.0
Sherwood Sandstone Group	'Clayey' sand, fine, bright red quartz	2.4+	16.4

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Sand			Gravel
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	11	89	0	4.0-5.0	11	83	5	1	0	0	0
				5.0-6.0	13	82	4	1	0	0	0
				6.0-7.7	12	66	21	1	0	0	0
				7.7-8.6	8	70	20	2	0	0	0
				Mean	11	74	14	1	0	0	0
<b>b</b>	20	72	8	12.2-14.0	20	59	10	3	3	5	0
<b>a + b</b>	14	84	2	Mean	14	69	13	2	1	1	0



Surface level +15.8 m  
 Water struck approximately +4 m  
 152 mm percussion  
 April 1978

Waste 13.2 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, mottled grey and reddish brown at top, changing below 3.0 m to dark grey, firm to stiff, with poor lamination below 1.9 m shown by partings of reddish brown fine sand which become more numerous near the base	8.1	8.1
Till	Pebbly clay, some sand at top with increasing proportion of sand downwards, dark greyish brown, stiff to hard, pebbles up to 100 mm longest axis	5.1	13.2
Sherwood Sandstone Group	'Very clayey' sand, reddish brown, contains several pebbles of fine-grained red sandstone	1.0+	14.2

Surface level +12.1 m  
 Water struck at +3.0 m  
 152 mm percussion  
 April 1978

Overburden 1.6 m  
 Mineral 5.4 m  
 Waste 2.1 m  
 Mineral 5.9 m  
 Bedrock 1.5 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, with scattered pebbles, becoming sandy downwards, mottled grey and reddish brown, firm to stiff becoming soft at base	1.6	1.6
Glacial Lake Deposits	<b>a</b> 'Clayey' sand Sand: fine with medium, quartz with sandstone and some limestone fragments Fines: dark grey	5.4	7.0
Till	Pebbly clay, dark reddish brown, stiff becoming softer downwards; most pebbles are subangular to subrounded light brown sandstone	2.1	9.1
Fluvio-glacial and Older River Sand and Gravel	<b>b</b> 'Clayey' pebbly sand, fines content below 10% in parts Gravel: fine and coarse, equant, subrounded to rounded, light brown sandstone with black limestone and some buff dolomite Sand: medium, mostly equant, subangular to subrounded quartz with fragments of black limestone Fines: greyish brown and reddish brown	5.9	15.0
Sherwood Sandstone Group	Sand, silty, bright red, contains pebbles of fine-grained red sandstone and some erratic fragments of black limestone from deposit above	1.5+	16.5

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64
<b>a</b>	16	84	0	1.6-2.6	18	21	36	25	0	0	0
				2.6-5.0	17	55	22	6	0	0	0
				5.0-7.0	13	47	36	4	0	0	0
				Mean	16	46	29	9	0	0	0
<b>b</b>	10	80	10	9.1-10.0	14	21	50	6	5	4	0
				10.0-11.0	8	16	72	4	0	0	0
				11.0-12.0	14	20	58	6	2	0	0
				12.0-13.0	8	13	62	12	3	2	0
				13.0-14.0	7	14	43	11	11	14	0
				14.0-15.0	8	18	46	10	12	6	0
				Mean	10	17	55	8	5	5	0
<b>a + b</b>	13	82	5	Mean	13	31	42	9	3	2	0

Surface level +12.9 m  
 Water struck at +9.9 m  
 152 mm percussion  
 April 1978

Overburden 3.0 m  
 Mineral 1.8 m  
 Waste 1.7 m  
 Mineral 2.3 m  
 Waste 2.0 m  
 Mineral 1.7 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark brown, firm, grading downwards into an incohesive mixture of silt and fine sand	3.0	3.0
	<b>a</b> Sand, scattered fine pebbles below 4.0 m Sand: fine with medium, mostly quartz	1.8	4.8
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, pebbles mostly light brown sandstone	1.7	6.5
Glacial Sand and Gravel	<b>b</b> Sand, medium, subrounded to rounded, brown and opaque quartz with some black limestone	2.3	8.8
Till	Pebbly clay, dark greyish brown, firm, pebbles mostly 4–16 mm of light brown sandstone and black limestone	2.0	10.8
Fluvio-glacial and Older River Sand and Gravel	<b>c</b> Gravel: contains scattered cobbles Gravel: coarse with fine, equant, tabular and prolate, subangular to subrounded, light brown sandstone with some black limestone Sand: medium, equant, subrounded quartz with sandstone and limestone fragments	1.7	12.5
Sherwood Sandstone Group	Silt, sandy, bright red quartz	1.0+	13.5

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	8	91	1	3.0-4.0	8	28	44	20	0	0	0
				4.0-4.8	8	71	14	5	2	0	0
				Mean	8	47	31	13	1	0	0
<b>b</b>	9	91	0	6.5-8.8	9	26	54	11	0	0	0
<b>c</b>	3	41	56	10.8-11.8	4	19	26	3	16	32	0
				11.8-12.5	1	7	16	9	25	32	9
				Mean	3	14	22	5	20	32	4
<b>a + b + c</b>	7	77	16	Mean	7	29	38	10	6	9	1

Surface level +12.9 m  
 Water struck at +7.4 m  
 152 mm percussion  
 June 1978

Mineral 1.5 m  
 Waste 4.0 m  
 Bedrock 1.6 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	'Clayey' sand; fine, mostly rounded quartz with some sandstone and limestone fragments Fines: grey and yellowish brown silt as sub-horizontal layers	1.5	1.5
Till	Pebbly clay, sandy, dark reddish brown, firm, pebbles mostly 4-16 mm of subangular to subrounded light brown sandstone with some black limestone. Boulder encountered from 5.0 to 5.5 m	4.0	5.5
Sherwood Sandstone Group	'Very clayey' sand, includes small pebbles of fine-grained red sandstone	1.6+	7.1

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
18	82	0	0.0-1.5	18	61	20	1	0	0	0

Surface level +13.6 m  
 Water struck at +7.6 m  
 152 mm percussion  
 August 1978

Overburden 0.3 m  
 Mineral 12.7 m  
 Waste 3.8 m  
 Bedrock 0.6 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silty soil, brown, dry and incohesive	0.3	0.3
	'Very clayey' sand, proportion of fines showing marked decrease below 6.0 m due to presence of water Sand: fine, equant, subrounded to rounded brown and opaque quartz with some black limestone Fines: dispersed brown silt <i>At 9.8 m, wood fragments discovered—giving radiocarbon date of 2120 BP</i>	9.5	9.8
?Glacial Lake Deposits	'Clayey' sand; fine and medium with some coarse, equant, subrounded brown and opaque quartz, with equant to tabular, subrounded black limestone and mudstone especially abundant in coarse fraction Fines: nodular, greyish brown clay with faint laminations of brown silt	3.2	13.0
Till	Pebbly clay, dark brown, stiff, pebbles mostly 4–32 mm of equant, subangular to subrounded brown sandstone and black limestone with equant, rounded soft red sandstone	3.8	16.8
Sherwood Sandstone Group	Sandstone, red, fine-grained, well bedded, micaceous	0.6+	17.4

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
23	77	0	0.3-2.3	37	61	2	0	0	0	0
			2.3-4.0	43	55	2	0	0	0	0
			4.0-6.0	34	58	8	0	0	0	0
			6.0-9.8	11	47	42	0	0	0	0
			9.8-11.8	13	42	35	10	0	0	0
			11.8-13.0	7	61	28	4	0	0	0
			Mean	23	53	22	2	0	0	0

Surface level +12.0 m  
 Water struck at +3.0 m  
 152 mm percussion  
 April 1978

Overburden 9.0 m  
 Mineral 3.3 m  
 Bedrock 2.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark brown mottled with grey and reddish brown, soft to firm	2.5	2.5
?Glacial Lake Deposits	Clay, brown, with bands of reddish brown fine sand up to 5 cm thick	4.8	7.3
Till	Pebbly clay, dark reddish brown, firm to stiff, pebbles 4–64 mm, mostly subangular black limestone and brown sandstone	1.7	9.0
Fluvio-glacial and Older River Sand and Gravel	Gravel, sandy below 11.0 m Gravel: coarse and fine with few cobbles below 11.0 m (broken by drilling), equant to prolate, subrounded to rounded brown sandstone, and tabular to equant, rounded black limestone with some buff limestone and grey igneous rock Sand: medium and coarse with fine, mostly rounded quartz	3.3	12.3
Sherwood Sandstone Group	'Clayey' sand, includes some tabular pebbles of dark red, fine-grained, well bedded sandstone	2.0+	14.3

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines			Gravel			
				– <sup>1</sup> / <sub>16</sub>	+ <sup>1</sup> / <sub>16</sub> – <sup>1</sup> / <sub>4</sub>	+ <sup>1</sup> / <sub>4</sub> –1	+1–4	+4–16	+16–64	+64
2	37	61	9.0–11.0	3	8	11	9	33	36	0
			11.0–12.3	2	7	28	15	12	36	0
			Mean	2	8	17	12	25	36	0

**COMPOSITION**

Depth below surface (m)	Percentage by weight (and number) in 4–64 mm fraction						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
9.0–11.0	74 (43)	14 (37)	1 (trace)	5 (9)	–	6 (11)	–
11.0–12.3	87 (49)	10 (33)	trace (2)	2 (2)	trace (2)	trace (1)	trace (11)

Surface level +12.6 m  
 Water struck at +9.6 m  
 152 mm percussion  
 April 1978

Overburden 7.5 m  
 Mineral 6.2 m  
 Bedrock 1.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty and sandy, brown mottled in places with grey and reddish brown, firm to stiff becoming soft near base as sand increases	3.7	3.7
Till	Pebbly clay, sandy, dark reddish brown to greyish brown, firm to stiff, with pebbles of brown sandstone and black limestone	3.8	7.5
Fluvio-glacial and Older River Sand and Gravel	Gravel, with high proportion of fines in top 1 m Gravel: coarse and fine, equant, subrounded to rounded yellowish brown sandstone with subangular black limestone and some angular buff dolomite Sand: medium with coarse, mostly subrounded to rounded brown sandstone and black limestone fragments with opaque quartz	6.2	13.7
Sherwood Sandstone Group	Sand, silty, contains small pebbles of fine-grained, red sandstone	1.3+	15.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
5	44	51	7.5-8.5	15	14	46	8	6	11	0
			8.5-9.5	3	6	28	14	31	18	0
			9.5-10.5	2	5	24	10	25	34	0
			10.5-11.5	2	6	22	16	22	27	5
			11.5-12.5	3	7	14	12	37	27	0
			12.5-13.7	6	4	16	14	19	39	2
			Mean	5	7	25	12	23	27	1

Surface level +15.1 m  
 Water struck at +9.4 m  
 152 mm percussion  
 June 1978

Overburden 5.7 m  
 Mineral 2.6 m  
 Waste 5.0 m  
 Mineral 2.0 m  
 Bedrock 5.9 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt, sandy, rich in organic matter, passing down into	0.5	0.5
	Clay, silty and with some fine sand, mottled brown and grey in near-horizontal layers, firm	5.2	5.7
Till	a Sand, fine with medium, mostly quartz stained grey and brown	2.6	8.3
	Pebbly clay, sandy, dark greyish brown, firm to stiff becoming more silty and less pebbly below 12.0 m	5.0	13.3
Fluvio-glacial and Older River Sand and Gravel	b Pebbly sand, 'clayey' at top	2.0	15.3
	Gravel: coarse and fine, equant to prolate, subrounded to rounded brown sandstone and black limestone with equant, subangular buff limestone and a trace of soft red sandstone Sand: medium with fine and some coarse, mostly subrounded quartz, with some sandstone and black limestone and mudstone in coarse fraction		
Sherwood Sandstone Group	'Clayey' sand, fine, yellowish brown and reddish brown quartz	5.9+	21.2

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	7	92	1	5.7-8.3	7	72	19	1	0	1	0
<b>b</b>	9	82	9	13.3-14.3	10	17	64	2	1	6	0
				14.3-15.3	8	30	47	5	4	6	0
				Mean	9	23	55	4	3	6	0
<b>a + b</b>	8	88	4	Mean	8	51	35	2	1	3	0

## COMPOSITION

Depth below surface (n)	Percentage by weight (and number) in 4-64 mm fraction					
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Ironstone
13.3-15.3	57 (40)	36 (38)	1 (2)	5 (11)	1 (8)	trace (1)



Surface level +35.9 m  
 Water struck at +27.4 m  
 152 mm percussion  
 August 1978

Waste 10.0 m  
 Bedrock 0.2 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy, reddish brown, stiff, grey and hard near base, numerous pebbles of subangular to subrounded black limestone and brown sandstone	8.5	8.5
Glacial Sand and Gravel	'Very clayey' pebbly sand, reddish brown Gravel: coarse with fine, equant to tabular, subangular to subrounded black limestone and brown sandstone with buff dolomite Sand: fine with medium and some coarse, equant, subrounded to well-rounded light brown quartz; sandstone noticeable in coarse fraction	1.5	10.0
Sherwood Sandstone Group	Sandstone, red, fine-grained, thinly bedded	0.2+	10.2

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*32	61	7	8.5-10.0	32	49	9	3	2	5	0

**COMPOSITION**

Depth below surface (m)	Percentage by weight (and number) in 4-16 mm fraction			
	Sandstone	Limestone	Dolomite	Soft sedimentary
8.5-10.0	36 (29)	44 (49)	14 (15)	6 (7)

\*Non-mineral: excessive overburden

Surface level +18.2 m  
 Water struck at +13.8 m  
 203 mm percussion  
 October 1978

Overburden 3.4 m  
 Mineral 5.8 m  
 Bedrock 0.2 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Clay, silty, dark brown, soft to firm, passing downwards into	1.0	1.0
	Pebbly, clay, brown, firm to stiff, pebbles mostly 4–16 mm of equant, subangular to subrounded brown sandstone and black limestone with few of equant, rounded red sandstone	2.4	3.4
Glacial Sand and Gravel	Sandy gravel, with high proportion of fines at top and bottom of deposit Gravel: fine and coarse, equant to tabular, subangular to subrounded brown sandstone and black limestone, with some equant, subrounded buff dolomite and rounded red sandstone Sand: fine with medium and coarse, equant, subrounded to rounded brown and opaque quartz, with equant to tabular, subrounded sandstone and limestone and some subangular buff dolomite fragments	5.8	9.2
Sherwood Sandstone Group	Sandstone, red, fine- to medium-grained, well bedded	0.2+	9.4

## GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				– <sup>1</sup> / <sub>16</sub>	+ <sup>1</sup> / <sub>16</sub> – <sup>1</sup> / <sub>4</sub>	+ <sup>1</sup> / <sub>4</sub> –1	+1–4	+4–16	+16–64	+64
9	57	34	3.4–4.4	21	49	14	3	5	8	0
			4.4–5.5	5	11	12	16	35	21	0
			5.5–7.3	5	11	16	15	24	22	7
			7.3–8.3	7	40	23	10	7	13	0
			8.3–9.2	12	47	23	12	3	3	0
			Mean	9	28	17	12	17	15	2

Surface level +13.5 m  
 Water struck at +6.3 m  
 152 mm percussion  
 August 1978

Waste 13.2 m  
 Bedrock 3.3 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, dark brown mottled with grey and reddish brown, firm to stiff. Below 2.8 m silt exists as thin sub-horizontal partings which become thicker near base and include fine sand	10.7	10.7
Till	Pebbly clay, sandy, dark brown, firm, pebbles mostly 4–16 mm of equant, subangular to rounded brown sandstone and angular to subrounded black limestone	2.5	13.2
Sherwood Sandstone Group	'Clayey' sand, fine, red and opaque quartz, with tabular, subangular pebbles of soft red sandstone below 16.3 m	3.3+	16.5

Surface level +11.4 m  
 Water struck at +4.9 m  
 152 mm percussion  
 June 1978

Waste 13.2 m  
 Bedrock 1.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, mottled grey and brown, stiff to firm; contains patches of black organic matter from 2.5 to 4.7 m, below this clay is homogeneous dark brown and more silty	6.5	6.5
Glacial Sand and Gravel	Sandy gravel, dark grey Gravel: fine and coarse, equant to tabular, angular to subrounded brown sandstone and black limestone Sand: medium, dark brown quartz and black limestone and mudstone fragments	1.3	7.8
Till	Pebbly clay, dark reddish brown, firm to stiff	2.6	10.4
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel, yellowish brown, with scattered cobbles Gravel: coarse with fine, mostly equant, subangular to subrounded brown sandstone, with some subrounded black limestone Sand: medium, mostly rounded quartz with some black limestone and mudstone	2.8	13.2
Sherwood Sandstone Group	'Clayey' sand, fine red quartz	1.0+	14.2

## GRADING

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*5	59	36	6.5-7.8	5	14	31	14	21	15	0
*4	51	45	10.4-11.4	4	26	24	9	13	16	8
			11.4-12.4	4	11	27	8	20	30	0
			12.4-13.2	4	11	22	16	17	27	3
			Mean	4	16	25	10	17	24	4

## COMPOSITION

Depth below surface (m)	<i>Percentage by weight (and number) in 4-64 mm fraction</i>						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
6.5-7.8	69 (66)	13 (5)	2 (2)	2 (1)	13 (24)	1 (2)	—
10.4-11.4	70 (56)	17 (25)	3 (2)	3 (5)	5 (7)	1 (1)	1 (4)
11.4-12.4	79 (62)	14 (22)	1 (2)	—	4 (7)	—	2 (7)
12.4-13.2	75 (60)	13 (20)	3 (2)	1 (trace)	5 (9)	1 (trace)	2 (8)

\* Non-mineral: excessive overburden

Surface level +11.9 m.  
Water struck at +4.1 m  
152 mm percussion  
June 1978

Waste 13.4 m  
Bedrock 3.4 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty with proportion of silt increasing downwards, dark brown mottled with grey, firm, contains much organic matter in top 1.1 m	2.3	2.3
?Glacial Lake Deposits	Clay, uniform grey, firm, plastic, with poor lamination as shown by thin partings of silt	5.5	7.8
	'Clayey' sand, fine, equant, rounded brown quartz with some dark grey limestone fragments	1.1	8.9
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, with pebbles of equant, subangular to subrounded, brown sandstone and black limestone	1.5	10.4
Fluvio-glacial and Older River Sand and Gravel	Gravel, yellowish brown, contains scattered cobbles Gravel: coarse with fine, equant to tabular, subangular to rounded, light brown sandstone with black limestone Sand: medium, equant and rounded brown quartz	3.0	13.4
Sherwood Sandstone Group	'Clayey' sand, fine, rounded yellowish brown quartz, with pebbles of light grey, medium-grained sandstone below 16.5 m	3.4+	16.8

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*10	90	0	7.8-8.9	10	71	18	1	0	0	0
* 4	29	67	10.4-11.9	5	12	7	5	29	42	0
			11.9-13.4	3	7	17	10	15	43	5
			Mean	4	10	12	7	22	43	2

**COMPOSITION**

Depth below surface (m)	Percentage by weight (and number) in 4-64 mm fraction					
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous
10.4-13.4	60 (54)	13 (20)	1 (3)	22 (14)	trace (1)	4 (8)

\* Non-mineral: excessive overburden

Surface level +13.0 m  
 Water struck at +4.5 m  
 152 mm percussion  
 August 1978

Overburden 8.9 m  
 Mineral 1.4 m  
 Waste 1.4 m  
 Mineral 4.8 m  
 Bedrock 1.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, dark brown and grey, firm, with scattered pebbles of light brown sandstone; passing into	0.5	0.5
	Silt, yellowish brown, soft to firm, containing thin bands of grey clay and few large pebbles	1.1	1.6
	Clay, silty, dark brown, firm to stiff; by 2.6 m silt appears as thin partings giving poor lamination; passing into	5.9	7.5
	Silt, becoming sandy downwards, uniform grey-brown, soft to firm	1.4	8.9
Till	<b>a</b> 'Clayey' sand, fine, equant, subrounded to rounded, brown and opaque quartz with some black limestone	1.4	10.3
	Pebbly clay, silty, dark brown, firm to stiff, with pebbles of subangular to subrounded brown sandstone with some black limestone and soft red sandstone	1.4	11.7
Fluvio-glacial and Older River Sand and Gravel	<b>b</b> Sandy gravel, light brown Gravel: coarse and fine, equant, subangular to rounded light brown sandstone with some dark grey limestone Sand: medium, equant, subrounded to rounded brown sandstone and quartz, with tabular, subangular to subrounded dark grey limestone	4.8	16.5
Sherwood Sandstone Group	'Clayey' sand, fine, equant, rounded grey quartz grains sometimes cemented into coarse sand granules	1.1+	17.6

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		Fines			Sand				Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64		
<b>a</b>	10	90	0	8.9-10.3	10	80	9	1	0	0	0		
<b>b</b>	4	57	39	11.7-13.0	3	24	27	6	20	20	0		
				13.0-14.0	4	27	38	5	11	15	0		
				14.0-15.0	8	12	26	7	22	25	0		
				15.0-16.5	2	14	33	8	17	26	0		
				Mean	4	19	32	6	17	22	0		
<b>a + b</b>	5	64	31	Mean	5	33	26	5	14	17	0		

**SE 46 NE 10 4509 6995 Rag Hill, Helperby****Block E**

Surface level +21.7 m  
 Water struck at +5.7 m  
 152 mm percussion  
 May 1978

Waste 16.0 m  
 Bedrock 1.4 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, grey with ochre mottling, firm to stiff, includes thin fine sand laminae	2.0	2.0
Till	Pebbly clay, sandy except for sand-poor band between 9.1 and 11.5 m, reddish brown with greyish brown between 9.1 and 11.5 m, firm to stiff, with pebbles of angular to subrounded brown sandstone, grey chert, black limestone, buff dolomite and green siltstone	14.0	16.0
Sherwood Sandstone Group	'Clayey' sand, fine, red and brown quartz	1.4+	17.4

**SE 46 NE 11 4641 6970 Delhi Plantation, Raskelf****Block E**

Surface level +16.4 m  
 Water not struck  
 152 mm percussion  
 May 1978

Waste 18.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, slightly silty, brown with grey mottling, soft to firm, contains scattered coarse sand granules	3.1	3.1
	Silt, slightly sandy, dark grey, soft, sand exists in thin subhorizontal partings	1.4	4.5
	Clay, dark grey, firm	2.5	7.0
	Silt, dark grey, soft, good lamination indicated by thin partings of coarser silt	0.5	7.5
	Clay, silty, dark grey, firm becoming stiff, with widely spaced silt laminae above 14.0 m depth, becoming closely spaced below	10.5+	18.0

**SE 46 NE 12 4777 6968 Fox Hills, Raskelf****Block E**

Surface level +20.5 m  
 Water not struck  
 152 mm percussion  
 June 1978

Waste 15.6 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, slightly silty, mottled brown and grey, stiff to hard, with few small pebbles (4-10 mm)	1.8	1.8
	Clay, brown, stiff to hard, good lamination shown by widely spaced, thin partings of grey silt becoming more closely spaced downwards	5.7	7.5
Till	Pebbly clay, dark reddish brown, stiff to hard, pebbles mostly 4-16 mm, of subangular light brown and green sandstone, with subangular to subrounded black and light grey limestone becoming abundant below 11.0 m	8.1+	15.6

Surface level +17.3 m  
 Water struck at -0.3 m  
 152 mm percussion  
 July 1978

Overburden 1.0 m  
 Mineral 3.0 m  
 Waste 14.6 m  
 Bedrock 0.8 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt and sand, dark brown, soft to firm, passing downwards into dark grey silty clay	1.0	1.0
	'Clayey' sand; fine, equant, rounded brown and opaque quartz with a trace of black limestone	3.0	4.0
	Clay, slightly silty, brown, firm to stiff, lamination shown by thin partings of reddish brown, fine sand	8.7	12.7
Till	Pebbly clay, dark reddish brown, hard, most pebbles are 4-16 mm of light brown and greyish green siltstone with dark grey limestone; below 17.6 m proportion of greyish green siltstone increases markedly	5.9	18.6
Mercia Mudstone Group	Siltstone, dark, greyish green, micaceous, well bedded, contains crystalline fragments, possibly gypsum	0.8+	19.4

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
17	83	0	1.0-3.0	19	70	10	1	0	0	0
			3.0-4.0	13	74	12	1	0	0	0
			Mean	17	72	10	1	0	0	0

Surface level +20.0 m  
 Water struck about + 7 m  
 203 and 152 mm percussion  
 January 1979

Overburden 0.2 m  
 Mineral 5.0 m  
 Waste 8.2 m  
 Bedrock 1.4 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil, brown	0.2	0.2
Glacial Lake Deposits	'Very clayey' sand; fine with medium, equant, subangular to subrounded brown and opaque quartz; also contains scattered pebbles	5.0	5.2
	Silt, passing downwards into silty clay, greyish brown, soft becoming stiff, laminated in parts	2.6	7.8
Till	Pebbly clay, reddish brown, hard, with pebbles of black mudstone and limestone and yellow sandstone	5.6	13.4
Mercia Mudstone Group	Mudstone, pale reddish brown with green mottling, containing bands of harder siltstone	1.4+	14.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
22	77	1	0.2-0.6	28	48	23	0	0	1	0
			0.6-1.5	16	55	29	0	0	0	0
			1.5-2.5	27	46	27	0	0	0	0
			2.5-5.2	21	59	18	1	1	0	0
			Mean	22	54	22	1	1	0	0

Surface level +13.5 m  
 Water not struck  
 152 mm percussion  
 June 1978

Waste 18.4 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt, sandy, becoming clayey downwards, dark brown and organic, rich at surface, uniform grey below 1.2 m, soft to firm	3.5	3.5
Glacial Lake Deposits	Clay, silty, grey with small areas of reddish brown near top, firm to stiff, showing poor lamination below 8.0 m	14.9+	18.4



SE 46 NE 16 4808 6842 Webb's Plantation, Tholthorpe

Block E

Surface level +21.5 m  
 Water struck at +11.9 m  
 203 mm percussion  
 January 1979

Waste 14.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt, sandy, light brown, soft becoming firm	1.0	1.0
	Clay, brown, stiff, with rootlets near top, contains thin silt laminae below 1.5 m	5.8	6.8
Till	Pebbly clay, dark brown, stiff, subangular to subrounded pebbles of grey sandstone and black limestone with yellowish green and red sandstone and red mudstone	5.7	12.5
	Mudstone boulder, grey	1.5+	14.0

SE 46 NE 17 4918 6878 Spring House, Raskelf

Block E

Surface level +15.2 m  
 Water not struck  
 203 and 152 mm percussion  
 January 1979

Waste 18.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt, clayey, dark yellowish brown	1.4	1.4
Glacial Lake Deposits	'Very clayey' sand; medium with fine, yellowish brown quartz	0.4	1.8
	Clay, uniform brown, finely laminated 3 mm separation	2.7	4.5
	Silt, clayey, uniform brown, soft, faint lamination	4.8	9.3
Till	Pebbly clay, reddish brown, pebbles mostly 4-32 mm of black limestone, brown and grey sandstone with soft red and greyish green sandstone. Below 18.3 m, hard grey mudstone fragments predominate	9.4+	18.7

Surface level +19.2 m  
 Water struck at +11.9 m  
 152 mm percussion  
 June 1978

Overburden 0.5 m  
 Mineral 2.0 m  
 Waste 4.8 m  
 Mineral 4.2 m  
 Waste 2.3 m  
 Mineral 1.6 m  
 Bedrock 1.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Soil, silty with sand	0.5	0.5
	a 'Clayey' sand, fines increasing downwards Sand: fine, rounded brown and opaque quartz with some black limestone	2.0	2.5
	Clay, silty, uniform dark brown, stiff, lamination shown by thin silt partings, which become thicker downwards	2.0	4.5
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, pebbles mostly 4-16 mm of subrounded black limestone and brown sandstone with some rounded soft red sandstone	1.2	5.7
Laminated clay closely associated with Glacial Deposits	Clay, dark brown, stiff, faintly laminated near base by thin seams of fine sand	1.6	7.3
Glacial Sand and Gravel	b Pebbly sand, fines increasing downwards, no pebbles below 9.3 m Gravel: coarse with fine, mostly subrounded brown sandstone Sand: fine, rounded red quartz	4.2	11.5
Till	Pebbly clay, sandy, dark reddish brown, stiff, pebbles mostly 4-32 mm of subangular black limestone and brown sandstone	2.3	13.8
Glacial Sand and Gravel	c Gravel, with some yellowish brown fines Gravel: coarse with fine, subangular to rounded light brown sandstone with some black limestone Sand: medium, equant, rounded brown and opaque quartz	1.6	15.4
Sherwood Sandstone Group	'Very clayey' sand, fine quartz, contains few rounded pebbles of soft red sandstone	1.0+	16.4

## GRADING

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages								
	Fines	Sand	Gravel		Fines			Sand				Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64		
a	18	82	0	0.5-1.5	9	70	20	1	0	0	0		
				1.5-2.5	26	64	9	1	0	0	0		
				Mean	18	66	15	1	0	0	0		
b	9	84	7	7.3-9.3	7	67	9	2	2	13	0		
				9.3-11.5	12	76	10	2	0	0	0		
				Mean	9	72	10	2	1	6	0		
c	3	45	52	13.8-14.8	3	14	18	4	22	36	3		
				14.8-15.4	3	20	32	9	11	22	3		
				Mean	3	16	23	6	18	31	3		
a + b + c	10	76	14	Mean	10	60	14	2	4	9	1		

## COMPOSITION

Depth below surface (m)	Percentage by weight (and number) in 4-64 mm fraction					
	Sandstone	Limestone	Chert	Soft sedimentary	Igneous	Ironstone
13.8-15.4	89 (84)	1 (3)	6 (4)	3 (8)	1 (trace)	trace (1)

Surface level +18.8 m  
Water not struck  
152 mm percussion  
June 1978

Overburden 0.6 m  
Mineral 1.2 m  
Waste 1.0 m  
Mineral 1.0 m  
Waste 14.4 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silty and sandy soil, black	0.6	0.6
	a 'Clayey' sand, fine, equant and rounded brown-stained quartz changing downwards to opaque and red quartz	1.2	1.8
	Clay, silty, mottled reddish brown and brown, stiff	1.0	2.8
	b 'Very clayey' sand, fine, rounded quartz with some noticeable dark grains in coarse fraction	1.0	3.8
	Clay, dark grey with greyish brown silty bands, showing horizontal lamination, firm to stiff. Below 12.5 m, silty bands also contain sand	13.7	17.5
Till	Pebbly clay, reddish brown, stiff, pebbles mostly 4-32 mm of sandstone and black limestone	0.7+	18.2

## GRADING

	Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	17	83	0	0.6-1.8	17	61	21	1	0	0	0
<b>b</b>	29	71	0	2.8-3.8	29	51	19	1	0	0	0
<b>a + b</b>	21	79	0	Mean	21	58	20	1	0	0	0

Surface level +18.2 m  
Water not struck  
152 mm percussion  
July 1978

Waste 18.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt, sandy, dark brown with reddish brown mottling, soft to firm, contains small nodules of white fibrous mineral	2.5	2.5
	Clay, silty, greyish brown with reddish brown silt laminae, firm to stiff, laminae more numerous below 12.5 m	14.6	17.1
Till	Pebbly clay, dark grey becoming reddish brown below 17.7 m; pebbles are mostly 4-16 mm of subangular to subrounded black limestone with red sandstone and greyish green siltstone; the latter more numerous below 17.7 m	0.9+	18.0

Surface level +16.6 m  
 Water struck at +2.2 m  
 152 mm percussion  
 June 1978

Mineral 1.3 m  
 Waste 13.1 m  
 Bedrock 0.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	'Very clayey' sand; fine, red and opaque quartz	1.3	1.3
	Clay, silty, reddish brown, stiff, contains partings of fine sand, partings changing to silt downwards	3.7	5.0
Glacial Sand and Gravel	'Clayey' pebbly sand, reddish brown Gravel: coarse with fine, subrounded light brown sandstone with black limestone Sand: fine, rounded red quartz	1.0	6.0
Till	Pebbly clay, sandy, reddish brown, firm to stiff, with pebbles of angular to subrounded brown sandstone with some black limestone	8.4	14.4
Sherwood Sandstone Group	Sandstone, dark red, fine-grained, well bedded, tabular pebbles	0.1+	14.5

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
24	76	0	0.0-1.3	24	55	19	2	0	0	0
*19	75	6	5.0-6.0	19	63	10	2	2	4	0

\* Non-mineral: excessive overburden

Surface level +32.8 m  
 Water struck at +15.7 m  
 152 mm percussion  
 June 1978

Overburden 2.0 m  
 Mineral 2.0 m  
 Waste 1.3 m  
 Mineral 19.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy, dark reddish brown, firm, becoming more sandy downwards	2.0	2.0
Glacial Sand and Gravel	<b>a</b> 'Very clayey' sandy gravel, dark reddish brown Gravel: coarse, equant, tabular and prolate, angular to subrounded, light brown sandstone and black limestone with some soft red siltstone Sand: fine, rounded opaque and red quartz	2.0	4.0
Till	Pebbly clay, sandy, dark reddish brown, stiff	1.3	5.3
Glacial Sand and Gravel	<b>b</b> 'Clayey' sand, scattered pebbles down to 11.3 m Sand : fine, rounded red quartz with opaque quartz and some black limestone Fines: most evenly dispersed within sand, includes several bands of layered silt between 13.3 and 18.3 m	19.7+	25.0

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64
<b>a</b>	26	48	26	2.0-3.0	23	34	11	5	7	20	0
				3.0-4.0	29	31	11	5	7	17	0
				Mean	26	32	11	5	7	19	0
<b>b</b>	10	89	1	5.3-6.3	18	53	20	4	2	3	0
				6.3-7.3	12	61	16	2	4	5	0
				7.3-8.3	11	79	6	1	2	1	0
				8.3-9.3	12	79	6	1	1	1	0
				9.3-10.3	6	84	8	1	1	0	0
				10.3-11.3	11	76	7	1	2	3	0
				11.3-12.3	9	89	2	0	0	0	0
				12.3-13.3	6	90	4	0	0	0	0
				13.3-14.3	12	83	5	0	0	0	0
				14.3-15.3	8	88	4	0	0	0	0
				15.3-16.3	10	87	3	0	0	0	0
				16.3-17.3	10	74	16	0	0	0	0
				17.3-18.3	38	59	3	0	0	0	0
				18.3-19.3	7	85	8	0	0	0	0
				19.3-20.3	4	85	11	0	0	0	0
				20.3-21.3	3	82	15	0	0	0	0
				21.3-22.3	5	80	15	0	0	0	0
				22.3-23.3	5	87	8	0	0	0	0
				23.3-25.0	5	89	6	0	0	0	0
				Mean	10	79	9	1	0.5	0.5	0
<b>a + b</b>	11	85	4	Mean	11	75	9	1	1	3	0

**COMPOSITION**

Depth below surface (m)	Percentage by weight (and number) in 4-64 mm fraction						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone*
2.0-4.0	70 (56)	19 (22)	4 (3)	1 (4)	4 (10)	2 (2)	trace (3)
5.3-11.3	73 (59)	15 (15)	3 (2)	3 (5)	3 (12)	2 (2)	1 (5)

\* Ironstone was found in the 4-8 mm fraction only

Surface level +26.2 m  
 Water struck at +20.3 m  
 203 and 152 mm percussion  
 January 1979

Mineral 2.5 m  
 Waste 3.4 m  
 Mineral 6.3 m  
 Waste 8.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	a 'Very clayey' sand; fine, brown quartz	2.5	2.5
Laminated clay closely associated with Glacial Deposits	Clay, variegated grey and brown, contains numerous thin silt laminae and scattered small sandstone pebbles	3.4	5.9
Glacial Sand and Gravel	b 'Very clayey' sandy gravel, with cobbles below 8 m Gravel: coarse and fine, yellowish brown sandstone predominates Sand: fine, mostly rounded red quartz	6.3	12.2
Laminated clay closely associated with Glacial Deposits	Silt, sandy at top, containing numerous partings of brown clay below 13.7 m	8.0+	20.2

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	24	76	0	0.0-2.5	24	50	26	0	0	0	0
<b>b</b>	34	39	27	5.9-7.9	36	30	10	5	9	10	0
				7.9-9.9	29	30	9	6	9	15	2
				9.9-12.2	37	16	8	5	13	16	5
				Mean	34	25	9	5	10	14	3
<b>a + b</b>	31	50	19	Mean	31	32	14	4	7	10	2

Surface level +23.3 m  
 Water struck at +12.9 m  
 152 mm percussion  
 June 1978

Mineral 1.7 m  
 Waste 1.0 m  
 Mineral 3.0 m  
 Waste 2.0 m  
 Mineral 17.3 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	a 'Very clayey' sand; fine, rounded opaque and brown quartz	1.7	1.7
Till	Clay, silty, red mottled with brown, firm to stiff, contains scattered pebbles	1.0	2.7
Glacial Sand and Gravel	b 'Clayey' pebbly sand, most pebbles in top 1 m Gravel: fine, black limestone and brown sandstone Sand: fine, rounded brown quartz with some black limestone	3.0	5.7
	Silt, sandy, mostly quartz	2.0	7.7
	c 'Clayey' sand, with bands containing coarse pebbles and boulders between 19.3–19.8 m and 23.5–25.0 m, mostly brown sandstone Sand: fine, red and opaque quartz Fines: mostly dispersed, with some silt bands of varying thicknesses	17.3+	25.0

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						–1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16–64
<b>a</b>	23	77	0	0.0–1.7	23	67	10	0	0	0	0
<b>b</b>	16	72	12	2.7–3.7	16	31	14	7	18	14	0
				3.7–4.7	7	66	17	7	3	0	0
				4.7–5.7	25	70	2	1	1	1	0
				Mean	16	56	11	5	7	5	0
<b>c</b>	12	85	3	7.7–8.7	21	73	2	1	1	2	0
				8.7–10.4	16	80	4	0	0	0	0
				10.4–12.0	5	91	4	0	0	0	0
				12.0–14.0	21	76	3	0	0	0	0
				14.0–16.0	14	85	1	0	0	0	0
				16.0–19.0	12	85	3	0	0	0	0
				19.0–20.0	8	66	2	1	1	18	4
				20.0–23.0	8	87	5	0	0	0	0
				23.0–25.0	8	64	7	4	1	10	6
Mean	12	80	4	1	trace	2	1				
<b>a + b + c</b>	13	83	4	Mean	13	77	5	1	1	2	1

## COMPOSITION

Depth below surface (m)	Percentage by weight (and number) in 4–64 mm fraction					
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous
2.7–3.7	55 (50)	23 (22)	1 (2)	7 (8)	12 (16)	2 (2)

Surface level +14.4 m  
 Water struck at +5.1 m  
 152 mm percussion  
 June 1978

Mineral 2.3  
 Waste 0.4 m  
 Mineral 1.8 m  
 Waste 4.8 m  
 Mineral 4.8 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	a 'Very clayey' sand, fine with medium, rounded red and opaque quartz	2.3	2.3
	Silt, light reddish brown, stiff	0.4	2.7
	b 'Clayey' sand, description as deposit above	1.8	4.5
Till	Pebbly clay, sandy, dark grey, stiff, pebbles mostly 4–32 mm, of equant, tabular and prolate, angular to subrounded brown sandstone and black limestone with soft red sandstone	4.8	9.3
Fluvio-glacial and Older River Sand and Gravel	c Pebbly sand, 'clayey' in top 1 m Gravel: coarse and fine, equant to tabular, subangular to subrounded, light brown sandstone with black limestone and some rounded soft red sandstone Sand: medium, equant, subrounded black limestone and brown sandstone	4.8+	14.1

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines				Gravel		
					– $\frac{1}{16}$	$+\frac{1}{16}$ – $\frac{1}{4}$	$+\frac{1}{4}$ –1	+1–4	+4–16	+16–64	+64
<b>a</b>	22	78	0	0.0–1.3	18	72	9	1	0	0	0
				1.3–2.3	28	64	7	1	0	0	0
				Mean	22	69	8	1	0	0	0
<b>b</b>	15	84	1	2.7–3.5	18	67	14	1	0	0	0
				3.5–4.5	13	61	24	1	1	0	0
				Mean	15	63	20	1	1	0	0
<b>c</b>	6	83	11	9.3–10.3	11	19	56	4	4	6	0
				10.3–11.3	5	17	41	14	10	13	0
				11.3–12.3	3	21	49	23	3	1	0
				12.3–13.3	5	15	49	23	4	4	0
				13.3–14.1	4	8	46	30	5	7	0
				Mean	6	16	49	18	5	6	0
<b>a + b + c</b>	12	82	6	Mean	12	40	32	10	3	3	0



Surface level +26.3 m  
 Water struck at +13.0 m  
 203 and 152 mm percussion  
 January 1979

Overburden 0.5 m  
 Mineral 8.7 m  
 Waste 14.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy brown	0.5	0.5
Glacial Sand and Gravel	'Clayey' sand, with pebbly bands between 1.5-2.0 m and 2.3-2.6 m, consisting mostly of light brown sandstone Sand: fine, angular to rounded, opaque and iron-stained quartz with some chert and black limestone fragments Fines: thin red-brown silt and silty clay bands	8.7	9.2
Laminated clay closely associated with Glacial Deposits	Clay, brown, laminated	0.3	9.5
	Silt, sandy, light brown	3.8	13.3
	Clay, brown, laminated with silt partings	7.9	21.2
	Silt, brown, with clay bands	1.8	23.0
Till	Pebbly clay, dark brown, slight lamination, pebbles mostly 4-32 mm of sandstone, limestone and mudstone	0.5+	23.5

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
11	86	3	0.5-1.5	20	58	13	4	4	1	0
			1.5-2.0	19	55	12	3	5	6	0
			2.0-2.6	17	28	20	10	14	11	0
			2.6-3.7	6	89	2	1	2	0	0
			3.7-4.7	10	84	3	1	1	1	0
			4.7-5.7	12	86	2	0	0	0	0
			5.7-7.9	4	92	4	0	0	0	0
			7.9-9.2	9	89	2	0	0	0	0
			Mean	11	78	6	2	2	1	0

Surface level +20.2 m  
 Water struck at +11.2 m  
 152 mm percussion  
 July 1978

Overburden 3.5 m  
 Mineral 1.3 m  
 Waste 1.4 m  
 Mineral 18.8 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty especially in top 0.6 m, mottled brown, grey and reddish brown, soft to stiff	3.5	3.5
Glacial Sand and Gravel	<b>a</b> 'Very clayey' pebbly sand, brown Gravel: fine and coarse, subangular to subrounded, light brown sandstone and some black limestone Sand: fine, mostly subrounded quartz	1.3	4.8
Till	Pebbly clay, sandy reddish brown, stiff	1.4	6.2
Glacial Sand and Gravel	<b>b</b> 'Very clayey' sand: fine, equant, subrounded to rounded, red quartz with some black limestone fragments in coarse fraction Fines: small nodules of reddish brown silt	2.8	9.0
	<b>c</b> Pebbly sand, pebbles concentrated in bands from 9.0–11.0 m and 22.0–25.0 m Gravel: coarse and fine, equant, subrounded to rounded brown sandstone with black limestone numerous in fine fraction Sand: fine, equant, rounded, red and opaque quartz with some black limestone noticeable in coarse fraction	16.0+	25.0

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64
<b>a</b>	29	57	14	3.5-4.8	29	38	10	9	7	7	0
<b>b</b>	25	74	1	6.2-7.2	24	74	2	0	0	0	0
				7.2-9.0	26	57	13	3	1	0	0
				Mean	25	63	9	2	1	0	0
<b>c</b>	7	83	10	9.0-10.0	12	17	28	17	9	17	0
				10.0-11.0	7	20	41	24	5	3	0
				11.0-12.0	10	74	15	1	0	0	0
				12.0-14.0	8	80	12	0	0	0	
				14.0-16.0	7	84	9	0	0	0	
				16.0-18.0	10	82	8	0	0	0	
				18.0-20.0	8	82	10	0	0	0	
				20.0-22.0	6	69	21	1	1	2	0
				22.0-23.5	5	31	18	9	14	23	0
				23.5-25.0	4	23	22	11	19	16	5
			Mean	7	61	17	5	4	5	1	
<b>a + b + c</b>	11	80	9	Mean	11	60	15	5	4	5	0

Surface level +21.4 m  
 Water struck about +13 m  
 152 mm percussion  
 July 1978

Overburden 9.3 m  
 Mineral 10.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Silt, sandy, variegated light brown with red-brown and dark grey-brown, soft to firm, includes scattered small pebbles	1.4	1.4
Laminated clay closely associated with Glacial Deposits	Clay, silty, grey with reddish brown non-horizontal partings, firm, becoming more silty downwards with thicker partings of sandy silt	4.8	6.2
Glacial Sand and Gravel	Silt, very sandy, opaque and red quartz, with numerous thin bands of grey clay	3.1	9.3
	'Clayey' sand, with low fines content below 15.3 m Sand: fine, rounded opaque and red quartz with few black limestone fragments in medium fraction Fines: red silt	10.7+	20.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64
10	90	0	9.3-10.3	19	80	1	0	0	0	0
			10.3-11.3	10	79	11	0	0	0	0
			11.3-13.3	12	81	7	0	0	0	0
			13.3-15.3	10	76	14	0	0	0	0
			15.3-17.3	6	72	22	0	0	0	0
			17.3-19.0	6	82	10	0	0	2	0
			19.0-20.0	6	78	16	0	0	0	0
			Mean	10	78	12	0	0	0	0

Surface level +15.5 m  
 Water struck at +12.5 m  
 203 and 152 mm percussion  
 January 1979

Overburden 0.3 m  
 Mineral 10.0 m  
 Waste 6.4 m  
 Mineral 5.0 m  
 Waste 3.3 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil	0.3	0.3
Glacial Lake Deposits (to 2.3 m depth)	a 'Very clayey' sand; fine, with some medium mostly between 2.3 and 4.3 m, subangular to subrounded opaque and brown quartz with a trace of limestone and mudstone fragments	10.0	10.3
Glacial Sand and Gravel (below 2.3 m)	Fines: grey clay bands		
Laminated clay closely associated with Glacial Deposits	Silt, sandy, fine red quartz	2.2	12.5
	Clay, grey, laminated with reddish brown fine sand	1.3	13.8
Till	Pebbly clay, greyish brown, hard, pebbles of brown sandstone, grey mudstone and black limestone	2.9	16.7
Glacial Sand and Gravel	b 'Very clayey' sand: fine, red and opaque quartz Fines: thin bands of greyish brown laminated clay	5.0	21.7
Laminated clay closely associated with Glacial Deposits	Clay, silty, brown	3.3+	25.0

## GRADING

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64			
<b>a</b>	32	68	0	0.3-1.3	39	46	14	1	0	0	0			
				1.3-2.3	35	52	13	0	0	0	0			
				2.3-3.3	27	48	25	0	0	0	0			
				3.3-4.3	8	33	58	1	0	0	0			
				4.3-5.3	7	74	19	0	0	0	0			
				5.3-6.3	39	58	3	0	0	0	0			
				6.3-8.3	44	53	3	0	0	0	0			
				8.3-10.3	39	59	2	0	0	0	0			
				Mean	32	54	14	0	0	0	0			
<b>b</b>	33	67	0	16.7-19.7	36	62	2	0	0	0	0			
				19.7-21.7	28	71	1	0	0	0	0			
				Mean	33	65	2	0	0	0	0			
<b>a + b</b>	32	68	0	Mean	32	58	10	0	0	0	0			

Surface level +20.2 m  
 Water struck at +16.0 m  
 203 mm percussion  
 January 1979

Overburden 0.2 m  
 Mineral 1.1 m  
 Waste 2.9 m  
 Mineral 3.8 m  
 Waste 1.0 m  
 Mineral 1.2 m  
 Waste 14.3 m  
 Bedrock 4.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Sandy soil	0.2	0.2
	a 'Very clayey' sand; fine with medium, subangular brown quartz, semi-cohesive	1.1	1.3
	Clay, brown, stiff, laminated with dark organic partings, contains rootlets	2.9	4.2
Glacial Sand and Gravel	b 'Very clayey' sand; fine, subangular red and brown quartz Fines: disseminated clay	3.8	8.0
	Silt, light brown, with thick grey clay partings	1.0	9.0
	c 'Very clayey' sand; fine, subangular red quartz Fines: brown silt partings	1.2	10.2
Laminated clay closely associated with Glacial Deposits	Silt, greyish brown, soft, with thick layers of stiff grey laminated clay	9.6	19.8
Till	Pebbly clay, with silt partings near top, reddish brown to dark brown, pebbles are angular to rounded black limestone, grey sandstone and soft greyish green sandstone	4.7	24.5
Sherwood Sandstone Group	Sand, silty, contains fragments of greyish brown mudstone and siltstone	3.1	27.6
	Sandstone, yellowish green, fine-grained, well bedded	0.9+	28.5

## GRADING

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines			Sand		Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	36	64	0	0.2-1.3	36	41	23	0	0	0	0
<b>b</b>	35	65	0	4.2-6.0	31	67	2	0	0	0	0
				6.0-8.0	38	62	0	0	0	0	0
				Mean	35	64	1	0	0	0	0
<b>c</b>	38	62	0	9.0-10.2	38	62	0	0	0	0	0
<b>a + b + c</b>	36	64	0	Mean	36	59	5	0	0	0	0

Surface level +36.8 m  
 Water struck at +24.4 m  
 203 mm percussion  
 October 1978

Waste 10.0 m  
 Bedrock 4.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, dark brown and reddish brown, firm to stiff, pebbles of equant, subangular to rounded, black limestone and brown sandstone	3.0	3.0
	Clay, silty, dark greyish brown, firm, contains scattered granules (2-4 mm) of brown sandstone and black limestone	2.0	5.0
	Pebbly clay, dark grey changing to dark reddish brown, stiff to hard, pebbles as deposit to 3.0 m depth	5.0	10.0
Sherwood Sandstone Group	'Very clayey' sand, fine with medium, red quartz with stronger bed between 11.0 and 11.8 m producing some tabular, subangular pebbles of red sandstone	4.0+	14.0

Surface level +26.2 m  
 Water struck at +13.4 m  
 203 mm percussion  
 October 1978

Mineral 3.0 m  
 Waste 1.5 m  
 Mineral 4.2 m  
 Waste 2.2 m  
 Bedrock 4.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	<b>a</b> 'Very clayey' pebbly sand; few pebbles below 2 m Gravel: fine, mostly brown sandstone Sand: fine with medium, equant, rounded red and opaque quartz Fines: thin bands of greyish red silty clay, numerous below 2 m	3.0	3.0
	Pebbly clay, silty at top, brown, soft to firm, pebbles becoming larger and more numerous downwards, of subangular to subrounded greyish brown sandstone and black limestone	1.5	4.5
Glacial Sand and Gravel	<b>b</b> 'Very clayey' pebbly sand, with scattered cobbles at top Gravel: coarse and fine, mostly equant, subrounded soft red sandstone with some rounded black limestone and brown sandstone Sand: fine, equant, rounded red quartz with some black limestone Fines: dispersed with sand	4.2	8.7
Till	Pebbly clay, sandy, reddish brown, stiff to hard, pebbles equant, subangular to rounded, brown sandstone with some black limestone	2.2	10.9
Sherwood Sandstone Group	Clayey sand, yellowish brown, fine subrounded quartz, containing pebbles of poorly bedded yellowish brown sandstone below 15.0 m	4.3+	15.2

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64			
<b>a</b>	33	62	5	0.0-2.0	28	26	27	12	6	1	0			
				2.0-3.0	44	55	1	0	0	0	0			
				Mean	33	35	19	8	4	1	0			
<b>b</b>	25	67	8	4.5-6.0	23	55	10	2	2	2	6			
				6.0-7.0	24	51	13	4	4	4	0			
				7.0-8.7	27	50	11	4	2	6	0			
				Mean	25	53	11	3	2	4	2			
<b>a + b</b>	28	65	7	Mean	28	46	14	5	3	3	1			

Surface level +20.2 m  
 Water struck at +11.4 m  
 152 mm percussion  
 August 1978

Overburden 2.0 m  
 Mineral 1.3 m  
 Waste 5.5 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, silty, dark brown, soft, pebbles becoming more numerous downwards, mostly 32–64 mm of equant to tabular, angular to subangular light brown sandstone	2.0	2.0
Glacial Sand and Gravel	‘Very clayey’ pebbly sand, reddish brown Gravel: fine and coarse, mostly equant to tabular, subangular to subrounded sandstone Sand: fine, equant, subrounded opaque and brown quartz	1.3	3.3
Till	Clay, silty, uniform dark grey, stiff, with patches of reddish brown fine sand with granules	2.7	6.0
	Pebbly clay, dark brown, stiff, pebbles mostly 4–16 mm, of equant, subangular white sandstone and subrounded red sandstone with some black limestone	1.6	7.6
	‘Clayey’ pebbly sand; yellowish brown Gravel: coarse, mostly equant and prolate, subrounded to rounded brown sandstone Sand: fine, equant, rounded opaque and brown quartz	1.2	8.8
Sherwood Sandstone Group	Sandstone, light yellowish brown, fine- to medium-grained	1.0+	9.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				–1/16	+1/16–1/4	+1/4–1	+1–4	+4–16	+16–64	+64
20	66	14	2.0–3.3	20	52	8	6	7	7	0



Surface level +12.6 m  
 Water struck at +4.6 m  
 152 mm percussion  
 August 1978

Waste 14.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, dark brown mottled with grey becoming dark grey below 2.9 m, stiff becoming softer downwards, with numerous thin bands of reddish brown silt below 2.9 m	8.3	8.3
	'Clayey' sand, brown Sand: fine with medium, equant, subrounded to rounded, brown and opaque quartz with some black limestone	2.5	10.8
Till	'Pebbly' clay, silty, dark grey with reddish brown patches, firm to stiff, pebbles mostly 4–16 mm of equant and tabular, angular to subrounded brown sandstone and black limestone	3.7+	14.5

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*	12	87	1	8.3-9.3	13	61	25	1	0	0	0
				9.3-10.8	11	57	28	2	trace	2	0
				Mean	12	59	26	2	trace	1	0

\* Non-mineral: excessive overburden

Surface level +13.5 m  
 Water struck at -1.0 m  
 152 mm percussion  
 August 1978

Overburden 3.8 m  
 Mineral 2.1 m  
 Waste 10.6 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt, clayey, mottled grey and brown, soft to firm becoming stiff, silty clay between 1.6 and 3.0 m	3.8	3.8
	Sand, fine with medium, equant, subangular to subrounded, brown and opaque quartz with numerous tabular, subangular black limestone and mudstone	2.1	5.9
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, pebbles mostly 4-32 mm of brown sandstone and black limestone, deposit becoming soft and incohesive below 14.7 m	10.6	16.5
Sherwood Sandstone Group	'Clayey' sand, fine, subrounded quartz containing small pebbles of red sandstone and larger of grey mudstone streaked with red	1.0+	17.5

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
6	93	1	3.8-4.8	9	58	31	2	0	0	0
			4.8-5.9	4	50	42	3	1	0	0
			Mean	6	54	37	2	1	0	0

Surface level +11.0 m  
 Water struck at +1.5 m, artesian  
 152 mm percussion  
 August 1978

Overburden 2.0 m  
 Mineral 1.5 m  
 Waste 6.0 m  
 Mineral 6.0 m  
 Bedrock 0.3 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt, light brown, firm	1.0	1.0
Peat	Clay, peaty, mottled black and dark brown, soft	1.0	2.0
Glacial Lake Deposits	a 'Clayey' sand, fine, equant, rounded brown and opaque quartz with some black limestone	1.5	3.5
Till	Pebbly clay, sandy, dark reddish brown, firm to stiff, pebbles of equant, subangular to subrounded brown sandstone with black limestone	6.0	9.5
Fluvio-glacial and Older River Sand and Gravel	b Pebbly sand, 'clayey' at base Gravel: fine, equant, subangular to rounded, brown sandstone with equant to tabular, subrounded, black limestone Sand: fine and medium, equant, subrounded quartz with equant to tabular, angular to subrounded, brown sandstone and black limestone fragments	6.0	15.5
Sherwood Sandstone Group	Sandstone, brown, fine-grained, contains yellowish grey mudstone nodules	0.3+	15.8

## GRADING

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines			Sand		Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	16	83	1	2.0-3.5	16	65	17	1	1	0	0
<b>b</b>	7	77	16	9.5-11.0	7	46	35	7	2	3	0
				11.0-12.5	5	29	37	15	14	0	0
				12.5-13.5	3	19	31	9	17	21	0
				13.5-15.5	10	52	16	7	9	6	0
				Mean	7	39	29	9	10	6	0
<b>a + b</b>	9	78	13	Mean	9	44	26	8	8	5	0

Surface level +49.8 m  
 Water not struck  
 203 mm percussion  
 October 1978

Mineral 1.6 m  
 Waste 17.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	'Very clayey' sand, fine, reddish brown quartz with a trace of limestone	1.6	1.6
Laminated clay closely associated with Glacial Deposits	Clay, silty, reddish grey with layers of red fine sand; includes scattered small granules below 6 m, soft to firm	6.4	8.0
Till	Pebbly clay, silty, dark greyish brown, firm to stiff, hard in places, pebbles of equant to tabular, angular to rounded, light brown and grey sandstone and black limestone with some equant, rounded red sandstone below 17.3 m	10.6+	18.6

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
29	71	0	0.0-1.6	29	65	5	1	0	0	0

Surface level +34.7 m  
 Water struck at +31.1 m  
 203 and 152 mm percussion  
 November 1978

Overburden 2.6 m  
 Mineral 4.8 m  
 Waste 5.6 m  
 Mineral 3.0 m  
 Bedrock 4.1 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.9	0.9
Till	Pebbly clay, silty at top, mottled reddish brown and grey patches, soft becoming stiff, pebbles mostly 4–16 mm of equant, subangular to subrounded brown sandstone with rounded red sandstone and some tabular black limestone	1.7	2.6
Glacial Sand and Gravel	a Gravel, 'very clayey' in top 1 m, numerous cobbles Gravel: coarse and fine, equant and prolate, subangular to rounded, light brown sandstone with some equant and tabular, black limestone Sand: medium, equant, tabular and prolate, subrounded to rounded, brown sandstone with some black limestone and some subangular buff dolomite	4.8	7.4
Till	Pebbly clay, reddish brown to greyish brown, stiff, pebbles mostly 4–32 mm of sandstone with black limestone and some dolomite	5.6	13.0
Glacial Sand and Gravel	b Sandy gravel Gravel: coarse and fine, equant to tabular, subangular to rounded, brown sandstone with black limestone and some buff dolomite Sand: fine, medium in top 1 m, description as gravel with sandstone and quartz content increasing downwards	3.0	16.0
Sherwood Sandstone Group	'Very clayey' sand, fine, red quartz, contains small fragments of soft red mudstone with irregular lenses of yellow-brown sand below 19.0 m	4.1+	20.1

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines				Gravel		
					– $\frac{1}{16}$	$+\frac{1}{16}$ – $\frac{1}{4}$	$+\frac{1}{4}$ –1	+1–4	+4–16	+16–64	+64
<b>a</b>	7	29	64	2.6–3.6	20	25	10	4	15	26	0
				3.6–5.0	2	4	5	12	32	37	8
				5.0–6.5	5	4	18	12	22	26	13
				6.5–7.4	4	5	10	6	31	38	6
				Mean	7	9	11	9	25	31	8
<b>b</b>	4	60	36	13.0–14.0	2	9	18	14	24	33	0
				14.0–16.0	5	44	20	7	10	12	2
				Mean	4	32	19	9	15	20	1
<b>a + b</b>	6	41	53	Mean	6	18	14	9	21	27	5

Surface level +36.9 m  
 Water not struck  
 203 mm percussion  
 October 1978

Overburden 4.0 m  
 Mineral 2.2 m  
 Waste 0.8 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy, dark and light brown, soft to firm, pebbles of equant and tabular, subangular to rounded, brown sandstone with black limestone and some subangular to subrounded buff dolomite and a trace of rounded red sandstone	4.0	4.0
Glacial Sand and Gravel	'Very clayey' sandy gravel, yellowish brown Gravel: fine and coarse, equant, subangular to rounded brown sandstone with some black limestone and buff dolomite Sand: fine, description as above	2.2	6.2
Till	Pebbly clay, sandy, reddish brown, stiff becoming soft downwards, pebbles as in till above	0.8	7.0
Sherwood Sandstone Group	Sandstone, yellowish brown, fine-grained, well bedded	1.0+	8.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
23	40	37	4.0-5.0	27	15	16	13	17	12	0
			5.0-6.2	20	29	5	2	19	25	0
			Mean	23	23	10	7	18	19	0

Surface level +17.6 m  
 Water struck at +4.7 m  
 152 mm percussion  
 August 1978

Overburden 0.5 m  
 Mineral 1.8 m  
 Waste 4.2 m  
 Mineral 2.5 m  
 Bedrock 4.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Silty soil, dark brown, soft	0.5	0.5
Glacial Sand and Gravel	<b>a</b> 'Clayey' sand, fine, equant, subrounded to rounded opaque and brown quartz	1.8	2.3
Till	Pebbly clay, silty, dark brown, firm to stiff, contains granules (1-4 mm) and pebbles (4-8 mm) of equant subangular to subrounded, black limestone with brown sandstone and some equant, rounded red sandstone	4.2	6.5
Glacial Sand and Gravel	<b>b</b> 'Clayey' pebbly sand, reddish brown Gravel: coarse with fine, mostly concentrated between 8.7 to 9.0 m, brown sandstone Sand: fine equant, subrounded to rounded red and brown quartz	2.5	9.0
Sherwood Sandstone Group	'Clayey' sand, fine red quartz, with pebbles of red sandstone below 12.9 m	4.7+	13.7

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Sand		Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	12	84	4	0.5-2.3	12	54	28	2	2	2	0
<b>b</b>	16	74	10	6.5-7.5	19	67	7	2	1	4	0
				7.5-9.0	14	57	11	4	2	12	0
				Mean	16	62	9	3	2	8	0
<b>a + b</b>	14	78	8	Mean	14	59	17	2	2	6	0

Surface level +62.0 m  
 Water not struck  
 203 and 152 mm percussion  
 November 1978

Overburden 4.8 m  
 Mineral 13.5 m  
 Waste 0.2 m  
 Mineral 4.3 m  
 Waste 2.2 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy, dark brown and reddish brown, soft becoming stiff, pebbles of brown sandstone with black limestone and some red sandstone below 4.0 m	4.8	4.8
Glacial Sand and Gravel	a 'Very clayey' sand, scattered pebbles below 16.6 m Sand: fine with medium, rounded quartz with some equant, subrounded black limestone noticeable in medium fraction Fines: yellowish brown	13.5	18.3
Till	Pebbly clay, dark brown	0.2	18.5
Glacial Sand and Gravel	b 'Very clayey' pebbly sand, scattered cobbles Gravel: coarse, equant, tabular and prolate, angular to rounded, brown sandstone with some black limestone Sand: fine with medium, mostly rounded quartz Fines: reddish brown	4.3	22.8
Till	Pebbly clay, sandy, reddish brown, stiff, pebbles of equant and tabular, subangular to rounded brown sandstone with black limestone and some buff dolomite and rounded soft red sandstone	2.2+	25.0

## GRADING

	Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
	Fines	Sand	Gravel		Fines			Gravel			
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	24	76	0	4.8-5.8	18	55	26	1	0	0	0
				5.8-7.8	8	56	35	1	0	0	0
				7.8-9.8	14	56	30	0	0	0	0
				9.8-11.8	15	77	8	0	0	0	0
				11.8-14.0	38	61	1	0	0	0	0
				14.0-16.6	40	58	2	0	0	0	0
				16.6-18.3	22	63	10	2	1	2	0
Mean	24	61	14	1	0	0	0				
<b>b</b>	25	58	17	18.5-21.5	29	46	13	4	2	6	0
				21.5-22.8	15	25	14	7	3	24	12
				Mean	25	40	13	5	2	11	4
<b>a + b</b>	24	72	4	Mean	24	56	14	2	1	2	1



Surface level +49.8 m  
 Water not struck  
 203 mm percussion  
 November 1978

Mineral 6.0 m  
 Bedrock 2.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	'Very clayey' sandy gravel, scattered cobbles Gravel: coarse, equant and tabular, subangular to rounded brown sandstone with some black limestone Sand: fine with medium and some coarse, equant, rounded opaque and brown quartz Fines: reddish brown	6.0	6.0
Sherwood Sandstone Group	'Clayey' sand, fine, rounded brown quartz, becoming compact downwards	2.1+	8.1

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
21	52	27	0.0-1.5	19	39	14	5	7	16	0
			1.5-3.0	22	43	14	5	5	11	0
			3.0-4.5	24	36	9	5	9	10	7
			4.5-5.7	18	17	8	6	8	38	5
			5.7-6.0	22	48	11	6	7	6	0
			Mean	21	35	12	5	7	17	3

Surface level +49.5 m  
 Water seepage at +43.5 m  
 203 mm percussion  
 September 1978

Overburden 0.5 m  
 Mineral 2.0 m  
 Waste 8.0 m  
 Bedrock 3.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil, brown	0.5	0.5
Till	'Very clayey' pebbly sand, scattered cobbles at top Gravel: coarse, black limestone, brown sandstone with some red sandstone Sand: fine, mostly equant, quartz Fines: irregular thin seams of clay	2.0	2.5
	Pebbly clay, sandy, reddish brown to grey, firm becoming stiff, pebbles mostly brown sandstone	8.0	10.5
Sherwood Sandstone Group	Sand, medium to fine, reddish brown quartz, cemented to soft sandstone in parts	3.3+	13.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	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
30	63	7	0.5-1.5	33	47	9	3	1	4	3
			1.5-2.5	26	54	10	3	2	5	0
			Mean	30	51	9	3	1	4	2

Surface level +41.8 m  
 Water not struck  
 203 mm percussion  
 September 1978

Overburden 0.3 m  
 Mineral 3.0 m  
 Bedrock 0.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Sandy soil	0.3	0.3
	'Very clayey' pebbly sand, with cobbles Gravel: coarse, angular to rounded, black limestone and brown sandstone Sand: fine, equant, rounded brown quartz Fines: reddish brown	3.0	3.3
Sherwood Sandstone Group	Sand, fine to medium, yellow and brown quartz becoming compact downwards	0.5+	3.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
24	60	16	0.3-1.3	21	47	7	3	3	10	9
			1.3-2.3	26	53	6	2	2	3	8
			2.3-3.3	26	52	8	2	3	4	5
			Mean	24	51	7	2	3	6	7

Surface level +21.9 m  
 Water struck at +12.9 m  
 203 mm percussion  
 November 1978

Overburden 4.2 m  
 Mineral 2.6 m  
 Waste 2.2 m  
 Mineral 1.5 m  
 Waste 1.7 m  
 Mineral 1.6 m  
 Bedrock 1.5 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy, dark brown becoming red-brown, soft to stiff, pebbles of equant and tabular, subangular to rounded brown sandstone with black limestone and some soft red sandstone	4.2	4.2
Glacial Sand and Gravel	a 'Very clayey' sand, with scattered pebbles Sand: fine, red and brown quartz	2.6	6.8
Till	Pebbly clay, dark greyish brown, stiff, pebbles of black limestone with brown sandstone	2.2	9.0
Glacial Sand and Gravel	b 'Clayey' gravel, scattered cobbles Gravel: coarse, equant and prolate, subangular to subrounded brown sandstone and equant and tabular, subangular to rounded black limestone Sand: fine with medium and coarse, equant rounded quartz with some sandstone and limestone fragments in medium and coarse fractions	1.5	10.5
Till	Pebbly clay, sandy, reddish brown, very hard	1.7	12.2
Glacial Sand and Gravel	c 'Clayey' pebbly sand Gravel: coarse and fine, as 9.0 to 10.5 m Sand: fine, mostly rounded red and brown quartz	1.6	13.8
Sherwood Sandstone Group	'Clayey' sand, fine, opaque and brown quartz with scattered fragments of yellow siltstone	1.5+	15.3

## GRADING

	Mean for deposit <i>percentages</i>			Depth below surface (m)	Depth below surface (m) <i>percentages</i>						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	21	77	2	4.2-5.5	26	71	2	1	0	0	0
				5.5-6.8	15	79	2	1	3	0	0
				Mean	21	74	2	1	2	0	0
<b>b</b>	12	41	47	9.0-10.5	12	25	10	6	13	30	4
<b>c</b>	14	79	7	12.2-13.8	14	64	12	3	1	2	4
<b>a + b + c</b>	17	68	15	Mean	17	58	7	3	5	8	2

Surface level +50.6 m  
 Water struck at +40.1 m  
 203 mm percussion  
 November 1978

Overburden 7.2 m  
 Mineral 3.3 m  
 Bedrock 1.9 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, sandy at top, brown and grey, firm, changing below 2.4 m to reddish brown and stiff, pebbles of tabular and equant, subangular to rounded brown sandstone with equant, subrounded black limestone and some rounded red sandstone	7.2	7.2
Glacial Sand and Gravel	Gravel, contains cobbles Gravel: coarse, equant, angular (after chiselling) to rounded, brown sandstone with black limestone and some buff dolomite Sand: coarse, equant to tabular, subangular to rounded, sandstone and limestone	3.3	10.5
Sherwood Sandstone Group	'Clayey' sand, fine, mostly opaque quartz, with tabular pebbles of bedded, greyish brown sandstone below 12.3 m	1.9+	12.4

## GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
2	40	58	7.2-8.5	3	8	12	24	26	19	8
			8.5-10.5	2	14	13	10	19	39	3
			Mean	2	11	13	16	22	31	5

Surface level +62.9 m  
 Water not struck  
 203 mm percussion  
 September 1978

Waste 18.0 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Silt and sand soil, dark brown, soft, passing into Pebbly clay, reddish brown, firm becoming hard downwards, pebbles and cobbles of equant to tabular, subangular to subrounded, black limestone and brown sandstone, with pebbles of equant, subrounded buff dolomite, and some small pebbles of rounded red sandstone becoming more numerous below 12 m	0.2 17.8+	0.2 18.0

Surface level +43.6 m  
 Water not struck  
 152 mm percussion  
 August 1978

Overburden 0.5 m  
 Mineral 2.0 m  
 Bedrock 3.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Silt, sandy, dark brown, firm, contains very few sandstone pebbles	0.5	0.5
Glacial Sand and Gravel	'Very clayey' pebbly sand, reddish brown Gravel: scattered fine and coarse brown sandstone Sand: fine, equant, subangular to rounded, opaque quartz with some red and brown-stained quartz	2.0	2.5
Sherwood Sandstone Group	'Clayey' sand, fine, equant, rounded opaque and red quartz	3.0+	5.5

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
22	74	4	0.5-1.5	23	60	10	2	2	3	0
			1.5-2.5	20	74	3	1	2	0	0
			Mean	22	65	7	2	2	2	0

Surface level +20.0 m  
 Water struck at +16.0 m  
 152 mm percussion  
 August 1978

Overburden 4.0 m  
 Mineral 3.8 m  
 Bedrock 0.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark brown, firm	0.4	0.4
	Peat, clayey, black, with some brown vegetation, soft	0.9	1.3
	Clay, with small nodules of sand, greyish brown, soft to firm; contains small patches of vegetation	1.7	3.0
Till	Pebbly clay, silty, reddish brown, firm to stiff, pebbles of angular to subangular brown sandstone and black limestone	1.0	4.0
Glacial Sand and Gravel	Sandy gravel, brown Gravel: coarse and fine, equant, tabular and prolate, angular to subrounded brown sandstone with equant to tabular, black and grey limestone and some tabular to prolate, subangular to rounded buff dolomite Sand: fine, equant, subrounded opaque quartz with some red and brown-stained quartz	3.8	7.8
Sherwood Sandstone Group	Sandstone, yellowish brown, fine- to medium-grained, opaque and iron-stained quartz, poorly bedded	0.7+	8.5

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
4	57	39	4.0-5.5	6	37	13	7	20	17	0
			5.5-7.0	3	24	13	13	19	25	3
			7.0-7.8	2	41	20	11	15	11	0
			Mean	4	33	14	10	18	20	1

Surface level +52.7 m  
 Water struck about +38 m  
 203 mm percussion  
 November 1978

Overburden 6.2 m  
 Mineral 5.4 m  
 Bedrock 3.6 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, silty, dark brown to greyish brown, soft, containing decaying vegetation	1.8	1.8
Till	Pebbly clay, sandy, grey and reddish brown, soft becoming stiff, pebbles of black limestone with brown sandstone and a trace of soft red sandstone	4.4	6.2
Glacial Sand and Gravel	Gravel, 'very clayey' in top 1 m, numerous cobbles Gravel: coarse, equant, tabular and prolate, angular to rounded brown sandstone with subangular to rounded black limestone and some buff dolomite Sand: fine with medium and coarse, rounded quartz with sandstone and limestone fragments	5.4	11.6
Sherwood Sandstone Group	'Clayey' sand, fine, red and brown rounded quartz	3.6+	15.2

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines			Sand		Gravel	
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
8	27	65	6.2-7.2	20	23	7	6	8	29	7
			7.2-8.2	2	7	12	12	21	33	13
			8.2-9.2	9	12	8	5	24	35	7
			9.2-10.2	4	11	8	8	23	39	7
			10.2-11.6	6	9	6	6	13	31	29
			Mean	8	12	8	7	17	34	14



Surface level +53.4 m  
 Water struck at +47.9 m  
 203 and 152 mm percussion  
 September 1978

Overburden 4.5 m  
 Mineral 2.3 m  
 Waste 0.2 m  
 Mineral 2.5 m  
 Waste 11.1 m  
 Bedrock 0.6 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Till	Clay, with silt and fine sand and few pebbles, reddish brown, firm to stiff, pebbles more numerous below 1.2 m	4.5	4.5
Glacial Sand and Gravel	<b>a</b> Gravel, with cobbles Gravel: coarse, equant and tabular, subrounded brown sandstone with equant subangular to subrounded black limestone Sand: medium, equant and rounded quartz with equant and tabular, subrounded brown sandstone and black limestone becoming more numerous downwards	2.3	6.8
Till	Pebbly clay, red, stiff	0.2	7.0
Glacial Sand and Gravel	<b>b</b> Gravel, description as above with more angular pebbles	2.5	9.5
Till	Pebbly clay, sandy, dark reddish brown, stiff, pebbles, mostly 4–16 mm of brown sandstone, black limestone, buff dolomite and red sandstone	11.1	20.6
Sherwood Sandstone Group	Sandstone, red, medium- to fine-grained, poorly cemented	0.6+	21.2

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					– 1/16	+ 1/16–1/4	+ 1/4–1	+1–4	+4–16	+16–64	+64
<b>a</b>	5	33	62	4.5–5.5	9	14	14	7	22	31	3
				5.5–6.8	2	5	16	11	23	34	9
				Mean	5	9	15	9	23	33	6
<b>b</b>	5	32	63	7.0–9.0	3	8	12	6	20	42	9
				9.0–9.5	13	18	31	5	11	18	4
				Mean	5	10	16	6	18	37	8
<b>a + b</b>	5	32	63	Mean	5	9	16	7	20	36	7

## COMPOSITION

Depth below surface (m)	Percentage by weight (and number) in 4–64 mm fraction					
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous
4.5–5.5	61 (39)	27 (39)	5 (7)	4 (9)	3 (6)	trace (trace)
5.5–6.8	54 (37)	32 (41)	2 (3)	8 (10)	3 (6)	1 (3)
7.0–9.0	57 (44)	24 (30)	2 (3)	10 (11)	5 (8)	2 (4)
9.0–9.5	47 (35)	37 (32)	–	12 (25)	3 (6)	1 (2)

Surface level +27.2 m  
 Water struck at +24.9 m  
 203 mm percussion  
 September 1978

Overburden 1.3 m  
 Mineral 5.2 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil, passing downwards into	0.2	0.2
Glacial Lake Deposits	Clayey sand becoming laminated with grey clay laminae	0.6	0.8
Till	Clay, sandy, dark grey, stiff, contains scattered pebbles	0.5	1.3
Glacial Sand and Gravel	'Very clayey' pebbly sand Gravel: coarse, rounded brown sandstone and black limestone with angular buff dolomite and red soft sandstone Sand: fine, rounded red and brown quartz Fines: discrete bands of clay and silt	5.2	6.5
Sherwood Sandstone Group	Sand, fine to medium, rounded red quartz	1.0+	7.5

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
20	72	8	1.3-2.3	31	61	4	1	1	2	0
			2.3-4.3	19	53	10	5	4	7	2
			4.3-5.3	21	59	10	3	3	4	0
			5.3-6.5	12	58	7	18	1	4	0
			Mean	20	57	8	7	2	5	1

Surface level +10.7 m  
 Water struck at +0.7 m, artesian  
 152 mm percussion  
 August 1978

Overburden 10.4 m  
 Mineral 6.0 m  
 Bedrock 2.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt and clay, dark brown, incohesive	0.5	0.5
	Clay, laminated, brown and grey, silty towards the base, with abundant fragments of fossil wood	3.0	3.5
Till	Pebbly clay, silty; matrix red with dark brown patches; pebbles usually small and consisting of light greyish brown sandstone and soft red sandstone	6.9	10.4
Fluvio-glacial and Older River Sand and Gravel	Gravel; pebbly sand below 14.4 m Gravel: fine and coarse, subrounded to rounded, light brown and grey sandstone Sand: medium and fine with some coarse; mostly subangular to rounded quartz and sandstone, with some dark limestone fragments	6.0	16.4
Sherwood Sandstone Group	Sand; fine, subrounded brown and yellow quartz, includes small nodules of soft, micaceous, well bedded, greyish brown siltstone	2.3+	18.7

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64	
5	56	39	10.4-10.7	6	8	16	8	38	24	0
			10.7-13.5	3	14	22	6	16	36	3
			13.5-14.4	2	17	23	6	14	33	5
			14.4-16.4	7	63	16	7	3	4	0
			Mean	5	30	20	6	13	24	2

Surface level +27.4 m  
 Water struck at +7.9 m  
 203 and 152 mm percussion  
 December 1978

Mineral 10.0 m  
 Waste 10.7 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	'Clayey', sandy gravel, lower fines content in parts Gravel: coarse and fine, subangular to rounded, light grey and brown sandstone with dark and light grey limestone Sand: fine with medium and coarse, mostly equant quartz with sandstone and limestone fragments in coarse fraction	10.0	10.0
Laminated clay closely associated with Glacial Deposits	Silt, sandy, red and brown quartz, incohesive Silt, contains bands of laminated clay at top and bottom, dark brown, firm	4.7 3.8	14.7 18.5
Till	Pebbly clay, sandy, dark brown, stiff, pebbles mostly 4–16 mm of subrounded to rounded sandstone and dark limestone	2.2+	20.7

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
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
10	50	40	0.0–1.5	11	33	15	3	7	24	7
			1.5–3.0	12	13	12	12	18	33	0
			3.0–5.0	6	7	7	9	15	41	15
			5.0–7.0	6	20	15	19	23	17	0
			7.0–8.0	4	44	5	1	11	26	9
			8.0–10.0	17	69	11	2	1	0	0
			Mean	10	31	11	8	13	22	5

Surface level +21.2 m  
 Water struck at +3.7 m  
 203 and 152 mm percussion  
 December 1978

Overburden 0.4 m  
 Mineral 3.5 m  
 Waste 13.6 m  
 Mineral 7.9 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Sandy silty soil	0.4	0.4
Glacial Sand and Gravel	<b>a</b> 'Very clayey' sand, with sporadic sandstone pebbles Sand: fine with some medium, red-stained quartz Fines: dark brown	3.5	3.9
Laminated clay closely associated with Glacial Deposits	Clay, brown and reddish brown, laminated with bands of silt and sand up to 5 cm thick	0.7	4.6
Till	Pebbly clay, sandy, dark reddish brown, firm becoming hard, pebbles of sandstone and black limestone	12.9	17.5
Fluvio-glacial and Older River Sand and Gravel	<b>b</b> Sandy gravel Gravel: fine and coarse, with some cobbles, subangular to subrounded light grey sandstone and dark limestone Sand: medium with fine and coarse, mostly quartz, with some dark limestone	7.9+	25.4

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines		Sand		Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	31	69	0	0.4-1.4	39	56	5	0	0	0	0
				1.4-3.9	27	72	1	0	0	0	0
				Mean	31	66	3	0	0	0	0
<b>b</b>	7	54	39	17.5-19.5	6	9	16	12	15	30	12
				19.5-21.5	9	27	36	11	14	3	0
				21.5-23.0	8	15	23	10	27	15	2
				23.0-24.4	3	14	21	7	23	27	5
				24.4-25.4	7	27	12	32	14	8	0
				Mean	7	18	23	13	18	17	4
<b>a + b</b>	15	59	26	Mean	15	34	16	9	12	11	3

Surface level +23.4 m  
 Water struck at +14.9 m  
 203 and 152 mm percussion  
 December 1978

Waste 23.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy silt, dark brown	0.2	0.2
Till	Pebbly clay, silty, yellowish brown with reddish brown mottling, stiff, pebbles mostly 4-32 mm with very few boulders, of equant to tabular, subangular limestone and brown sandstone with some dolomite and red sandstone	9.9	10.1
Glacial Sand and Gravel	'Very clayey' sand Sand: fine, red quartz with some equant, subrounded limestone fragments Fines: reddish brown	2.9	13.0
Laminated clay closely associated with Glacial Deposits	Clay, silty, dark brown, firm, contains thin laminae of reddish brown sand regularly spaced. Below 16.0 m, alternating layers (2-5 cm thick) of brown clay and red-brown silt, becoming uniform brown silty clay below 18.0 m	8.0	21.0
Till	Pebbly clay, dark brown, stiff, pebbles of grey and red sandstones and black limestone	0.5	21.5
?Glacial Sand and Gravel	Gravel Gravel: coarse with fine, equant to tabular, subangular to rounded, grey sandstone with rounded dark limestone Sand: medium and fine, brown quartz and subrounded sandstone and limestone fragments	1.6+	23.1

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*34	66	0	10.1-11.1	24	75	1	0	0	0	0
			11.1-13.0	40	59	1	0	0	0	0
			Mean	34	65	1	0	0	0	0
* 6	34	60	21.5-23.1	6	12	16	6	21	39	0

\* Non-mineral: excessive overburden

Surface level +20.4 m  
 Water struck at +15.9 m  
 203 and 152 mm percussion  
 December 1978

Mineral 10.5 m  
 Waste 10.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	'Very clayey' sand Sand: fine with some medium, quartz, stained red, with some dark limestone Fines: dark brown and reddish brown	10.5	10.5
Laminated clay closely associated with Glacial Deposits	Clay, silty, dark brown, with thin laminae of reddish brown silt, which in parts are in a sub-vertical orientation	10.0+	20.5

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64
25	75	0	0.0-1.1	17	69	14	0	0	0	0
			1.1-2.1	42	52	6	0	0	0	0
			2.1-4.0	14	81	5	0	0	0	0
			4.0-7.0	27	71	2	0	0	0	0
			7.0-10.5	27	72	1	0	0	0	0
			Mean	25	71	4	0	0	0	0

Surface level +19.4 m  
 Water struck at +16.4 m  
 203 and 152 mm percussion  
 February 1979

Overburden 0.2 m  
 Mineral 6.0 m  
 Waste 18.8 m  
 Bedrock 4.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial Sand and Gravel	'Very clayey' sand, scattered pebbles to 2.2 m Sand: fine with medium especially to 2.2 m, reddish brown subangular quartz	6.0	6.2
Laminated clay closely associated with Glacial Deposits	Clay, silty, grey, laminated with partings of red silt and fine sand	12.4	18.6
	Silt, pale brown subangular quartz, containing clay partings near base	5.6	24.2
Till	Pebbly clay, silty, reddish brown, with pebbles of brown sandstone and soft flakes of grey-green variegated mudstone	0.8	25.0
Sherwood Sandstone Group	Sandstone, greyish green, medium- to coarse-grained, poorly bedded	4.0+	29.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines			Sand		Gravel	
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
26	73	1	0.2-2.2	17	61	15	3	3	1	0
			2.2-4.3	34	64	2	0	0	0	0
			4.3-6.2	26	73	1	0	0	0	0
			Mean	26	66	6	1	1	0	0



Surface level +16.0 m  
Water struck at +5.3 m  
152 mm percussion  
July 1978

Overburden 1.0 m  
Mineral 1.0 m  
Waste 10.5 m  
Mineral 4.0 m  
Bedrock 0.8 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Silt with some fine and medium sand becoming more sandy downwards	1.0	1.0
	a 'Very clayey' sand Sand: fine, with some medium, mostly subrounded quartz, yellow and red stained Fines: grey and brown	1.0	2.0
	Silt, and laminated clay, reddish-brown and greyish brown	5.7	7.7
Till	Pebbly clay, silty, dark greyish brown, firm to stiff, with granules and pebbles of sandstone and some limestone, passing down into silt with pebbles in lowest 1.8 m	4.8	12.5
Fluvio-glacial and Older River Sand and Gravel	b Sandy gravel Gravel: coarse and fine, subrounded to rounded grey sandstone and subangular and subrounded black limestone Sand: fine with medium and coarse, quartz, sandstone and black limestone	4.0	16.5
Sherwood Sandstone Group	Sandstone, soft, red, well bedded, micaceous	0.8+	17.3

## GRADING

	Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>									
	Fines	Sand	Gravel		Fines			Sand				Gravel		
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64			
<b>a</b>	29	71	0	1.0-2.0	29	67	4	0	0	0	0			
<b>b</b>	5	70	25	12.5-13.5	4	13	12	11	17	41	2			
				13.5-14.5	6	38	20	12	12	12	0			
				14.5-16.5	6	57	19	11	5	1	0			
				Mean	5	42	17	11	10	14	1			
<b>a + b</b>	10	71	19	Mean	10	47	15	9	8	11	0			

## COMPOSITION

Depth below surface (m)	<i>Percentage by weight (and number) in 4-64 mm fraction</i>						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
12.5-13.5	68 (47)	22 (26)	1 (2)	5 (10)	4 (12)	trace (1)	trace (2)
13.5-14.5	72 (65)	15 (16)	1 (1)	6 (6)	5 (10)	1 (1)	trace (1)

Surface level +16.7 m  
 Water struck at +14.7 m  
 203 and 152 mm percussion  
 February 1979

Overburden 0.2 m  
 Mineral 5.0 m  
 Waste 10.2 m  
 Bedrock 3.6 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil, light brown	0.2	0.2
Glacial Sand and Gravel	'Very clayey' sand, fine with medium, angular reddish brown quartz with a trace of dark chert and mudstone	5.0	5.2
Laminated clay closely associated with Glacial Deposits	Silt with some fine sand, subangular reddish brown quartz, contains many bands up to 20 cm thick of grey laminated clay	6.8	12.0
	Clay, grey, firm, contains thin partings of brown silt	2.8	14.8
Till	Pebbly clay, brown, firm, with pebbles of well rounded tabular greyish green sandstone with brown sandstone and black limestone	0.6	15.4
Sherwood Sandstone Group	Sand, brown and grey, contains small pebbles of sandstone, more consolidated with depth	3.6+	19.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages									
Fines	Sand	Gravel		Fines			Sand			Gravel			
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64			
20	80	0	0.2-1.2	37	60	3	0	0	0	0			
			1.2-2.2	11	86	3	0	0	0	0			
			2.2-3.7	21	76	3	0	0	0	0			
			3.7-5.2	11	85	4	0	0	0	0			
			Mean	20	77	3	0	0	0	0			

Surface level +18.4 m  
 Water struck at +15.4 m  
 203 and 152 mm percussion  
 February 1979

Overburden 0.3 m  
 Mineral 13.0 m  
 Waste 11.9 m  
 Bedrock 3.2 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
	Sandy soil, brown	0.3	0.3
Glacial Sand and Gravel	'Very clayey' sand, fine, angular brown quartz, with traces of black flakey mineral and mica Fines: light reddish brown	13.0	13.3
Laminated clay closely associated with Glacial Deposits	Clay, silty, grey, laminated, and with bands of brown silt, contains few small pebbles near base	6.7	20.0
	Silt, with fine sand down to 22 m, reddish brown and grey, contains few fragments of greyish green sandstone	5.0	25.0
?Till	Pebbly clay, green to grey, pebbles of soft greyish green marly sandstone	0.2	25.2
Sherwood Sandstone Group	Sandstone, grey, medium-grained	3.2+	28.4

## GRADING

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
24	76	0	0.3-1.3	35	64	1	0	0	0	0
			1.3-2.3	18	78	4	0	0	0	0
			2.3-3.3	13	86	1	0	0	0	0
			3.3-5.3	15	84	1	0	0	0	0
			5.3-7.3	38	60	2	0	0	0	0
			7.3-9.3	24	74	2	0	0	0	0
			9.3-11.3	19	78	3	0	0	0	0
			11.3-13.3	22	76	2	0	0	0	0
			Mean	24	74	2	0	0	0	0

Surface level +18.8 m  
 Water struck at +1.8 m  
 152 mm percussion  
 July 1978

Waste 18.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, silty, dark brown with dark reddish brown patches, pebbles of sandstone and dark grey limestone, with laminae of fine sand between 10.5 and 12 m depth	17.3	17.3
Glacial Sand and Gravel	'Clayey' pebbly sand, yellowish brown Sand: fine with medium, brown and opaque white quartz	1.0+	18.3

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64
*18	77	5	17.3-18.3	18	62	12	3	4	1	0

\* Non-mineral: excessive overburden

Surface level +17.4 m  
 Water struck at +2.4 m  
 152 mm percussion  
 July 1978

Waste 18.7 m  
 Bedrock 3.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, silty, dark brown, with pebbles and cobbles of subrounded sandstone and dark limestone, with some red sandstone; poorly laminated from 9.1 to 10.3 m depth	15.0	15.0
Glacial Sand and Gravel	'Very clayey' sand, with sporadic pebbles of yellowish brown sandstone Sand: fine with medium, rounded quartz, yellow and red stained Fines: brown silt and thin bands of red clay	3.0	18.0
Till	Clay, bright red, stiff, with a few small pebbles of sandstone	0.7	18.7
Sherwood Sandstone Group	'Very clayey' sand, fine with some medium, contains few red mudstone nodules and fragments of medium-grained, light grey sandstone	3.3+	22.0

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
*25	72	3	15.0-16.5	15	58	16	6	1	4	0
			16.5-18.0	35	47	14	3	1	0	0
			Mean	25	53	15	4	1	2	0

\* Non-mineral: excessive overburden

Surface level +16.7 m  
 Water struck -0.3 m  
 203 and 152 mm percussion  
 November 1978

Mineral 1.0 m  
 Waste 16.0 m  
 Mineral 6.5 m  
 Bedrock 0.3 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	<b>a</b> 'Very clayey' sand Sand: fine with medium, quartz with a trace of limestone Fines: dark brown, organic-rich	1.0	1.0
Till	Pebbly clay, brown with reddish brown and grey mottles, silty, with pebbles of sandstone, cream dolomite and some red sandstone	9.0	10.0
Laminated clay closely associated with Glacial Deposits	Clay, dark brown, becoming laminated downwards with thin silt partings and sub-horizontal colour banding below 15 m	7.0	17.0
Fluvio-glacial and Older River Sand and Gravel	<b>b</b> Sandy gravel, contains cobbles Gravel: fine and coarse, equant to tabular, subangular to rounded light brown and grey sandstone with dark grey limestone and with some cream dolomite Sand: medium with fine and coarse, rounded quartz, and rock fragments as in gravel fraction	6.5	23.5
Sherwood Sandstone Group	Sandstone, fine-grained, red, micaceous	0.3+	23.8

## GRADING

	Mean for deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	36	62	2	0.0-1.0	36	53	9	0	0	2	0
<b>b</b>	7	47	46	17.0-19.0	8	16	14	19	22	16	5
				19.0-21.0	4	21	21	4	14	36	0
				21.0-23.5	7	13	25	9	16	22	8
				Mean	7	16	20	11	17	24	5
<b>a + b</b>	11	49	40	Mean	11	21	19	9	15	21	4

Surface level +14.3 m  
 Water struck at -5.7 m  
 203 and 152 mm percussion  
 October 1978

Overburden 1.5 m  
 Mineral 4.0 m  
 Waste 15.1 m  
 Bedrock 0.2 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, grey, poor lamination	1.5	1.5
	'Clayey' sand Sand: fine with some medium, mainly quartz, with some limestone particles Fines: greyish brown	4.0	5.5
?Laminated clay closely associated with Glacial Deposits	Clay, slightly silty, greyish brown with reddish brown silt layers 3-5 cm thick; poorly laminated below 8.5 m depth	14.5	20.0
Till	Pebbly clay, silty and sandy, dark brown, firm, pebbles of light brown sandstone and dark grey limestone with some red sandstone	0.6	20.6
Sherwood Sandstone Group	Sandstone, fine- to medium-grained, light brown	0.2+	20.8

**GRADING**

Mean for deposit <i>percentages</i>			Depth below surface (m)	<i>percentages</i>						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
15	85	0	1.5-3.0	5	92	3	0	0	0	0
			3.0-4.5	13	82	5	0	0	0	0
			4.5-5.5	31	65	3	1	0	0	0
			Mean	15	82	3	0	0	0	0

Surface level +14.8 m  
 Water struck at +12.3 m  
 203 and 152 mm percussion  
 September 1978

Mineral 1.5 m  
 Waste 0.5 m  
 Mineral 6.0 m  
 Waste 15.0 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
?Glacial Lake Deposits	<b>a</b> 'Clayey' sand; fine with medium, equant, rounded brown quartz, with some dark limestone particles	1.5	1.5
	Clay, reddish brown and light grey, with thin partings of grey sand	0.5	2.0
	<b>b</b> Sand, fine, with some medium, mainly brown and red-stained quartz	6.0	8.0
Laminated clay closely associated with Glacial Deposits	Clay, greyish brown to brown colour banding, with partings of reddish brown medium sand 1-3 cm spacing	8.0	16.0
Till	Pebbly clay, silty, greyish brown with reddish brown mottles, firm to stiff, with numerous pebbles 4-32 mm of subrounded to rounded light greenish grey sandstone, subangular to subrounded dark limestone and red sandstone	7.0	23.0
Sherwood Sandstone Group	Sandstone, fine-grained, grey	1.0+	24.0

**GRADING**

	Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
	Fines	Sand	Gravel		Fines			Sand		Gravel	
					-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
<b>a</b>	13	86	1	0.0-1.5	13	80	6	0	1	0	0
<b>b</b>	5	95	0	2.0-4.0	3	90	7	0	0	0	0
				4.0-6.0	4	89	7	0	0	0	0
				6.0-8.0	8	90	2	0	0	0	0
				Mean	5	89	6	0	0	0	0
<b>a + b</b>	6	94	0	Mean	6	88	6	0	0	0	0



Surface level +23.2 m  
 Water struck at +11.7 m  
 203 and 152 mm percussion  
 November 1978

Mineral 10.6 m  
 Waste 0.9 m  
 Bedrock 7.2 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Sand and Gravel	'Very clayey' sand, fine with medium, mainly brown quartz with trace of dark limestone fragments Fines: dispersed with sand down to 8.1 m, below 8.1 m as discrete silty clay bands	10.6	10.6
Till	Pebbly clay, very sandy, reddish brown, firm to stiff, pebbles of black limestone and light brown sandstone	0.9	11.5
Sherwood Sandstone Group	'Clayey' sand, fine quartz, passing down into medium-grained, soft, light brown sandstone below 16.5 m depth	7.2+	18.7

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
21	79	0	0.0-1.0	23	63	14	0	0	0	0
			1.0-3.0	16	69	14	0	0	0	0
			3.0-5.0	9	81	10	0	0	0	0
			5.0-6.5	10	79	11	0	0	0	0
			6.5-8.1	27	71	2	0	0	0	0
			8.1-10.6	38	61	1	0	0	0	0
			Mean	21	71	8	0	0	0	0

Surface level +15.5 m  
 Water struck at +8.0 m  
 203 mm percussion  
 November 1978

Overburden 7.5 m  
 Mineral 4.5 m  
 Waste 2.0 m  
 Bedrock 1.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Till	Pebbly clay, slightly silty, brown with grey and reddish brown mottles, with sporadic pebbles of grey and with some red, sandstone	5.0	5.0
Laminated clay closely associated with Glacial Deposits	Clay, dark and light brown bands, stiff, well laminated with thin grey partings	2.5	7.5
Glacial Sand and Gravel	'Very clayey' pebbly sand, no pebbles below 10.2 m Gravel: fine and coarse, angular to subrounded, brown sandstone with some dark limestone Sand: fine, equant, subrounded quartz with some limestone Fines: brown	4.5	12.0
	Sandy silt, brown quartz	2.0	14.0
Sherwood Sandstone Group	Sandstone, medium-grained, reddish brown	1.0+	15.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
29	66	5	7.5-10.2	28	45	13	5	6	3	0
			10.2-12.0	30	65	5	0	0	0	0
			Mean	29	53	10	3	3	2	0

Surface level +13.6 m  
 Water struck at -1.4 m  
 203 mm percussion  
 October 1978

Overburden 15.0 m  
 Mineral 5.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, dark brown, laminated, with partings of reddish brown silt and fine sand	13.7	13.7
Till	Pebbly clay, very sandy, containing numerous pebbles of light grey sandstone with some dark limestone	1.3	15.0
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel, 'clayey' between 18.0 to 19.4 m Gravel: fine and coarse, light brown and grey sandstone, with some dark limestone, mostly in fine gravel fraction Sand: medium and fine with coarse, sandstone and limestone fragments as above	5.1+	20.1

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
7	70	23	15.0-16.0	7	30	34	7	8	14	0
			16.0-17.0	7	26	52	12	2	1	0
			17.0-18.0	4	15	16	10	22	34	0
			18.0-19.4	11	23	31	12	9	14	0
			19.4-20.1	8	46	29	9	7	1	0
			Mean	7	27	33	10	10	13	0

Surface level +12.9 m  
 Water struck at -3.6 m  
 203 and 152 mm percussion  
 October 1978

Waste 18.5 m  
 Bedrock 1.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, silty, greyish brown and reddish brown with silty partings, and, below 15.0 m depth, bands of fine sand with small weathered pebbles of red sandstone	16.0	16.0
Till	Pebbly clay, grey with some reddish brown mottles, with pebbles of light brown and grey sandstone and smaller pebbles and granules of black limestone	2.5	18.5
Sherwood Sandstone Group	Sand, medium and fine with some coarse, mainly quartz	1.3+	19.8

Surface level +22.7 m  
 Water struck at +17.7 m  
 203 mm percussion  
 September 1978

Overburden 0.9 m  
 Mineral 1.1 m  
 Waste 5.5 m  
 Bedrock 0.3 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay and silt, dark brown, firm	0.9	0.9
Glacial Sand and Gravel	'Very clayey' sand Sand: fine with medium, mainly quartz with some limestone Fines: dark greyish brown	1.1	2.0
Laminated clay closely associated with Glacial Deposits	Silt and laminated clay, greyish brown, in parts containing partings of reddish brown fine sand	5.5	7.5
Sherwood Sandstone Group	Sandstone, red, fine- to medium-grained, poorly bedded, micaceous	0.3+	7.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
28	72	0	0.9-2.0	28	64	7	1	0	0	0

Surface level +16.8 m  
 Water struck at +10.3 m  
 203 mm percussion  
 November 1978

Waste 6.5  
 Bedrock 2.5 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Glacial Lake Deposits	Clay, dark brown, laminated	4.1	4.1
Till	Pebbly clay, dark brown, very silty and sandy, with pebbles of light coloured sandstone and black limestone	2.4	6.5
Sherwood Sandstone Group	Sandstone, red, fine-grained	2.5+	9.0

Surface level +9.3 m  
 Water struck at +2.8 m  
 203 mm percussion  
 September 1978

Overburden 8.5 m  
 Mineral 7.2 m  
 Bedrock 2.1 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, very silty, grey with reddish brown mottling	3.6	3.6
Till	Pebbly clay, silty, dark brown, with pebbles of dark limestone, and some light grey sandstone and a trace of red mudstone	4.9	8.5
Fluvio-glacial and Older River Sand and Gravel	Pebbly sand, 'clayey' in parts Gravel: coarse and fine, subrounded to rounded brown and grey sandstone and some subangular to subrounded dark grey limestone Sand: fine with medium and coarse, rounded quartz with dark limestone particles	7.2	15.7
Sherwood Sandstone Group	'Clayey' sand, reddish brown	2.1+	17.8

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
8	70	22	8.5-9.5	4	13	9	5	16	49	4
			9.5-10.5	18	22	35	6	7	3	9
			10.5-11.5	4	43	34	10	9	0	0
			11.5-12.5	10	54	15	10	9	2	0
			12.5-13.5	13	59	10	5	6	7	0
			13.5-15.7	4	49	22	8	6	11	0
			Mean	8	41	21	8	8	12	2

Surface level +8.3 m  
 Water struck at -2.5 m, artesian  
 203 mm percussion  
 September 1978

Overburden 10.8 m  
 Mineral 6.3 m  
 Bedrock 0.9 m+

## LOG

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Clay, slightly silty, dark brown, grey streaks	2.0	2.0
?Glacial Lake Deposits	Clay, yellowish brown and dark greyish brown, with sporadic pebbles, laminated below 2.4 m depth with greyish brown silt partings, includes erratic nodules of till near base	8.8	10.8
Fluvio-glacial and Older River Sand and Gravel	Sandy gravel, dark greyish brown Gravel: fine and coarse, subangular to rounded, light brown and grey sandstone and black limestone, with some tabular subangular mudstone and buff dolomite Sand: medium, mostly subrounded, quartz with some sandstone and limestone fragments	6.3	17.1
Sherwood Sandstone Group	Sandstone, dark red, fine quartz, muddy and poorly bedded	0.9+	18.0

## GRADING

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
3	51	46	10.8-12.0	2	19	28	4	15	32	0
			12.0-13.0	5	18	31	12	19	15	0
			13.0-14.0	4	17	30	13	17	19	0
			14.0-15.0	1	6	13	13	38	29	0
			15.0-16.0	0	7	35	9	19	30	0
			16.0-17.1	4	22	17	13	25	19	0
			Mean	3	15	26	10	22	24	0

## COMPOSITION

Depth below surface (m)	Percentage by weight (and number) in 4-64 mm fraction						
	Sandstone	Limestone	Chert	Dolomite	Soft sedimentary	Igneous	Ironstone
10.8-12.0	78 (45)	4 (15)	8 (10)	3 (3)	4 (13)	1 (1)	2 (13)
12.0-13.0	75 (61)	5 (11)	5 (4)	3 (5)	6 (6)	2 (3)	4 (10)
13.0-14.0	75 (64)	3 (7)	7 (6)	1 (3)	10 (11)	1 (2)	3 (7)
14.0-15.0	70 (52)	10 (11)	6 (10)	1 (2)	11 (17)	trace (trace)	2 (8)
15.0-16.0	85 (60)	4 (9)	3 (6)	1 (2)	6 (13)	-	1 (10)
16.0-17.1	72 (58)	6 (4)	6 (9)	1 (trace)	11 (17)	1 (2)	3 (10)

Surface level +8.4 m  
 Water struck at -6.7 m  
 203 mm percussion  
 September 1978

Overburden 2.0 m  
 Mineral 1.0 m  
 Waste 15.0 m+

**LOG**

Geological classification	Lithology	Thickness m	Depth m
Alluvium	Silt and clay, dark brown	2.0	2.0
	'Very clayey' sand, fine with medium, rounded quartz	1.0	3.0
Glacial Lake Deposits	Clay, greyish brown, stiff, laminated with thin partings of reddish brown fine sand	11.4	14.4
Till	Pebbly clay, dark greyish brown, stiff, with small pebbles of soft red sandstone and some dark grey limestone and light grey sandstone up to 32 mm in size	2.8	17.2
?Fluvio-glacial and Older River Sand and Gravel	Sand, with rare pebbles, medium and coarse, sandstone and limestone fragments with quartz	0.8+	18.0

**GRADING**

Mean for deposit percentages			Depth below surface (m)	Depth below surface (m) percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
				-1/16	+1/16-1/4	+1/4-1	+1-4	+4-16	+16-64	+64
33	67	0	2.0-3.0	33	60	6	1	0	0	0

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THE SAND & GRAVEL RESOURCES OF THE COUNTRY AROUND THOLTHORPE, NORTH YORKSHIRE

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

ORDNANCE SURVEY  
SHEET SE 46  
PROVISIONAL EDITION

88

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

EXPLANATION OF SYMBOLS AND ABBREVIATIONS

- DRIFT**
- Peat P-1
  - Alluvium-clay, sandy in places A-59
  - River Terrace Deposits, undifferentiated-silty clay RT-23
  - Glacial Lake Deposits, Sand and Gravel-very clayey sand and sandy silt, locally with some pebbles
  - Glacial Lake Deposits, Silt and Clay-clay with numerous thin silt laminae and silt with clay laminae
  - Laminated Clay closely associated with Glacial Deposits-clay with thick silt and sand layers
  - Glacial Sand and Gravel-sand to clayey sandy gravel
  - Till and Sandy Till-pebbly clay, sandy in places
  - Fluvio-glacial and Older River Sand and Gravel-gravel, locally sandy (Hidden by other Drift deposits)

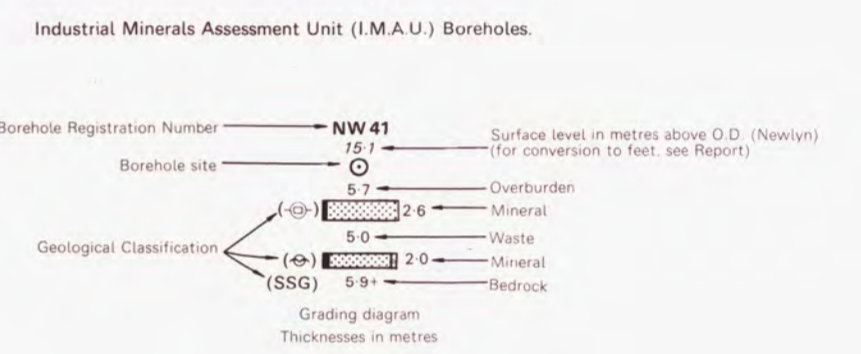
- SOLID**
- MMG Mercia Mudstone Group-reddish-brown mudstone with green mottles and gypsum layers
  - SSG Sherwood Sandstone Group-red and light grey fine sandstone with siltstone and mudstone beds

- Made ground. MG-2
- Area worked for sand and gravel. WO-20

- BOUNDARY LINES**
- Geological boundary, Drift.
  - Geological boundary, Solid.
  - Fault; crossmark indicates downthrow side.
  - Resource Block boundary.
  - Inferred boundary between recognised categories of deposits.

I.M.A.U. BOREHOLE DATA

SITE LOCATIONS



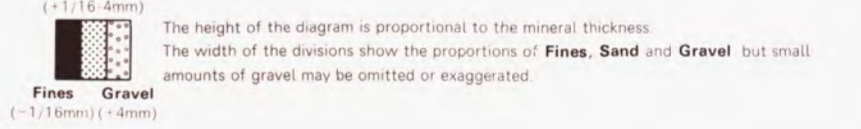
- Note:
- (i) Figures underlined denote thicknesses used in the assessment of resources.
  - (ii) The + sign indicates that the base of the deposit was not reached.
  - (iii) The Geological Classification is given only for mineral and bedrock.

Borehole Registration Number

Each I.M.A.U. borehole is identified by a Registration Number, e.g. NW 41. The letters refer to the quarter sheet and the figures to the I.G.S. serial numbers for that quarter. The unique designation for borehole NW 41 is SE 46 NW 41.

Grading Diagrams

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



CATEGORIES OF DEPOSITS

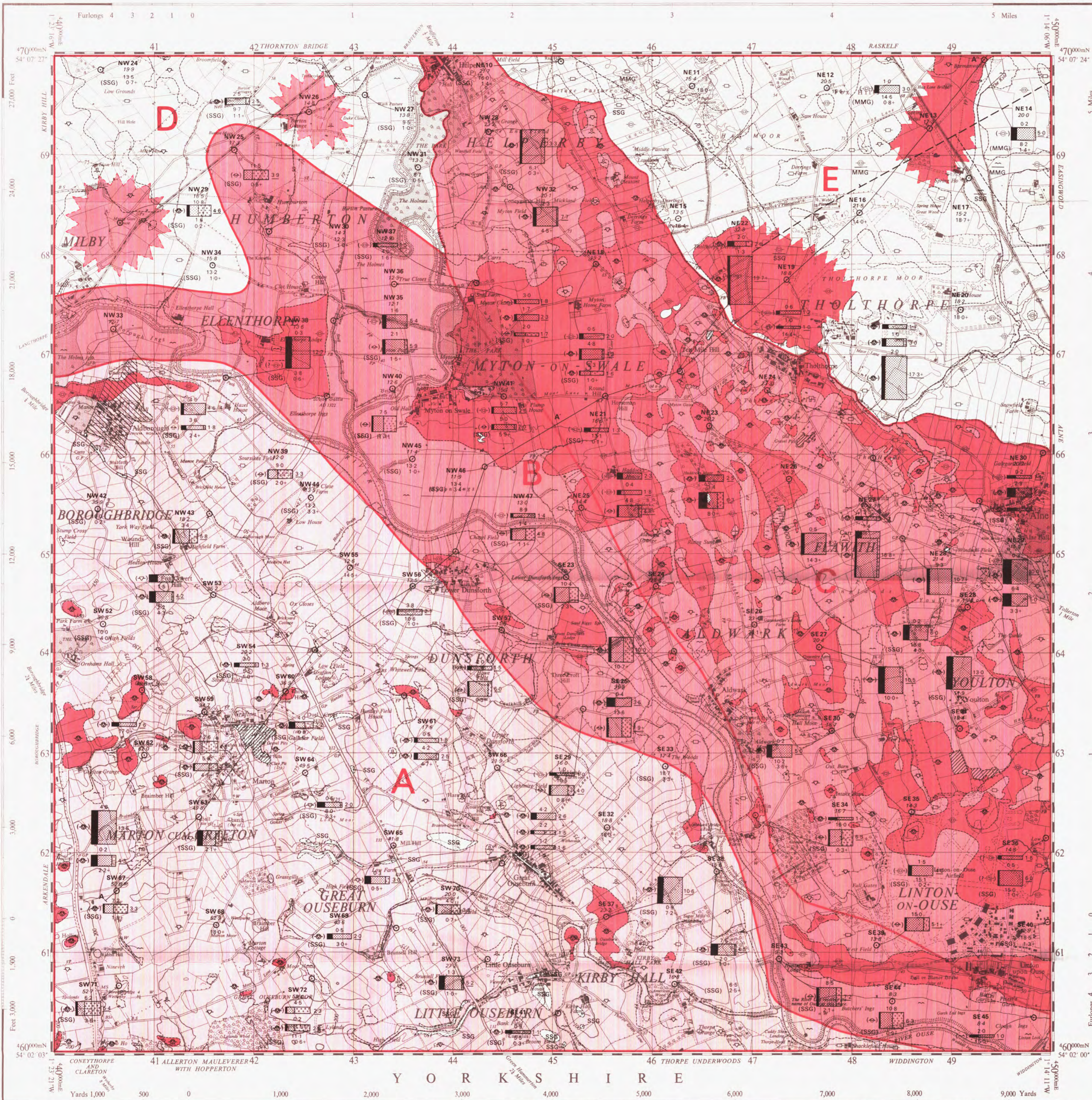
- Exposed mineral CAT-E6
- Continuous or almost continuous spreads of mineral beneath overburden CAT-C2
- Discontinuous mineral beneath overburden CAT-D1
- Sand and gravel either not potentially workable (see Report) or absent CAT-A2

RESOURCE BLOCKS

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

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

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



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

Original geological survey by C. Fox-Strangways between 1865 and 1871. Published as part of one-inch Old Series Sheet 93 NW in 1874 (subsequently New Series Sheet 62). Re-surveyed by H. Johnson and J. P. B. Symonds in 1926 and 1976. E. G. Smith, District Geologist.

Sand and Gravel Survey by R. Stanczyzyn, A. M. Harrison, D. Price, and D. Thomas in 1978 and 1979. R. G. Thurvell, Head, Industrial Minerals Assessment Unit.

1:25 000 Sand and Gravel Resource Sheet, published 1981. G. M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences, 1100.81

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 revised 1907-10. Other partial systematic revision 1950-51 has been incorporated. Major roads and Linton-on-Ouse Airfield revised 1970.

Made and published by the Ordnance Survey, Southampton. Reprinted with the addition of airfield.

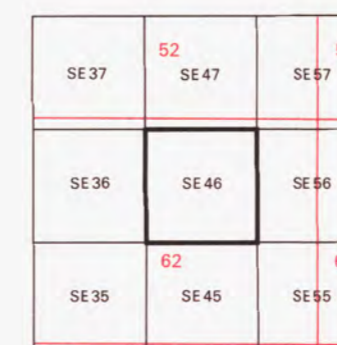


Diagram showing the relation of the National Grid 1:25 000 sheets with the New Series One-Inch Geological Sheets 52, 53, 62 and 63.